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The 2013 Plains Nutrition Council Spring Conference

Thursday, April 18

8:30 AM - 11:30 AM **Preconference Symposium -** *presented and sponsored by* ***Elanco***

11:00 AM - 1:00 PM **Graduate research poster presentations**

2013 Plains Nutrition Council Spring Conference

1:00 PM **Welcome and Introduction** - *Dr. Matt Cravey, Amarillo, TX*

1:10 **Domestic and Global Influences Shaping Markets for Beef, Cattle, and Feed Commodities** - *Mr.Charles McVean, McVean Trading & Investments, Memphis, TN*

2:00 **Sorting Feedlot Cattle - Can We Improve Management and Marketing? -** *Dr. Steve Armbruster, Steve Armbruster Consulting, Stillwater, OK*

2:45 **Break and View Graduate Research Poster Presentations**

3:15 **Research Update** – *Dr. Harvey Freetly, USDA-ARS, Clay Center, NE*

3:45 **AIP: Etiology, Management and Environment** - *Dr. Tim McAllister, Agriculture and Agri-Food Canada, Lethbridge, Alberta*

4:30 **Foot Health in Feedlot Cattle** - *Dr. Shane Terrell, Kansas State Univ., Manhattan*

5:15 **View Graduate Research Poster Presentations**

6:00-7:30 **Evening Reception** *Sponsored by* ***RAMP– Sweet Bran Cargill***

Friday, April 19

8:00 AM **PNC Business Meeting**

8:30 **Revision of the NRC Requirements for Beef Cattle -** *Dr. Mike Galyean, Texas Tech Univ., Lubbock, Dr. Andy Cole, USDA-ARS, Bushland, TX, Dr. Clint Krehbiel, Oklahoma State Univ., Stillwater, Dr. Galen Erickson, Univ. of Nebraska, Lincoln*

9:00 **Growing/Backgrounding Programs for Calves - Management Regimens, Carryover Influences on Finishing Performance, Carcass Weights and Carcass Composition -** *Dr. Robbi Pritchard, South Dakota State Univ., Brookings*

9:45 **Dr. Kenneth and Caroline Eng Foundation Graduate Student Recognition -** *Dr. Kenneth Eng, San Antonio, TX, and Dr. Nathan Elam, Nutrition Services Assoc., Hereford, TX*

10:00 **Break**

10:30 **Research Update -** *Dr. Chris Reinhardt, Kansas State University, Manhattan*

11:00 **Feed Grains, Processing, and Feeding Value** – *Dr. Fred Owens, Pioneer Hi-bred International, Johnston, IA*

12:00PM **Adjourn**

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Sorting Feedlot Cattle by Body Weight

S. L. Armbruster[1], P. T. Anderson[2] and M. N. Streeter[3]
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[2]Midwest PMS, LLC, Firestone, CO
[3]Merck Animal Health, DeSoto, KS

Introduction

Many cattle feeders are asking their consultants for recommendations regarding sorting feedlot cattle. Sorting has potential to increase the value of cattle and improve industry-wide product profile but has associated costs and risks. Applicable research is limited, and specific sorting strategies are not well proven.

The primary reason to consider sorting is the opportunity to increase the value of a group of cattle by increasing the value of some of the individual animals within the group. Avoiding discounts or achieving premiums increases individual animal value. Weight-related discounts are the most critical to focus on because they have greater economic impact than quality grade or yield grade factors (Table 1). Weight is also more easily and accurately identified than other traits, so most current sorting systems focus solely or largely on individual animal live or carcass weight.

Each National Beef Quality Audit (NBQA) conducted since 1995 listed some measure of size or uniformity among the highest priority challenges for the industry (Figure 1) so improving the weight profile of the population would provide industry benefits as well. Other high priority industry challenges could be addressed by sorting as well. Improving the USDA quality or yield grade profile of the population would increase value, but muscling and fatness are not easily quantified in live animals.

Earlier Research

Although numerous studies on sorting have been published, they differed widely in design so pooling data for a comprehensive overview of the research is not possible. Several trials were conducted with yearlings from a common grazing background or with calves from a small number of cow herds (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009). These research animals likely were more uniform in genetics, weight, frame, age, and body condition than many cattle entering commercial feedlots, especially from sale-barn origins.

Sorting trials have been conducted almost exclusively with steers. Considering gender differences in physiology and growth performance, it could be potentially misleading to extrapolate sorting data from steers to heifers. In this review, references and comments are for steers unless noted otherwise.

The majority of research was conducted in small pens with relatively low numbers of animals (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009; Hussey et al., 2012; Rolf et al., 2012). Inherently, there is the question of applicability of small-pen results to large-pen environments. Larger populations might be necessary to evaluate data occurring at low frequency or to define meaningful distributions of values.

In most studies, sorted steers were fed 1-2 weeks longer and subsequently to heavier weights than unsorted steers (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009; Hussey et al., 2012; Rolf et al., 2012). Those outcomes were by design, because researchers assumed sorted steers would have less variation in hot carcass weight (HCW), thereby reducing discounts for carcasses that were too heavy and/or too fat. Consequently, the effects of sorting per se were confounded by differences between sorted and unsorted steers in days on feed (DOF) and HCW.

Typically steers were sorted by body weight (BW) only once, upon entry into the feedlot (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009; Rolf et al., 2012). Limited research has been reported regarding the effects of sorting at reimplant or nearer slaughter (Hussey et al., 2012). None included sorting a pen more than once during the finishing period. Further, no studies were designed to examine the comingling effects of sorting on health, behavior, or feed intake.

Usually steers were sorted upon entry into three outcome groups, with dissimilar numbers of steers among the groups (Folmer et al., 2008; Griffin et al., 2009; Rolf et al., 2012). Although the middle-weight sort was usually the largest head count, the proportion among sort groups varied from trial to trial. Sorting into groups of disproportionate size might fit the population better but can create issues in feedlots, especially for light and heavy sorts. Challenges include inefficient use of pen space and prolonged periods required to complete lots for cattle sorted on entry. Other sorting strategies examined to a limited extent included 2-way sorting by entry BW (MacDonald et al., 2006), or "topping off" of pens near the end of the finishing period (Cooper et al., 2000; Hussey et al., 2012).

Sorting steers by BW alone had no consistent or predictable effect on dry matter intake, average daily gain or feed efficiency (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009; Hussey et al., 2012; Rolf et al., 2012). Because sorted steers were often fed longer and to heavier weights, one could extrapolate that sorting by BW slightly improved performance in cattle fed to a common weight. A conservative conclusion is that sorted steers fed 1-2 weeks longer had similar daily gain and feed efficiency, compared to unsorted contemporaries.

Sorting steers reduced variation in final BW (Folmer et al., 2008; Griffin et al., 2009). Across studies, ranges in standard deviation (SD) for final BW were 62 to 78 lb and 99 to 100 lb in sorted and unsorted steers, respectively. The range in SD for initial BW was 42 to 71 lb depending on study, relatively low variation compared to cattle typically entering commercial feedlots. Frequently, steers in a study were from a common source, i.e. cow herd or grazing background. When variation in BW is higher upon entry to a feedlot, a reasonable question is whether sorting reduces SD of final BW to the same extent as in the research trials.

Sorting reduced variation in HCW in most studies (Folmer et al., 2008; Griffin et al., 2009; Hussey et al., 2012) except one with a 2-way entry sort of ranch-source calves from a common grazing background (MacDonald et al., 2006). Ranges in SD for HCW were 39 to 60 lb and 63 to 82 lb for sorted and unsorted steers, respectively. As with live BW, the SD of HCW were often low compared to those observed in commercial feedlots.

In recent trials (Hussey et al., 2012; Rolf et al., 2012) HCW were typical of current industry weights. In earlier studies (MacDonald et al., 2006; Folmer et al., 2008; Griffin et al., 2009), HCW were lower. Thus the reduction in HCW variation from sorting in research trials might not necessarily be representative of results with larger populations of more varied steers fed to heavier weights.

Sorting did not consistently reduce the percentage of overweight carcasses in most studies. Thresholds for discounts varied by trial and were > 870 lb (MacDonald et al., 2006), > 950 lb (Folmer et al., 2008; Griffin et al., 2009), >1000 lb (Griffin et al., 2009; Hussey et al., 2012; Rolf et al., 2012) and >1050 lb (Hussey et al., 2012). Minimal effect on heavy-carcass discounts was not surprising, given the low means and SD for HCW in several research trials, compared to those often observed in the feedlot industry.

Sorting by BW alone had no consistent or predictable effect on carcass composition in these studies. MacDonald et al. (2006) and Folmer et al. (2008) reported no differences in carcass traits between sorted and unsorted steers. Griffin et al. (2009) reported higher fat thickness and higher percentage of yield grade 4 (YG4) in sorted steers but no difference in average YG. Hussey et al. (2012) noted sorted steers had higher marbling scores, higher percent choice and above, higher percent YG4 and lower percent YG2. Rolf et al. (2012) reported higher marbling scores and average YG in sorted steers.

Results in some studies suggested sorted steers were fatter, but data on carcass composition were confounded by higher HCW in sorted steers, the consequence of more DOF. Research leaves unanswered the question about the impact of sorting (BW alone) on the percentage of YG4 and YG5 carcasses, particularly relevant with heifers.

There have been few studies of the relationships between sorting and growth promoting compounds such as implants and beta agonists. Griffin et al. (2009) reported no interaction between sorting and Optaflexx. Hussey et al. (2012) noted that Zilmax increased SD of HCW in unsorted steers, in contrast to the findings of Hilscher et al. (2013) where Zilmax had no effect on HCW variation. In a practical context, sorting is a tool for managing the additional HCW resulting from use of the growth-promoting products.

Several studies included detailed economic analyses of sorting effects (Folmer et al., 2008; Griffin et al., 2009; Hussey et al., 2012; Rolf et al., 2012). Often the conclusion was that sorting did not improve profitably, even with modest increases in carcass weight and decreases in carcass-weight variation. However, the models were static rather than dynamic, applied in eras of lower carcass weights, prices and discounts than those prevalent in the industry today.

Current Terminal Sorting Research

Streeter et al. (2012) reviewed serial harvest research and concluded that carcass weight gain remains linear for several weeks after cattle were projected to be marketed. This occurs despite declining live performance and reflects increasing proportion of live weight gained as carcass weight. When the value of daily carcass gain exceeds the daily cost to feed cattle, market conditions encourage feeding cattle to heavier weights. Carcasses in excess of 1000 or 1050 lb are discounted and these discounts are often the factor most likely to limit feeding duration of steers. For heifers, an increasing proportion USDA Yield Grade 4 and 5 carcasses is the carcass factor most likely to limit feeding duration. Terminally sorting steers based predominantly on weight is one potential method to reduce the percentage of carcasses exceeding the heavy weight discount point while increasing the average carcass weight of a pen or lot.

Two large-pen (90 hd/pen) and one medium-pen (25 hd/pen) well replicated studies were completed under similar protocols (Table 2). The primary objective of these studies was to determine the impact of terminally sorting steers 50 to 80 days before projected harvest on standard deviation of HCW and resulting percentage of carcasses greater than industry standard heavy carcass discount points (≥1000 lb and ≥1050 lb). A secondary objective was to evaluate live and carcass performance within individual sorted groups. In all studies, steers in the sorted groups were fed as one group until terminal sorting occurred so dry matter intake (DMI) and feed efficiency are reported post-sorting. Average daily gain (ADG) is reported pre- and post-sort in Study 1 and Study 2 where individual BW measurements were obtained at study initiation. In Study 3, only pen weights were obtained at study initiation eliminating the option to determine pre-sort ADG. All studies included an unsorted control, unsorted Zilmax (fed for 20 days with 3-day withdrawal) and sorted Zilmax treatments, with four sort groups of equal size, based on weight. Only the unsorted and sorted Zilmax groups have been included for consideration.

Cattle Origin

Cattle included in Study 1 were of sale barn origin sorted on arrival with a commercial sorting system and blocked by arrival group (Table 2). Cattle used in Study 2 were also sale barn derived steers blocked by arrival date but not sorted on arrival. Cattle in Study 3 originated from 5 different ranches. Ranch of origin was the blocking factor such that no block included cattle from multiple ranches. In this study steers were not sorted on arrival.

Sorting Methodology

Steers in Studies 1 and 2 were terminally sorted 50 days prior to the projected harvest date for the positive control treatment group; whereas, steers in Study 3 were sorted 80 days prior to projected harvest. Studies 1 and 3 used a commercial sorting system that included body weight in combination with a proxy for frame size to identify optimal cattle endpoints based on predicted formula outcomes. In addition, this commercial system included a model that modified expected marketing date based on actual DMI and resulting projected performance and carcass composition. Steers in Study 2 were sorted solely on body weight 50 days prior to projected harvest for the unsorted positive control group. For all three studies, steers were proportionately sorted into four equal-sized outcome groups.

Live Performance for Unsorted and Sorted Groups

Compared with the unsorted treatment, DOF were extended for the sorted treatment in all three studies (Table 3). Live performance was reduced by sorting in Study 1 with sorted steers having a higher final BW but reduced ADG, DMI and feed efficiency. In Studies 2 and 3 live performance was not altered by sorting even though sorted groups were fed for additional days compared with their unsorted cohorts. Reasons for differences between studies are not apparent but differences in origin and day of sorting are likely involved.

Carcass Performance

HCW was increased (P=0.01) by sorting and adding days for Study 1 and numerically greater for Studies 2 and 3 (Table 4). Dressed yield was not affected by sorting in Studies 2 and 3 but was increased (P=0.002) in Study 1. Terminally sorting steers decreased carcass weight variation in all three studies with standard deviation of carcass weight reduced 30% to 38% across studies. The net effect of reduced variation in carcass weight was a reduction in the percentage of carcasses weighing greater than 1000 lb or 1050 lb. Collectively, the three studies support the use of terminally sorting as an effective tool to reduce heavy weight carcass discounts while allowing for greater average carcass weight. Yield grade and quality grade distributions were not altered (P > 0.15) by sorting for any of the studies.

Results from these studies demonstrate that sorting can be used to increase carcass revenue while adding days on feed by reducing discounts associated with heavy carcasses without adversely affecting yield grade or quality grade. Further optimization of sorted cattle performance may be possible by investigating cattle performance and carcass characteristics within sorted groups.

Performance of Sorted Groups

Understanding pre- and post-sort performance is critical in managing sorting expectations. As an example, cattle could be sorted into a particular weight group due to their growth rate or simply because they were younger or older than their cohorts when placed. Post-sort performance would be expected to differ based on the reason for inclusion in their sort group.

In studies 1 and 2, individual steer weights were recorded at study initiation and terminal sorting allowing ADG determination prior to sorting. These measurements provide insight about how individuals of sale barn origin become part of specific sorted groups. Similar information is not available from Study 3 with ranch origin steers. Steers were terminal sorted on a proportional basis in all studies. Proportional sorting allows for greater pen utilization than sorting into more discrete outcome groups. Proportional sorting also forces all the variation associated with tails of a normal distribution to be included in the lightest and heaviest sorted group.

In Study 1 (Table 5), steers had the same (P=0.73) initial weight regardless of their sort group. However, at terminal sorting the Heavy sort group steers weighed 227 lb more (P<0.001) than their Light sort group cohorts with the Mid-heavy and Mid-light groups intermediate but different from other groups. Pre-sort ADG was 2.25 lb/d greater for the Heavy group compared with the Light group with all four groups differing (P<0.001) from each other. Post-sort ADG and feed efficiency, adjusted for the effects of Zilmax in periods of differing length, appeared to be best for the Heavy group, poorest for the Light group, with Mid-Heavy and Mid-light groups intermediate. The difference between Heavy and Light group performance was less dramatic post-sort compared with pre-sort. In fact, post-sort ADG was greater than pre-sort for the Light group, perhaps suggesting that steers in the Light group were unable to effectively compete in their previous comingled pen environment. DMI could not be determined pre-sort, because of comingled pens, but post sort DMI was greatest for the Heavy group, least for the Light group with Mid-heavy and Mid-light intermediate and not different (P>0.05) from each other.

In Study 2, initial weight differed among sort groups in a predictable manner with all groups different from each other (Table 5). The Heavy group weighed 121 lb more than the light group at study initiation. At terminal sort 110 days later, the Heavy group weighed 214 lb more than the Light group. The change in sort weight was reflected in pre-sort ADG with the Heavy group gaining 0.84 lb/d more than the Light group. Post-sort ADG and DMI were greatest for the Heavy group and least for the Light group with the Mid-heavy and Mid-light groups intermediate. Reductions in DMI for the Mid-heavy, Mid-light, and Light sort groups were disproportionate to changes in ADG resulting in poorer feed efficiency for these groups compared with the Heavy group. As noted in Study 1, adjusted ADG appeared to improve post-sort for the Light group. Unlike Study 1, adjusted post-sort ADG appeared to be improved in the Mid-light and Mid-heavy groups compared with pre-sort ADG.

Study 3 steers were from 5 ranches with ranch as the blocking factor. At the time of terminal sorting the Heavy group weighed 250 lb more than the Light group and all treatments differed from each other (Table 5). Arrival weights were not available for this so it is unknown whether steers arrived at the feed yard with differing weights as in Study 2 or similar initial weight as in Study 1 with differing pre-sort performance levels. As noted in Studies 1 and 2, post-sort DMI was greatest for the Heavy group and least for the Light group with the Mid-heavy and Mid-light groups intermediate but all treatments different from each other. Unlike Studies 1 and 2, changes in DMI appeared to be proportional to post-sort ADG as adjusted feed efficiency favored the light weight group and was poorest for the Heavy group.

Performance differences pre- and post-sort among sorted groups appear to be influenced by numerous factors beyond the scope of the studies reviewed. Understanding how individuals are ultimately sorted into outcome groups represents tremendous opportunity to optimize cattle performance through various management strategies and to determine appropriate feeding durations. Generally, when cattle were blocked by ranch, less variation in post-sort ADG and feed efficiency was observed than with sale-barn derived steers. This might have been due to chance or might have been the result of less genetic and management variation among ranch steers.

Carcass weight and characteristics of sorted groups

The goal of all three studies was to feed sorted groups to a similar carcass weight. However, large differences in DMI and feed efficiency resulted in poor predictability of live and ultimately carcass ADG. As a consequence, HCW varied among sort groups for Study 2 ($P < 0.05$) and appeared to vary for Study 3 (Table 6). However, HCW was not different ($P=0.77$) among sorted groups in Study 1. Standard deviation of HCW differed consistently across studies with the greatest HCW SD occurring in the Light group, the least in the Mid-heavy and Mid-light groups, with the Heavy group second greatest. This observation should be expected because steers were sorted on a proportional basis. Proportional sorting forces variation associated with the tails of a normal distribution into the Light and Heavy groups. The proportion of carcasses ≥1000 lb or ≥ 1050 lb is a function of two factors, HCW and SD of HCW. Consequently, for Studies 1 and 2 where less variation in HCW between sorted groups was noted, the greatest proportion of carcasses ≥ 1000 lb occurred in the Light and Heavy groups. In Study 3, HCW decreased with terminal sort weight resulting in the greatest proportion of carcasses ≥ 1000 lb occurring in the Heavy group and the least in the Light group.

A Model to Describe Unsorted vs. Sorted Populations

To illustrate potential effects of sorting based on live weight, a predictive model was developed. For the model, a key assumption is that both unsorted and sorted populations are normally distributed with regard to weight.

The model focuses solely on weight as a sorting factor. Other criteria such as frame size, age, fat thickness and/or marbling score are relevant but there are too few studies, where these measurements were components of sorting, to be confident of their impact.

Further, our focus is on the effects of sorting on variation in carcass weight and on management of carcass weight discounts. Research suggests that sorting by BW alone has minimal influence on carcass composition traits, such as yield grade and quality grade. Sorting could affect carcass composition but there is insufficient published data for conclusions and on which to base a sorting model.

The 2011 NBQA reported an SD of hot carcass weight (HCW) of 102.5 lb. For examples herein, SD for HCW of unsorted populations will be 100 lb, which is comparable to the NBQA data and supported by privately viewed data sets.

Sorting is often used as part of a strategy to increase weight while keeping heavy carcass discounts at an acceptable level. Figure 2 illustrates two normally distributed populations, each with a mean HCW of 900 lb and with SD of 100 lb (solid line) or 60 lb (dashed line). Figure 3 shows the original population with mean HCW of 900 and SD of 100 along with a heavier population with mean of 950 and SD of 60. With less variation, the heavier population has only a few more carcasses over 1000 lb and fewer above 1050 lb.

Data in Table 7 represent normally distributed populations with mean HCW from 700 to 1000 lb and SD of 100 or 60 and show the percentage of each population that is outside of designated weight categories. Usually, with the same mean, a smaller SD means that extreme cattle are closer to the mean and results in fewer penalized cattle. As an example, if mean HCW is 900, a population with SD of 100 lb would have more than three times as many carcasses over 1000 lb (15.87% vs. 4.78%) and more than ten times as many over 1050 lb (6.68% vs. 0.62%), compared to an SD of 60 lb. A rare exception to this would occur if the mean weight is at or above the penalty line, in which case a lower SD would increase the percentage penalized.

The primary economic factor addressed by the model is gross revenue, from an animal or a pen of cattle. Costs of sorting are important and include considerations such as pen-space utilization and yardage, added labor, specialized facilities and equipment, physical stress of cattle, disruptions of social order and feed intake, and the consequence of commingling on health. These costs can be quantified once the specifics of a sorting system are defined.

Output from the model is shown in linked Tables 8a and 8b. In the panel on the top (8a), the user has entered the following data (bold and bordered) to describe a population of carcasses and weight-related discounts:

Mean hot carcass weight:	850 lb
Base carcass price:	$200/cwt
Standard deviation of HCW:	100, 80 or 60 lb for comparison
Light penalty:	$30/cwt for carcasses lighter than 600 lb
Heavy 1 penalty:	$15/cwt for carcasses 1000-1049 lb
Heavy 2 penalty:	$35/cwt for carcasses 1050 lb and heavier

The remaining displayed values are calculated by the model. With mean HCW of 850 lb and SD of 100 lb, 6.5% of the carcasses would fall into penalty weight categories and the average carcass price would be reduced by $1.25/cwt due to heavy carcass discounts. At SD of 80 or 60 lb, fewer carcasses fall into penalty weight categories and discounts are reduced. Note that the model considers weight only and does not attempt to consider quality grade, yield grade or other factors that influence carcass value.

The panel on the bottom (8b) allows the user to enter additional data and predict what the population would look like at a heavier mean HCW. In this example, the user entered the following additional data:

Mean hot carcass weight:	900 lb
Carcass average daily gain:	2.5 lb
Daily cost:	$4.00/head

Given these inputs, the model projects that if the weight is added but SD not reduced, penalty carcasses would increase to 18.0% of the population and discounts would increase to $3.96/cwt. However, if the population could be sorted to a SD of 80 or 60 lb, fewer heavy penalties would be incurred, even with a higher mean weight. In this example, consider that the population with mean HCW of 850 lb and SD of 100 is an unsorted population and the population with mean HCW of 900 lb and SD of 60 lb is sorted. Given these inputs, revenue is greater and discounts lower in the sorted population. Compared to the unsorted population, revenue over cost is increased by $25.39 per head, of which $14.90 is due to added weight and the remainder due to reduced penalties. Note also that in this scenario, added weight without reduced SD was negative with SD of 100 lb (-$5.00) but positive ($5.35) with SD of 80 lb and more positive ($14.90) with SD of 60 lb.

The model can be used to illustrate several key points. In the example shown in Tables 9a and 9b, input has been changed so that heavy penalties are incurred at HCW of 1050, rather than 1000 lb in the previous example. As expected, this allows heavier mean HCW without substantial penalty, especially with a small SD.

The economics of additional weight are dependent on several key variables, including the rate of carcass gain, carcass price and daily cost. In the example shown in Tables 10a and 10b, each of these variables was adjusted slightly from the base example (8a and 8b), resulting in dramatically different output.

Fully describing all potential scenarios is beyond the scope of this paper. The critical message is that each production and marketing situation is unique. There are a number of economically relevant variables that must be taken into account when evaluating potential sorting strategies.

Verifying the Model

Data from the Elanco Benchmark© Performance Program (G. Vogel, Elanco Animal Health, Canyon, TX, personal communication) were used to describe the population with regard to frequency of heavy carcasses and to validate output from the model developed for this paper. The Benchmark data represent carcass information from 48,186 lots of steers marketed from January 2009 through January 2013. Figure 4 is derived from Benchmark data and illustrates the relationship between the mean HCW of the lot and the percentage of steer carcasses over 1000 lb, or over 1050 lb.

Benchmark mean and SD HCW data were entered into the model and predicted frequency of heavy carcasses compared to actual Benchmark results in Figure 5. Differences between the model output and actual Benchmark results are small indicating that the model can be used to predict frequency of heavy carcasses and suggesting that the Benchmark data represent normally distributed populations.

Data from recently reported studies by Hilscher et al. (2013) and Merck Animal Health (Study MS-04-10, M. N. Streeter, Merck Animal Health, DeSoto, KS, personal communication) were used to compare model predictions of heavy carcasses with research populations. Predicted (model) values were similar to actual (research) values, either sorted vs. unsorted (Tables 11 and 13), or across sort groups (Tables 12 and 14).

An interesting trend was observed in both the populations reported by Hilscher et al. (2013) and by Merck Animal Health. Each study included four equal-size weight sort groups to represent the sorted population. In each case, the outer sort groups had higher HCW SD than the inner groups. This would be expected in a normally distributed population.

Implications

- Terminal sorting of steers by body weight is an effective tool for increasing revenue, through reduced carcass weight variation, increased carcass weight and minimized discounts for heavy carcasses.
- The economic benefits from sorting can be dynamically modeled, but precisely estimating costs and risks associated with sorting is more challenging.
- Benefits from sorting related to carcass weight are relatively well defined. Data regarding effects on quality grade and yield grade distributions are not compelling.
- Outcomes can be very different among sort groups within a given lot of cattle. Thus success should be evaluated using the mean of sorted pens within the lot.

- Understanding why individuals are ultimately sorted into outcome groups represents tremendous opportunity to optimize cattle performance and carcass value within those groups.
- Accurately estimating pre- and post-sort performance of sort groups is critical in making decisions about optimum feeding periods and in predicting carcass weight and composition.
- A risk of underestimating the post-sort performance of a group is that, due to reduced variation, there can be a dramatic increase in weight-discounted carcasses.
- Optimum sorting strategy is probably unique to each feedlot and cattle population. Thus consultants advising clients on profitable sorting strategies will find value in dynamic sorting models.
- Further research is needed on important questions such as time to sort, frequency of sorting, number of sort groups, distribution among sort groups, post-sort performance, sorting criteria in addition to live weight, and impact of sorting on heifer performance and carcass value.

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Table 1. Typical carcass premiums and discounts

	Premium or discount, $/cwt	Weight	Impact, $/carcass
Prime	12.00	800	96.00
Choice	6.00	800	48.00
Standard/No roll	-12.00	800	-96.00
Yield grade 1	4.00	800	32.00
Yield grade 2	2.00	800	16.00
Yield grade 3	0.00	800	0.00
Yield grade 4	-12.00	800	-96.00
Yield grade 5	-15.00	800	-120.00
Light	-30.00	599	-179.70
Heavy	-30.00	1051	-315.30

Table 2. Description of Merck Animal Health sorting studies

Item	**Study 1**	**Study 2**	**Study 3**
Study reference	MS-04-10	Hilscher et al., 2013	MS – Zilmax-13-11
Study location	Texas	Nebraska	Idaho
Replicates/ treatment	8	8	6
Approximate pen size	90	25	100
Cattle Source	Sale barn	Sale barn / UNL pool	Ranch origin
Gender	Steer	Steer	Steer
Blocking factor	Feed yard arrival date	Feed yard arrival date	Ranch of origin
Sorted on arrival	Yes	No	No
Terminal sorting factor	Weight / Frame	Weight	Weight / Frame
Terminal sort, d*	50	50	80

*Days prior to projected harvest of Unsorted treatment group

Table 3. Effect of terminal sorting steers 50 to 80 d prior to projected harvest on live performance.

Item	Un-sorted	Sorted	P-value
Study 1			
Replicates	8	8	
Pens	8	32	
Days on Feed	143	153	<0.001
Initial wt, lb	781	783	0.59
Final wt, lb	1377	1396	0.04
ADG, lb/d	4.18	4.02	0.001
DMI, lb/d	21.8	21.4	0.03
Feed to Gain	5.21	5.32	0.003
Study 2			
Replicates	8	8	
Pens	8	32	
Days on Feed	154	159	0.28
Initial wt, lb	822	824	0.95
Final wt, lb	1492	1503	0.26
ADG, lb/d	4.34	4.30	0.59
DMI, lb/d	26.4	26.10	0.08
Feed to Gain	6.06	6.06	1.00
Study 3			
Replicates	6	6	
Pens	6	24	
Days on Feed	77	81	
Initial wt, lb	1105	1093	0.01
Final wt, lb	1381	1386	0.67
ADG, lb/d	3.61	3.66	0.43
DMI, lb/d	21.9	21.8	0.20
Feed to Gain	6.08	5.99	0.43

Table 4. Effect of terminal sorting steers 50 to 80 d prior to projected harvest on carcass performance

Item	Un-sorted	Sorted	P-value
Study 1			
Replicates	8	8	
Pens	8	32	
# Carcasses	702	2726	
HCW, lb	897	916	0.01
HCW SD, lb	70.6	49.5	<0.001
Dressed yield, %	65.17	65.61	0.002
% 1000 to 1049 lb	6.54	3.37	0.001
% ≥ 1050 lb	1.82	0.22	<0.001
Study 2			
Replicates	8	8	
Pens	8	32	
# Carcasses	200	800	
HCW, lb	948	957	0.124
HCW SD, lb	63.6	39.5	<0.01
Dressed yield, %	63.5	63.6	<0.001
% ≥1000 lb	17.61	13.64	0.16
% ≥ 1050 lb	4.42	1.38	0.006
Study 3			
Replicates	6	6	
Pens	6	24	
# Carcasses			
HCW, lb	905	910	0.61
HCW SD, lb	82.4	54.1	
Dressed yield, %	65.6	65.6	0.77
% ≥1000 lb	15.30	9.04	0.08

Table 5. Effect of terminal sorting on live performance within sorted groups

Item	Heavy	Mid-heavy	Mid-light	Light	p-value
Study 1					
Total DOF, d	125[d]	144[c]	157[b]	184[a]	<0.001
Post sort DOF, d	32[d]	51[c]	64[b]	90[a]	<0.001
Initial wt., lb	782	785	781	782	0.73
Sort wt., lb	1256[a]	1181[b]	1129[c]	1046[d]	<0.001
Final wt., lb	1419[a]	1410[a]	1390[ab]	1369[b]	0.002
ADG, lb/d					
Pre-sort	5.08[a]	4.23[b]	3.72[c]	2.83[d]	<0.001
Post-sort	5.14[a]	4.51[b]	4.09[c]	3.58[d]	<0.001
Adjusted Post-sort*	4.47	4.10	3.77	3.37	
Overall	5.10[a]	4.33[b]	3.87[c]	3.20[d]	<0.001
Post sort DMI, lb/d	22.6[a]	22.1[ab]	21.4[b]	20.3[c]	<0.001
Post sort F:G	4.41[a]	4.90[b]	5.22[c]	5.68[d]	<0.001
Adjusted F:G*	5.06	5.39	5.68	6.02	
Study 2					
Total DOF, d	140	154	161	182	
Post-sort DOF, d	30[d]	44[c]	51[b]	71[a]	<0.001
Initial wt., lb	887[a]	840[b]	803[c]	766[d]	<0.001
Sort wt., lb	1386[a]	1302[b]	1248[c]	1172[d]	<0.001
Final wt., lb	1543[a]	1509[b]	1490[bc]	1473[c]	<0.001
ADG, lb/d					
Pre-sort	4.53[a]	4.19[b]	4.03[c]	3.69[d]	<0.001
Post sort	5.34[a]	4.75[b]	4.77[b]	4.19[c]	<0.001
Adjusted Post-sort*	4.57	4.25	4.35	3.97	
Overall	4.69[a]	4.35[b]	4.27[c]	3.89[d]	<0.001
Post sort DMI, lb/d	29.13[a]	28.40[a]	28.13[a]	26.75[b]	<0.001
Post-sort F:G	5.44[c]	5.98[b]	5.88[b]	6.35[a]	<0.001
Adjusted F:G*	6.37	6.68	6.47	6.74	
Study 3					
Total DOF, d					
Post-sort DOF, d	55[d]	73[c]	90[b]	107[a]	0.04
Initial wt., lb					
Sort wt., lb	1216[a]	1129[b]	1059[c]	966[d]	<0.001
Final wt., lb	1427[a]	1398[ab]	1382[b]	1338[c]	<0.001
Post sort ADG, lb/d	3.82[a]	3.73[ab]	3.58[bc]	3.49[c]	0.004
Adjusted ADG, lb/d*	3.47	3.41	3.37	3.29	
Post sort DMI, lb/d	22.8[a]	22.2[b]	21.6[c]	20.7[d]	<0.001
Post sort F:G	5.99	5.97	6.05	5.95	
Adjusted F:G*	6.57	6.51	6.41	6.29	

*Zilmax was assumed to increase live weight gain by 20 lb, based on pooled summary of 18 studies involving 226 pens/treatment group and approximately 10,900 steers/treatment group.

Table 6. Effect of terminal sorting on carcass characteristics of sorted groups.

Item	Heavy	Mid-heavy	Mid-light	Light	P-value
Study 1					
HCW, lb	917	920	916	911	0.77
SD of HCW	44.7^{b}	37.3^{c}	42.2^{bc}	59.9^{a}	<0.001
Dressed Yield, %	64.64^{d}	65.28^{c}	65.87^{b}	66.54^{a}	<0.001
Carcasses ≥1000, %	4.30^{a}	1.53^{b}	2.33^{ab}	5.09^{a}	0.002
Carcasses ≥1050, %	0	0	0	0	
Study 2					
HCW, lb	977^{a}	959^{b}	947^{bc}	945^{c}	<0.05
SD of HCW	39.4^{b}	32.6^{bc}	29.4^{c}	56.7^{a}	<0.05
Dressed Yield, %	63.3^{b}	63.6^{b}	63.6^{b}	64.1^{a}	<0.05
Carcasses ≥1000, %	28.1^{a}	9.5^{bc}	4.0^{c}	15.3^{b}	<0.05
Carcasses ≥1050, %	5.6^{a}	0.0^{b}	0.0^{b}	1.0^{b}	<0.01
Study 3					
HCW, lb	932	914	914	878	
SD of HCW	55.5	45.2	48.5	67.3	
Dressed Yield, %	65.3	65.4	66.2	65.6	
Carcasses ≥1000, %	18.33	8.32	5.93	3.56	

Table 7. Percentage of carcasses discounted due to weight

Mean HCW	700	800	900	1000	700	800	900	1000
Std Dev	100	100	100	100	60	60	60	60
<600 lb	15.87	2.28	0.00	0.00	4.78	0.04	0.00	0.00
>1000 lb	0.13	2.28	15.87	50.00	0.00	0.04	4.78	50.00
>1050 lb	0.02	0.62	6.68	30.85	0.00	0.00	0.62	20.23
Total	16.00	4.56	15.87	50.00	4.78	0.08	4.78	50.00

Table 8a. Model base scenario

		Mean HCW	**850**		
		Base price, $/cwt	**200.00**		
		Mean HCW, lb	850	850	850
		StDev, lb	**100**	**80**	**60**
	Limit	Discount, $/cwt			
Light, %	**600**	**30.00**	0.1%	0.0%	0.0%
OK, %			93.5%	98.1%	99.9%
Heavy 1, %	**1000**	**15.00**	5.0%	1.8%	0.1%
Heavy 2, %	**1050**	**35.00**	1.4%	0.1%	0.0%
		Penalty, %	6.5%	1.9%	0.1%
		Discounts, $/cwt	1.25	0.32	0.02
		Net price, $/cwt	198.75	199.68	199.98

Table 8b. Model output with additional weight

Mean HCW	**900**		Carcass ADG, lb		**2.50**
Base price, $/cwt	200.00		Daily cost, $/head		**4.00**
			Added cost, $/hd		80.00
		Mean HCW, lb	900	900	900
		StDev, lb	100	80	60
	Limit	Discount, $/cwt			
Light, %	600	30.00	0.0%	0.0%	0.0%
OK, %			82.0%	89.7%	96.3%
Heavy 1, %	1000	15.00	11.7%	8.4%	3.6%
Heavy 2, %	1050	35.00	6.3%	1.9%	0.1%
Penalty, %		Penalty, %	18.0%	10.3%	3.7%
		Discounts, $/cwt	3.96	1.93	0.59
		Net price, $/cwt	196.04	198.07	199.41
		Added revenue, $/hd	75.00	85.35	94.90
		Net for added weight	-5.00	5.35	14.90
		Weight and reduced SD		13.30	25.39

Table 9a. Model base scenario with heavy penalty at 1050 lb

		Mean HCW	**900**		
		Base price, $/cwt	**200.00**		
		Mean HCW, lb	900	900	900
		StDev, lb	**100**	**80**	**60**
	Limit	Discount, $/cwt			
Light, %	**600**	**30.00**	0.0%	0.0%	0.0%
OK, %			93.7%	98.1%	99.9%
Heavy 1, %	**1050**	**35.00**	0.0%	0.0%	0.0%
Heavy 2, %	**1050**	**35.00**	6.3%	1.9%	0.1%
		Penalty, %	6.3%	1.9%	0.1%
		Discounts, $/cwt	2.21	0.67	0.05
		Net price, $/cwt	197.79	199.33	199.95

Table 9b. Model output with added weight and heavy penalty at 1050 lb

Mean HCW	**950**		Carcass ADG, lb		**2.50**
Base price, $/cwt	200.00		Daily cost, $/head		**4.00**
			Added cost, $/hd		80.00
		Mean HCW, lb	950	950	950
		StDev, lb	100	80	60
	Limit	Discount, $/cwt			
Light, %	600	30.00	0.0%	0.0%	0.0%
OK, %			82.1%	89.8%	96.3%
Heavy 1, %	1050	35.00	0.0%	0.0%	0.0%
Heavy 2, %	1050	35.00	17.9%	10.2%	3.7%
Penalty, %		Penalty, %	17.9%	10.2%	3.7%
		Discounts, $/cwt	6.25	3.58	1.30
		Net price, $/cwt	193.75	196.42	198.70
		Added revenue, $/hd	60.55	71.99	88.10
		Net for added weight	-19.45	-8.01	8.10
		Weight and reduced SD		5.87	27.59

Table 10a. Model base scenario

		Mean HCW	**850**		
		Base price, $/cwt	**190.00**		
		Mean HCW, lb	850	850	850
		StDev, lb	**100**	**80**	**60**
	Limit	Discount, $/cwt			
Light, %	**600**	**30.00**	0.1%	0.0%	0.0%
OK, %			93.5%	98.1%	99.9%
Heavy 1, %	**1000**	**15.00**	5.0%	1.8%	0.1%
Heavy 2, %	**1050**	**35.00**	1.4%	0.1%	0.0%
		Penalty, %	6.5%	1.9%	0.1%
		Discounts, $/cwt	1.25	0.32	0.02
		Net price, $/cwt	188.75	189.68	189.98

Table 10b. Model output with added weight

Mean HCW	**900**		Carcass ADG, lb		**2.30**
Base price, $/cwt	190.00		Daily cost, $/head		**4.20**
			Added cost, $/hd		91.30
		Mean HCW, lb	900	900	900
		StDev, lb	100	80	60
	Limit	Discount, $/cwt			
Light, %	600	30.00	0.0%	0.0%	0.0%
OK, %			82.0%	89.7%	96.3%
Heavy 1, %	1000	15.00	11.7%	8.4%	3.6%
Heavy 2, %	1050	35.00	6.3%	1.9%	0.1%
Penalty, %		Penalty, %	18.0%	10.3%	3.7%
		Discounts, $/cwt	3.96	1.93	0.59
		Net price, $/cwt	186.04	188.07	189.41
		Added revenue, $/hd	70.00	80.35	89.90
		Net for added weight	-21.30	-10.96	-1.41
		Weight and reduced SD		-3.00	9.08

Table 11. Actual vs. predicted heavy carcasses, sorted vs. unsorted (Hilscher et al., 2013)

		Neg Ctl	Pos Ctl	1 Sort	4 Sort
	HCW, lb	914	947	954	956
	HCW SD, lb	63.9	63.7	58.6	39.4
Actual	>1000 lb, %	9.8	17.6	22.3	13.6
Model	>1000 lb, %	8.8	17.8	20.1	13.3
Actual	>1050 lb, %	2.0	4.4	2.0	1.4
Model	>1050 lb, %	0.6	4.4	3.7	0.2

Table 12. Actual vs. predicted heavy carcasses, among sort groups, (Hilscher et al., 2013)

		Heavy	Mid-H	Mid-L	Light
	HCW, lb	976	958	945	943
	HCW SD, lb	39.4	32.6	29.3	56.6
Actual	>1000 lb, %	28.1	9.5	4.0	15.3
Model	>1000 lb, %	27.1	9.5	1.7	15.1
Actual	>1050 lb, %	5.6	0.0	0.5	1.0
Model	>1050 lb, %	1.8	0.0	0.0	1.8

Table 13. Actual vs. predicted heavy carcasses, sorted vs. unsorted (Merck Animal Health Study MS-04-10)

		Unsorted	Sorted
	HCW, lb	897	916
	HCW SD, lb	70.6	49.5
Actual	>1000 lb, %	6.5	3.4
Model	>1000 lb, %	5.4	3.1
Actual	>1050 lb, %	1.8	0.2
Model	>1050 lb, %	0.7	0.0

Table 14. Actual vs. predicted heavy carcasses, among sort groups (Merck Animal Health Study MS-04-10)

		Sort 1	Sort 2	Sort 3	Sort 4
	HCW, lb	917	920	916	911
	HCW SD, lb	44.7	37.3	42.2	59.9
Actual	>1000 lb, %	4.3	1.5	2.3	5.1
Model	>1000 lb, %	1.8	0.6	1.2	5.6
Actual	>1050 lb, %	0.0	0.0	0.0	0.0
Model	>1050 lb, %	0.0	0.0	0.0	0.3

1991	1995	2000	2005	2011
External fat	Uniformity	Uniformity	Traceability	Food safety
Seam fat	Palatability	Carcass weights	Uniformity	Easting satisfaction
Overall palatability	Marbling	Tenderness	Instrument grading	How and where cattle were raised
Tenderness	Tenderness	Marbling	Market signals	Lean, fat and bone
Cutability	External and seam fat	Reduced quality due to implants	Segmentation	Weight and size
Marbling	Cut weights	External fat	Carcass weights	Cattle genetics

Figure 1. Beef quality challenges as reported by the National Beef Quality Audit. Ranked by priority, 1991 to 2011

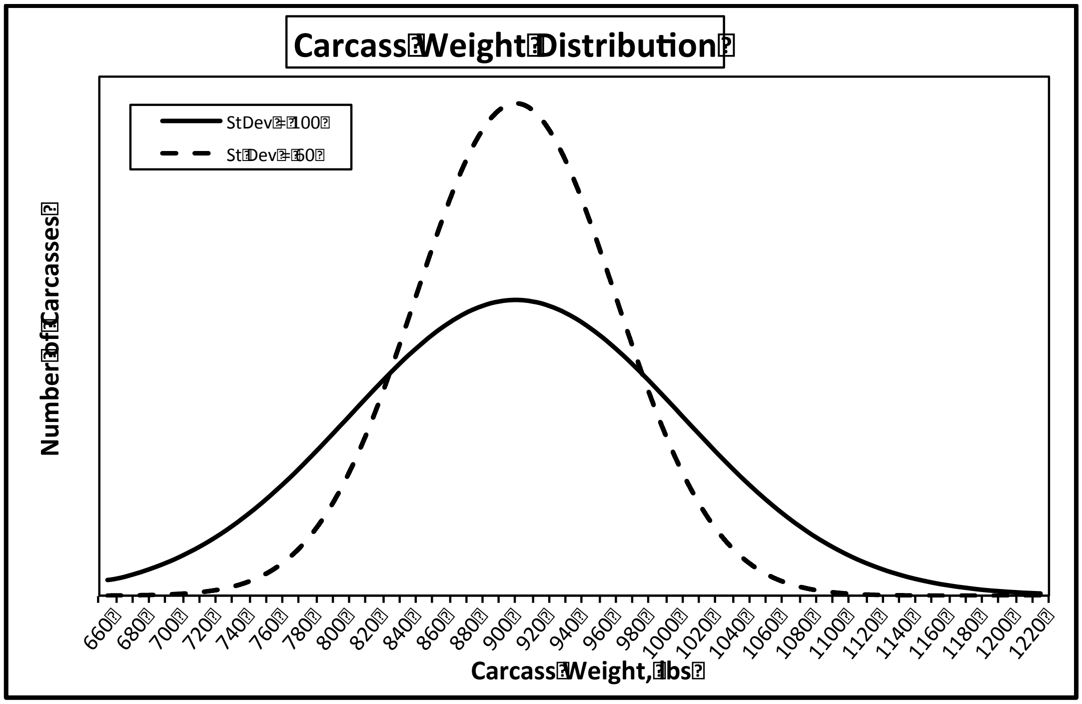

Figure 2. Normally distributed populations with mean HCW of 900 lb and standard deviation of 100 lb or 60 lb

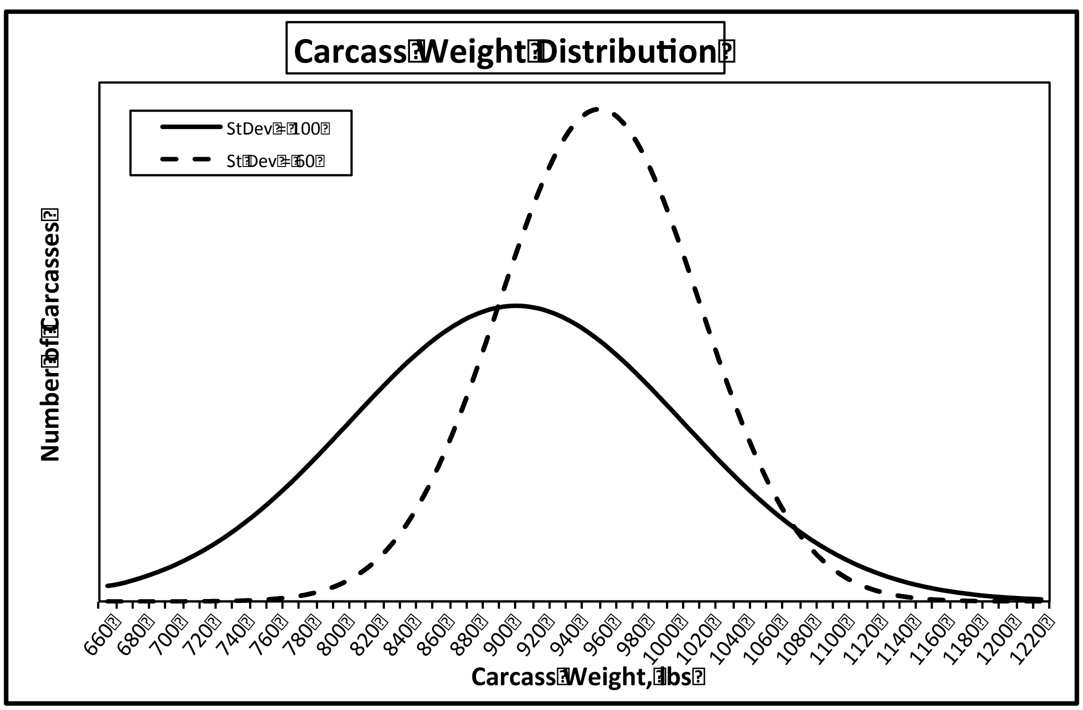

Figure 3. Normally distributed populations with mean HCW of 900 lb and standard deviation of 100 lb or mean of 950 lb and standard deviation of 60 lb

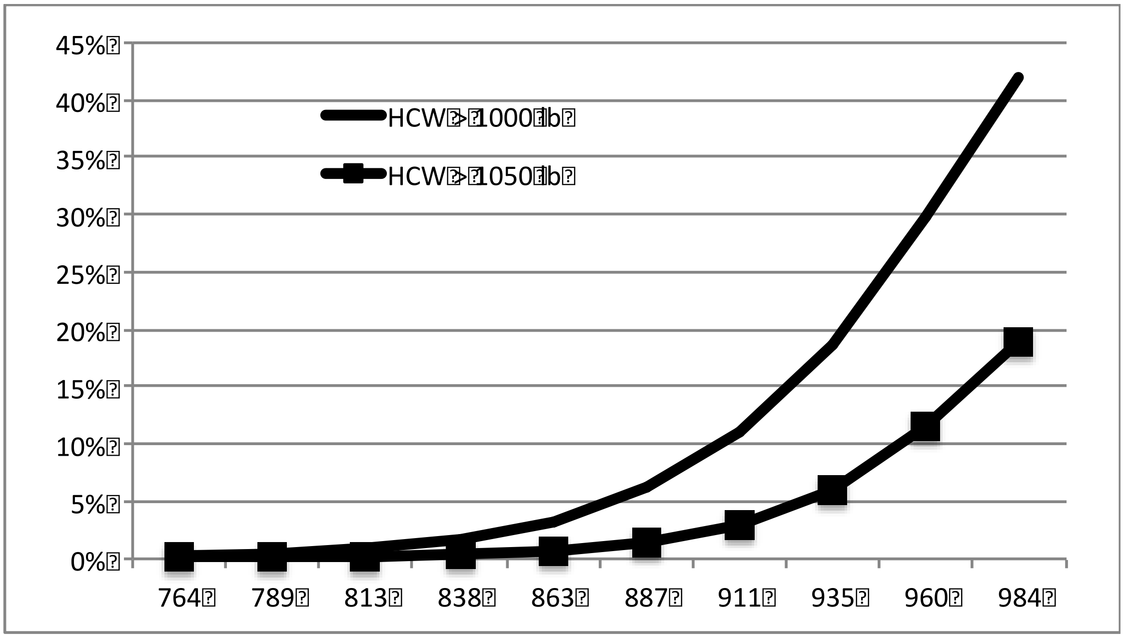

Figure 4. Percentage of heavy carcasses by mean HCW - steers, Benchmark Performance Program

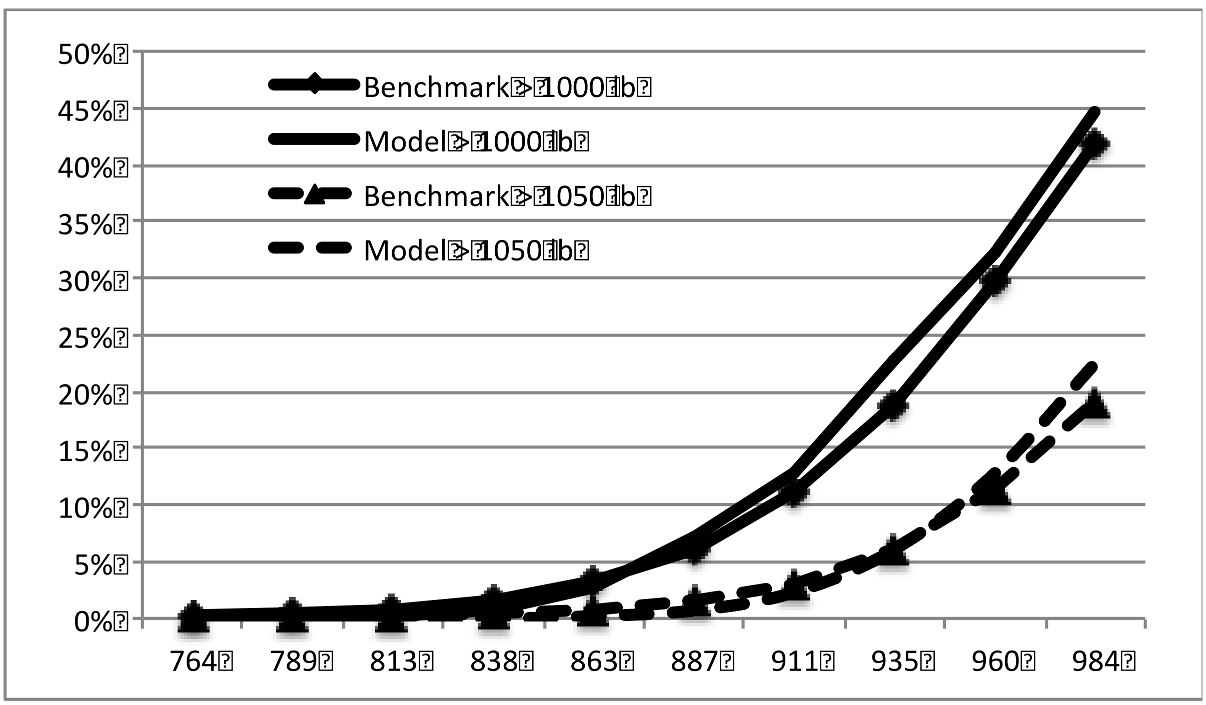

Figure 5. Comparison of model output and data from Benchmark Performance Program, steer data

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AIP: Etiology, Management and Environment

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For decades an often fatal respiratory syndrome of cattle has been recognized and described by various names including acute or atypical interstitial pneumonia (**AIP**) (Dungworth, 1993; Schiefer et al., 1974; Blood, 1962), acute bovine pulmonary emphysema (**ABPE**) (Blake and Thomas, 1974) pulmonary adenomatosis (Seaton, 1958) and acute respiratory distress syndrome (**ARDS**) (Breeze et al., 1978). Affected cattle have an acute onset of severe dyspnea, often with open-mouthed breathing and an expiratory grunt. Postmortem evaluation of cattle with this syndrome reveals dark red, heavy lungs that fail to collapse. The best characterized cause of this condition is associated with movement of beef cattle from heavily grazed summer pasture to lush pasture in the fall (Hammond et al., 1979). This form of the disease, also commonly known as ABPE or "fog fever", is due to damage of the lung by pneumotoxins resulting from ruminal conversion of forage-derived L-tryptophan. More recent evidence has also shown that the same pathway plays a role in feedlot AIP; however the connection is not near as clear, as feedlot AIP appears to be much more multi-factorial in nature. Bovine AIP can also be caused by pneumotoxic compounds ingested in moldy sweet potatoes (Doster et al., 1978) purple mint (Wilson et al., 1977), and rape, turnip tops, or kale (Wikse et al., 1978). Other factors and insults like bacterial or viral pneumonia can play a role, as can dust-borne allergens. These pneumotoxic compounds induce the final common result of AIP through damage of the alveolar wall. It appears that there are a number of combined factors as well as 3-methylindole metabolism that cause AIP in a feedlot setting.

Rates of death due to feedlot AIP have ranged from 0.5% to 5.3% (Jensen et al., 1976), with a case fatality rate of 50% to 60% (Ayroud et al., 2000; Loneragan et al., 2001). Occurrence of the disease is sporadic (Loneragan et al., 2001), although heifers are more likely to die of feedlot AIP than steers, and outbreaks are most common during the hot and dusty summer months (Ayroud et al., 2000). Compared to the typical BRD pneumonia-type cases that are observed within cattle in the first 40 days of the feedlot, AIP afflicts older cattle in which there has been a lot of money invested in terms of feed and management.

Acute interstitial pneumonia can only be confirmed by histologic evaluation. The hallmark histologic lesions of AIP are fibrin accumulation and hyaline membrane formation in alveolar spaces, alveolar epithelial hyperplasia and congestion and edema (Breeze et al., 1978). Within the lung tissue itself, neutrophils and macrophages invade into the alveolar tissue and the alveolar spaces fill with proteinaceous fluid. There is a thickening of the alveolar walls associated with the hyperplasia of type-2 pneumocytes. Respiratory cells can also slough off into the lumen of the alveoli. Grossly, lungs fail to collapse and their texture is firm and rubbery

In the past, individual feedlots have estimated losses of about $14,000 over a month to AIP. There are significant costs associated with the disease in terms of loss of carcass value upon marketing. When AIP outbreaks occur, the cattle industry recognizes it as a significant problem and scrambles for solutions, but its sporadicity of occurrence often results in it not being seen as a serious infliction for extended periods of time. The small amount of available information related to feedlot AIP provides some clues with regard to possible causes.

Pasture associated AIP results from damage to the alveolar wall by pneumotoxins generated by metabolism of 3-methylindole by mixed function oxidases and prostaglandin H synthetase in type II pneumocytes and Clara cells (Yost, 1989; Formosa and Bray, 1988). The pathway for production of 3-methylindole involves tryptophan metabolism to indole-3-acetic acid and then to 3-methylindole which forms reactive intermediates. 3-methylindole itself is not the toxin, but rather it is the reactive intermediates that result in pneumotoxicity. There are a number of enzymes and mechanisms involved in the conversion of 3-methylindole to reactive intermediates many of which are toxic, the most prominent of these being 3-methyleneindolenine (Yost, 1989). Cytochrome P450, mixed function oxidase and prostaglandin synthetase all play a role in the conversion of 3-methylindole to these reactive intermediates. Pasture AIP typically occurs when cattle are switched from a mature to a green pasture high in protein and tryptophan content. This leads to the excessive production of 3-methylindole from tryptophan and the formation of toxic metabolites. In the feedlot, AIP most frequently occurs in cattle that are being fed finishing diets comprised of 85% - 90% grain and at a point in the feeding period where cattle have already adapted to these diets for a period of 60-80 days. There is no obvious explanation as to how an increase in tryptophan intake could take place and account for the occurrence of AIP at this point in the feeding period. Consequently, it is difficult to draw a direct linkage between tryptophan concentration in the diet and the occurrence of feedlot AIP.

Research from our laboratory monitored close to a million head of feedlot cattle on finishing diets from 1998 through 2000 (Stanford et al., 2006). Plasma, urine, and lung tissue were collected at slaughter from 299 cattle clinically diagnosed with AIP and from 156 healthy pen mates and analyzed for 3-methylindole derivatives and reduced glutathione concentration. From each animal, the left lung was subsampled for histologic examination. We analyzed the urine, blood and lung tissues for glutathione concentration as it may potentially impact the formation of toxic metabolites. Collection was structured based on a clinical diagnosis of AIP by a veterinarian familiar with AIP. Collected samples were histologically examined and this was used as the basis for confirmation of AIP. About 11% of the cases clinical diagnosed as AIP by the veterinarian were not confirmed as being AIP after histological examination. The fact that AIP occurs sporadically, makes it difficult to obtain positive cases at the same time as funds are available to undertake research. Considerable resources must be spent in just monitoring for the occurrence of the disease and being in a position to collect positive cases 24 h per day, 7 days a week, 365 days of the year.

Results from a study in southern Alberta found 299 suspect AIP cases, of which 89% were histologically confirmed with 121 cases in year one, 85 cases in year two and 59 cases in year three. Cattle histologically confirmed as having AIP had higher levels of 3-methylindole protein adducts in blood and lung tissue than cattle that were AIP negative, but still underwent emergency slaughter. As observed previously, incidence of feedlot AIP was higher in heifers than steers. In 1998 and 1999, 92% and 94% of observed AIP cases occurred in heifers. All heifers had been on feed for a period of 130 days or more. Occurrences of AIP were strongly seasonal whereby cattle were 598 times more likely to exhibit AIP in June, July and August as compared to other months of the year (Ayroud et al., 2000).

Considerable research has been conducted to assess the value of ionophores in controlling AIP in terms of their ability to inhibit Gram-positive bacteria like *Lactobacillus*. Monensin is recognized to decrease the pulmonary damage arising from the metabolites of tryptophan metabolism (Hammond et al., 1978) however, the use of monensin has not prevented death from feedlot AIP in field studies (Ayroud et al., 2006; Woolums et al., 2004),

Other work from our laboratory (Popp et al., 1998) provided evidence that feeding melengestrol acetate (**MGA**), a synthetic progesterone used for estrus suppression in feedlot heifers, increased the susceptibility to pulmonary edema after oral administration of 3-methylindole to sheep. In 1999, we examined the incidence of AIP in relation to the dosage of MGA (Stanford et al., 2006). Feedlot heifers were fed MGA at levels of 0, 0.44, or 0.48 mg/head/d and the incidence of death and emergency slaughter attributable to AIP was recorded over the 7-mo AIP season (April through October). Results showed that there was a higher level of emergency slaughters and death loss for the heifers that did not feed any MGA. Specifically, within feedlots, where pens of heifers were fed either a standard dosage of MGA or none, the rate of death attributable to AIP was similar between treatment groups, but emergency slaughter after clinical diagnosis of AIP was 3.2 times higher ($P < 0.001$) in MGA-fed heifers than in those not fed MGA. Inclusion of MGA did not alter levels of glutathione in blood.

In another study we examined the impact of a number of potential control measures on the incidence of AIP (Stanford et al., 2007). These included i) inclusion of feather meal (1.5%) and vitamin E supplementation (500 IU) in the diet as well as ii) therapeutic treatment of AIP with acetylsalicylic acid (aspirin) in an effort to prolong life of afflicted cattle until they could be harvested. If 3-methylindole is involved in feedlot AIP, prophylactic treatment with aspirin could decrease prostaglandin H synthetase activity, an enzyme involved in the production of the pneumotoxin, 3-methyleneindolenine. As the cytotoxic metabolites of 3-methylindole can cause oxidative damage to cells, vitamin E supplementation might also decrease the severity of the disease by increasing the concentrations of glutathione, a free radical scavenger. Feather meal is a protein source high in cysteine and as cysteine is a precursor to the synthesis of glutathione, which inactivates oxidative intermediates, supplementation with feather meal may also provide some measure of protection against AIP. In a previous study using goats, supplementation with cysteine reduced the production of toxic metabolites when they were challenged with a dose of 3-methlyindole (Merrill and Bray, 1983).

In our study, blood and lung tissue were collected at slaughter from 83 cattle clinically diagnosed with AIP, 40 asymptomatic penmates, and 40 heifers receiving either feather meal or vitamin E with the left lung being subsampled for histologic examination (Stanford et al., 2007). Blood and lung tissue were analyzed for thiol adducts of 3-methyleneindolenine and reduced glutathione. Supplementation with feather meal or vitamin E had no effect on the rates of death or emergency slaughter attributable to AIP and did not influence the levels of 3-methylindole or reduced glutathione in blood or lung tissue. Although supplementation with greater amounts of feather meal or vitamin E may mitigate feedlot AIP, increased supplementation would be uneconomical for commercial feedlots, given the low incidence and sporadic nature of the disease.

To examine the effects of aspirin, heifers with clinical signs of AIP (n=30) were treated with 31.2 g aspirin every 12 h until slaughter. The left lung was subsampled for histological examination, analysed for 3-methyleneindolenine adduct and reduced glutathione. Of the heifers treated with aspirin, 63.3% survived to be slaughtered through normal channels, with 33.3% requiring emergency slaughter and 3.3% dying prior to slaughter. These results suggested that there may be some value in using aspirin to prolong the life of cattle suspected of suffering from AIP.

Because it is not possible to state with certainty the cause or causes of feedlot AIP, it is also not possible to outline control measures. However, based on the information summarized here, means of control can be theorized. In some lots where dust is particularly related to AIP, aggressive dust control measures such as sprinklers or decreased cattle density may significantly decrease losses. In any given lot the cost of the disease must be weighed against the cost of such intervention strategies. Ongoing research is necessary to clarify the most important etiologic factors, but has not been very forthcoming due to the challenges associated with studying this disease. More information is required so that consultants can determine which etiologic factors are most important in lots with excessive AIP deaths, enabling the development of rational and cost-effective control measures.

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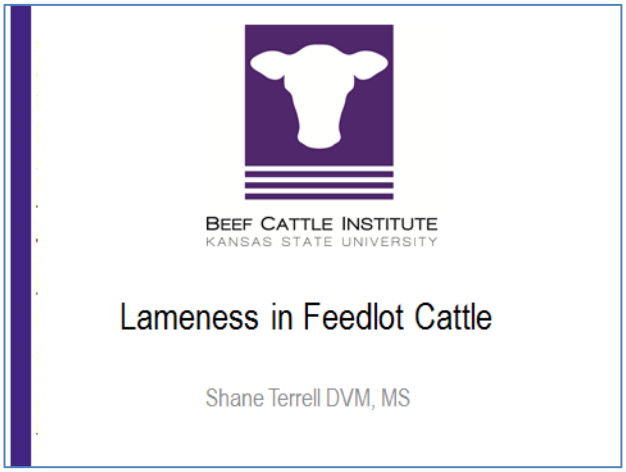
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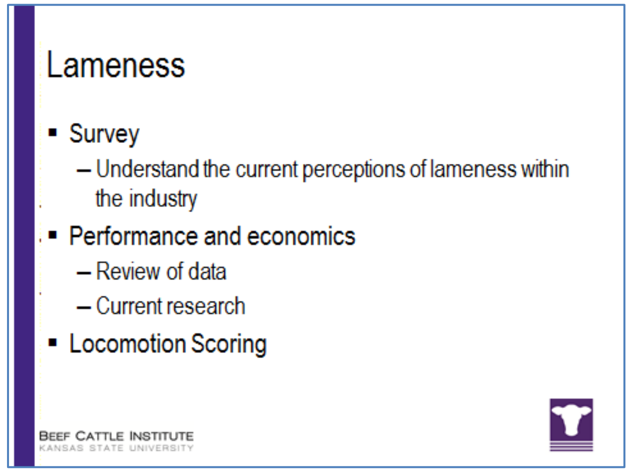
Lameness in Feedlot Cattle
Shane Terrell DVM, MS


Lameness
Survey
– Understand the current perceptions of lameness within the industry
Performance and economics
– Review of data
– Current research
Locomotion Scoring
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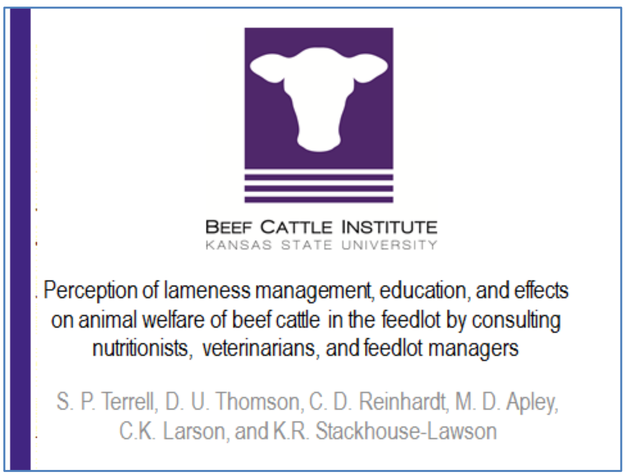
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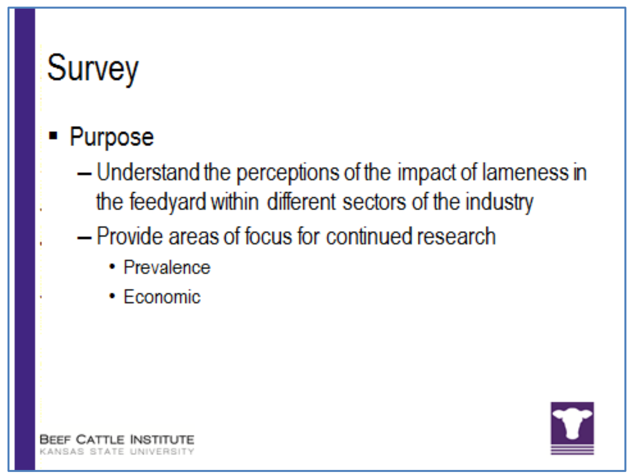
Perception of lameness management, education, and effects on animal welfare of beef cattle in the feedlot by consulting nutritionists, veterinarians, and feedlot managers
S. P. Terrell, D. U. Thomson, C. D. Reinhardt, M. D. Apley, C.K. Larson, and K.R. Stackhouse-Lawson


Survey
Purpose
– Understand the perceptions of the impact of lameness in the feedyard within different sectors of the industry
– Provide areas of focus for continued research
• Prevalence
• Economic
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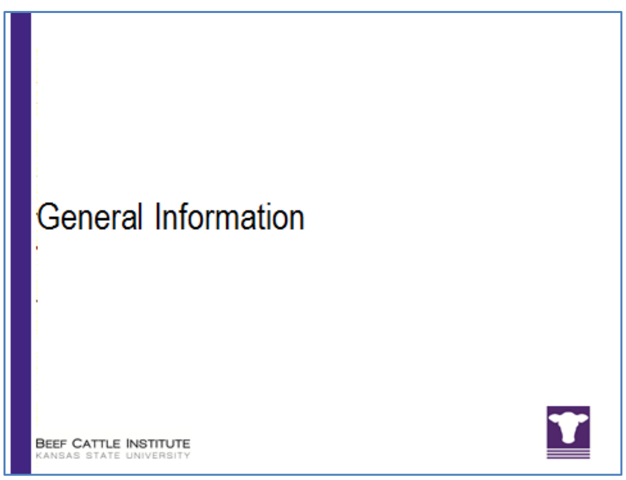
General Information
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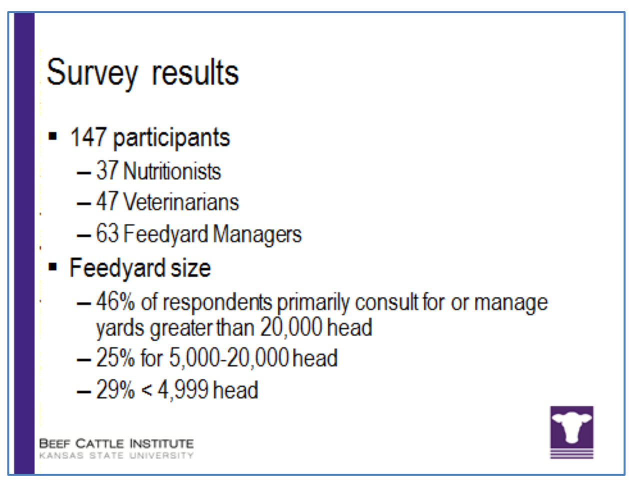
Survey results
147 participants
– 37 Nutritionists
– 47 Veterinarians
– 63 Feedyard Managers
Feedyard size
– 46% of respondents primarily consult for or manage yards greater than 20,000 head
– 25% for 5,000-20,000 head
– 29% < 4,999 head
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Prevalence and Health Impact

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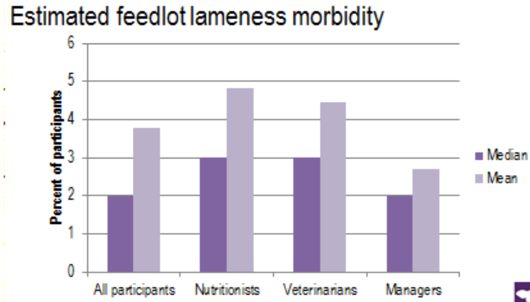
Survey results



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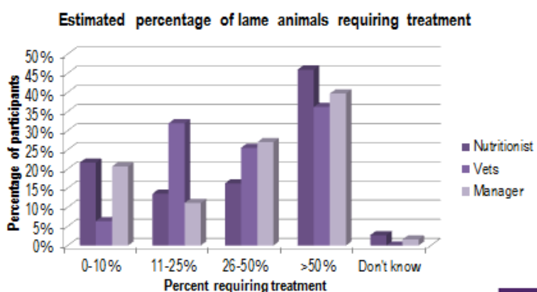
Survey results



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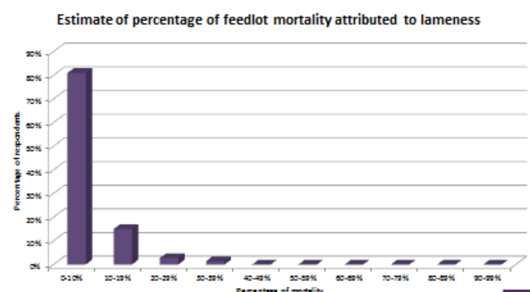
Survey results



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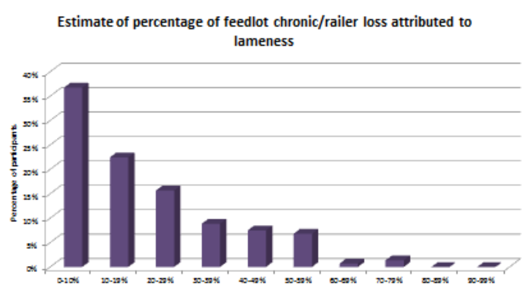
Survey results



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Causes and Contributing Factors

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Survey results

- The most common causes of lameness
  - Footrot
    - Identified by 41% of participants as the most common cause
  - Injuries
    - Identified by 37% of participants as the most common cause

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Contribution Factors

- Identified factors contributing to both infectious and none infectious causes of lameness
  - Infectious causes
    - Pen conditions
    - Pen surface
    - Weather patterns
  - Non-infectious causes of lameness
    - Cattle handling before arrival to the feedyard
    - Cattle handling after arrival to the feedyard
    - Cattle temperament

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Diagnosis

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Pen level diagnosis

At pen level, what criteria are used to identify a lameness pull?	
	% of respondents
Any sign of lameness	41%
Lameness along with depression, apparent significant pain	27%
Lameness along with a decrease in performance	18%
No set protocol	14%

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In-hospital diagnosis

What tools are used for diagnosing the cause of the lameness in the chute? (Could select multiple answers)	
	% of respondents
Palpation of foot, joints, and upper leg for swelling and heat	48%
Picking up the foot to visualize the bottom of the foot	60%
Picking up the foot and using hoof testers	20%
Visualization of foot, joints, and upper leg for swelling	89%
None	2%
Other:	3%

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Economic Impact

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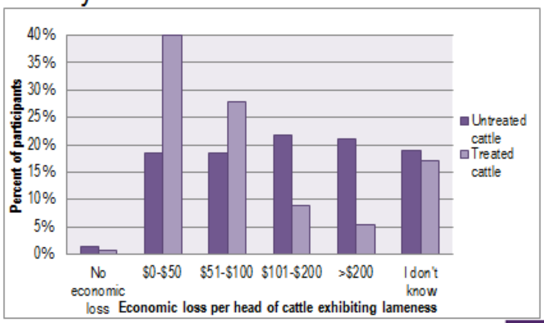
Survey results



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Education and Welfare

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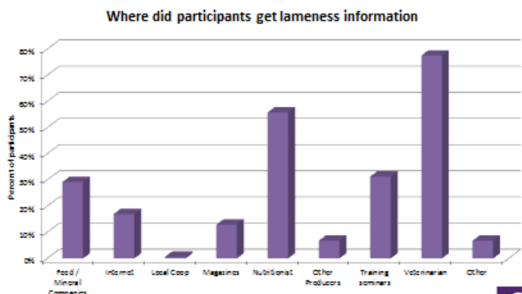
Survey results



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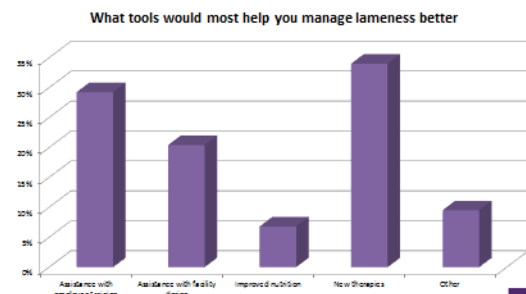
Survey results



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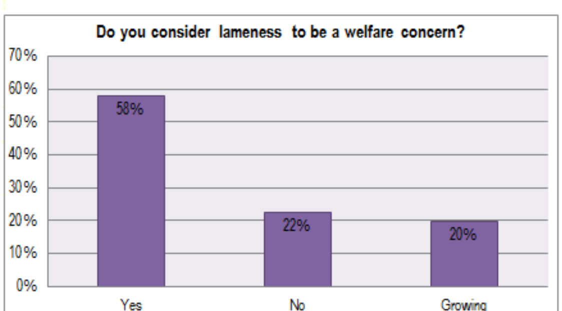

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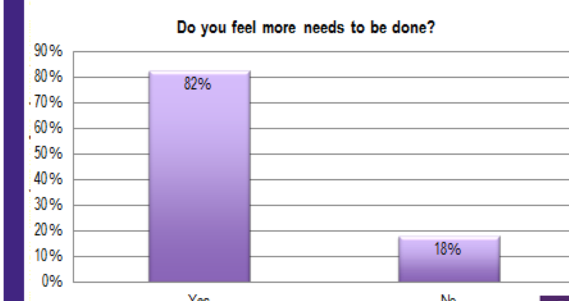

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Survey Summary

- Survey provides a baseline for the feedlot industry's perception of lameness
  - Target areas of future research
    - Prevalence
    - Economic impact
  - Intervention and prevention
    - Lameness diagnosis and treatment
    - Targeting factors contributing to lameness

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Available data

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The costs of lameness

- What we know
  - Performance losses
    - Cattle diagnosed with footrot at any point (Tibbets et. al)
      - ADG decreased 0.07 lb
      - Required 5 more days on feed
    - If in after 120 days on feed it changed to 14 additional days on feed and 0.11 lb decrease in ADG

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The costs of lameness

- Research has shown up to 16% of pulls and 5% of deads due to lameness
- Largest cost of lameness due to railers/realizers
  - Research has shown 70%

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The costs of lameness

- Model assumption
  - 0.05% lameness mortality
    - 1% total mortality x 5% of mortality due to lameness
  - Average value of dead animals- $1200
    - **$0.60 loss/ head in the feedyard due to lameness mortality**
  - 0.133% lameness railer rate
    - 70% of railers due to lameness based on .19% railer rate
  - $0.40/lb return on railer animals- 800 lb. average
    - $1000 initial value -$320 salvage value= $680 lost value
    - **$0.90/ head due to railer loss**

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Locomotion Scoring

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Locomotion Scoring

- Scores of 0-3
  - Severity score
  - Help pen level diagnosis
    - Data collection
    - "Real life"
      - Help identify lameness at pen level for earlier intervention

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LMS 0

- Animal walks normally
- No apparent lameness or change in gait.

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LMS 1

- Shortened stride
- Head may drop slightly, but no significant head bob
- No obvious limp/ effected limb at walk.

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LMS 2

- Obvious limp, but limb still bears weight
- Head bob present

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LMS 3

- Animal reluctant to move
- Animal applies little to no weight to affected limb

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Conclusion

- Lameness may be one of the single biggest opportunities for improvement in the modern feedlot industry
- Significant factor in death loss, loss due to salvage slaughter and performance
- If we take a look at fellow protein producing industries, lameness has been identified as a welfare concern by both industry members and consumers

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Update of the NRC 1996/2000 Nutrient Requirements of Beef Cattle

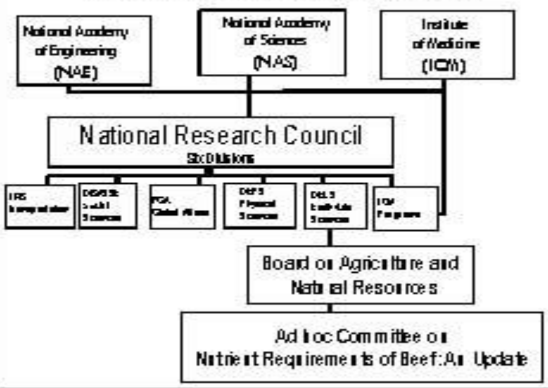
- Mike Galyean
- Galen Erickson
- Clint Krehbiel
- Luis Tedeschi
- Andy Cole

PNC, 2013

Background

What is the NRC?

The National Academies



The National Research Council

- National Research Council (NRC) is the working arm of the NAS, IOM, and NAE.
- Created in 1916 to advise the federal government and advance science and technology.
- Sponsors are usually federal agencies, with some state, local, and nonprofit support.

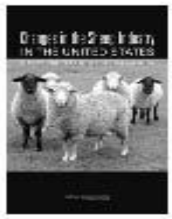
Unique Strengths of the NRC

- Stature of Academies' memberships
- Ability to get the very best to serve
- "Pro bono" nature of committee service
- Special relationship to the government
- Quality control procedures
- Independence, scientific objectivity, balance

Some Features of NRC

- They are not part of the government
- Funded by soft money (a small endowment).
- Volunteers receive no remuneration.
- Works mostly for federal government but also for states, foundations, associations, and sometimes, industry.
- Hallmarks are independence, objectivity, authority, and credibility.

The NRC releases about 1 report each working day on issues in science, technology, medicine, and education



Recent NRC Publications

NATIONAL RESEARCH COUNCIL

The Major Species

NATIONAL RESEARCH COUNCIL

Current Project

Overview of the Process

- Committee Formation (Sep-Dec, 2012)
  - Solicit suggestions for members
  - Contact potential members
  - Nominate committee members
  - Final appointment of members

Committee on Nutrient Requirements of Beef Cattle

- Mike Galyean (Chair)
- Joel Caton
- Karen Beauchemin
- Andy Cole
- Joan Eisemann
- Galen Erickson
- Terry Engle
- Clint Krehbiel
- Ron Lemenager
- Luis Tedeschi

NRC Study Director:
Camilla Ables

National Animal Nutrition Program
NRSP-9 Committees

- Coordinating Animal Nutrition
  - Feed Composition Sub-committee
  - Modeling Sub-committee

{National Research Support Project}

Overview of the Process

- 1st face-to-face Meeting (Feb. 2013)
  - Understand the Statement of Task
  - Developed an approach to the report
  - Drafted report outline
  - Made writing assignments
  - Comments from FDA, iFeeder, NCBA

FYI - Chapters in 1996 NRC

- Preface
- Overview

1) Energy
2) Protein
3) Growth and Body Reserves
4) Reproduction

FYI - Chapters in 1996 NRC

5) Minerals
6) Vitamins & Water
7) Feed Intake
8) Implications of Stress
9) Tables of Nutrient Requirements
10) Prediction Equations & Computer Model

FYI - Chapters in 1996 NRC

11) Composition of Selected Feeds
    - Feed Table

- Appendix
  - Feedlot Case Study
  - Cow-Calf Case Study
  - Tables – Feeds, Adjustment Factors, Requirements, Glossary

Possible Revisions ??

- Edit / revise / update current chapters
  - Revise – not rewrite
  - New data / information
- Delete chapter(s)?
- Add new chapter(s)?

Timeline

Feb.- Sept. 2013 - Drafts of chapters
Conference calls, Additional meetings

March 2014 - Finalize Report & Prepare for External Review

April 2014 - External Review

May-June 2014 – Address Reviewer Comments

Dec. 2014 – Report Delivery /Release

Statement of Task

A committee will prepare a report that reviews the scientific literature on the nutrition of beef cattle. All life phases and types of production will be addressed. The report will include the following elements: a comprehensive analysis of recent research on feeding and nutrition of beef cattle including research on the amounts of amino acids, lipids, minerals, vitamins, and water needed by growing and reproducing beef cattle; a summary of recent research on energy systems used in beef cattle nutrition; an update of the nutrient requirements contained in the 1996 NRC publication Nutrient Requirements of Beef Cattle; a summary of the composition of feed ingredients, mineral supplements, and feed additives routinely fed to beef cattle; a summary of information about coproducts from the biofuels industry, which will include information about the various types of products and their most effective use and information about phosphorus and sulfur contents; a review of nutritional and feeding strategies to minimize nutrient losses in manure and reduce greenhouse gas production; a discussion of the effect of feeding on the nutritional quality and food safety of beef; new information about nutrient metabolism and utilization (e.g., rumen bypass of protein and lipids, nutrient encapsulation, and starch processing); new information on feed additives that alter rumen metabolism and post-absorptive metabolism; and future areas of needed research. Depending on the extent of new information available, an update of the current computer model to calculate nutrient requirements may be developed.

The Task

Prepare a report that reviews the scientific literature on the nutrition of beef cattle:

- All life phases and types of production
- Include multiple elements related to various nutrients, feeding practices, etc., with a focus on new information
- Update of current model

The Task

The report will include the following elements:

- Amino acids, lipids, minerals, vitamins, and water requirements of growing and reproducing beef cattle
- Summary of recent research on energy systems
- Update on requirements in 1996 publication
- Summary of composition of feed ingredients, mineral supplements, and feed additives

The Task

The report will include the following elements:

- Summary of information about byproducts from biofuel production
  - Including types of products, most effective uses, and P and S contents
- Review nutritional strategies to minimize nutrient losses in manure and decrease greenhouse gas production

The Task

The report will include the following elements:

- Discuss effects of feeding on nutritional quality and safety of beef
- Discuss new information on nutrient metabolism and utilization (rumen bypass, nutrient encapsulation, and starch processing)

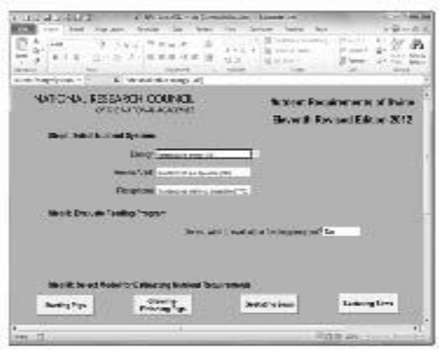
The Task

The report will include the following elements:

- New information on feed additives that alter ruminal and post-absorptive metabolism
- Future areas of needed research
- Updated computer model to calculate nutrient requirements

Beef NRC (1996/2000) Lotus 123, Baler compiled

Swine NRC (2012) – MS Excel

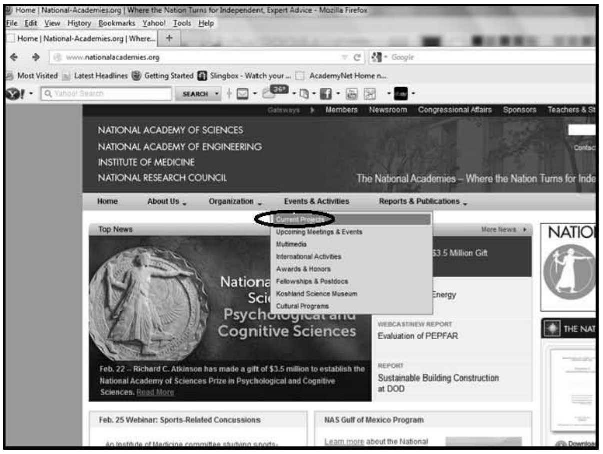


Desired Benefits of New Model

- Uses available computer languages
- Runs on almost "any" computer
- Customizable
- Easy to program / run
- Inexpensive
- Links to 3rd party software
- Uses stochastic modeling

Current Status

- Tentatively defined and prioritized elements of the 7th edition that need to be revised
- Assigned teams to work on revisions of each element / chapter
- Developed aggressive timeline for work to be done and drafts to be prepared
- *Seeking input from stakeholders*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YEAST CULTURE

Growing/Backgrounding Programs for Calves – Management Regimens, Carryover Influences on Finishing Performance, Carcass Weights and Carcass Composition

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Introduction

Approaches to growing or backgrounding feeder cattle are manifested in a wide variety of ways. The variety is spurred by the many different drivers that make this activity appealing. The paramount driver that we need to make more public is that growing calves is a sophisticated biotech process for converting cellulosic biomass into a high quality, high cash value product that benefits society.

Backgrounding is as diverse as calves grazing wheat or meadows, being fed hay or corn silage or limit feeding on a high concentrated diet. All of these systems contribute to key elements of: rebalancing feeder cattle supplies from unbalanced calving seasons; 2) weeding out defective cattle; and 3) significantly boosting the production system efficiency by increasing harvest body weight. A coordinated system also creates the opportunity for feedlots to streamline the logistics of cattle flows and to produce a more standardized incoming feeder. In creating this standardized calf we would like to specify the days, diet and implant that will optimize finishing phase performance and carcass value outcomes.

Much, if not most, of the backgrounding phase management influence on subsequent outcomes is a function of the backgrounding program impact on the calf growth curve. This is done by exploiting the prioritization of nutrient partitioning and tissue system differences in coefficients of allometric growth as described by Wilson and Osbourn (1960). The tissue prioritization for energy to support growth is: 1) CNS; 2) skeleton and connective tissue; 3) visceral organs; 4) skeletal muscle; and 5) adipose. In circumstances of limited nutrient availability bone growth can occur at a "normal" pace while muscle accretion is somewhat restricted and adipose growth is impaired. In other words we can frame out cattle.

Two excellent references addressing manipulations of the growth curve and carcass composition of beef cattle are Owens et al (1995) and the symposium proceeding "The Composition of Growth in Beef Cattle in honor of Rodney L. Preston" (1996). The content and citations included in those publications are very comprehensive. This essay will not suffice as an alternative brief; rather I will try to address some additional production issues that pertain to current industry circumstances.

Growth Channel

The backgrounded yearling steer model on which many of us base our paradigm is depicted in Table 1. It is the calf-fed versus yearling model of beef production. A prolonged grower phase causes the yearling steer to exhibit compensatory intake and growth during finishing and to produce a heavier carcass at a common Yield Grade. Janovick Guretzky et al (2005) used spring born and fall born calves to essentially create a dose titration of how extending the grower phase impacts feedlot production and carcass traits (Table 2). These data fit the paradigm that if cattle are older when they enter the feedlot, they will eat more and grow faster. The impact on efficiency may however be more variable. In their study a prolonged backgrounding program resulted in poorer feed conversions during finishing than occurred with a shorter backgrounding phase. That too, tends to fit general perceptions in the industry.

We may be inclined to extrapolate this model to fit how any degree of a backgrounding program may impact finishing performance. We must do so cautiously today because of 3 major factors that have changed in cattle production. The foremost change is the significant increase in the size and growth potential of cattle. Our paradigm is rooted in understanding the concept of a growth channel (Jackson, 1990). The historical data was based, more or less, on a 425 lb, 7 mo old, weaned calf with a mature BW of 1050 lb. Today there is a significant population of calves that can weigh 600 lbs at weaning with a mature BW >1300 lbs at 14 mo age. The unintended consequences of this shift in the growth channel have not yet been well defined.

The second important change from historical growth channel data is access to estradiol-trenbolone acetate implants and ß-agonists. These growth enhancement technologies cause a significant increase in mature BW (Guiroy et al, 2002). The third important change is a shift from live weight to hot carcass weight basis for marketing. Now the factors that influence dressing percentage (fill, visceral mass…) that might be influenced by the age/backgrounding program can alter feedlot economics.

In theory the growth channel of large framed, high growth potential steers should minimize the benefits of using a grower program to allow cattle to achieve adequate size. Jennings et al (2012) compared the effects of lower energy (LE) or higher energy (HE) 116d grower programs on growth traits and composition of steers fed to a common fat endpoint (0.4 in ribfat) or a constant days on feed. In those 8 mo old steer calves, grower phase ADG were 2.8 lb and 3.5 lb (Table 3). At 0.4 in ribfat the LE treatment resulted in heavier HCW and more carcass protein mass while carcass fat masses were similar. A unique aspect of young growing cattle is that when HE steers were fed to the same days endpoint as LE steers, the HE steers achieved the same carcass protein mass as the LE steers. Young growing steers on a high calorie plane of nutrition can fatten prematurely, but that does not impair their potential for true growth. As a consequence of continued true growth, the feed efficiency in this class of feeder cattle grown on higher energy backgrounding diets may not be adversely affected during finishing. In 2 subsequent studies with the same class of feeder steer calves, the HE backgrounding program led to higher ($P < .05$) ADG and lower ($P < .05$) DMI and F/G (Table 4). There were essentially no differences in HCW or marbling if HCW was covariately adjusted to a constant ribfat thickness.

Brethour (2000) modeled the effect of initial ribfat thickness on days required to reach 0.4 in ribfat. Since ribfat increases exponentially during the finishing phase, small differences in initial ribfat (2mm v 4mm) lead to substantial differences in ribfat by 80d into the finishing phase. Those 850 lb steers were 12-14 mo old when placed on feed and the effect of initial flesh fits the yearling steer paradigm. Those relationships, between days on feed and ribfat accretion rates, should re-evaluated in younger, higher growth potential, more aggressively implanted steers.

Contrasts of Diets and Growth Rates

McCurdy et al (2010) backgrounded calves (532 lb) on either wheat pasture (WP), sorghum silage (SS) or limit fed a high concentrate (LFHC) diet for 112d. Although backgrounding ADG were similar (Table 5) calves grazing WP appeared to have lower fat content in their empty body gain. The EB fat content of steers grazing WP actually declined to 15.0% from the 16.9% EB fat in the initial kill group. At the conclusion of the backgrounding phase EB fat content differed ($P < .05$) with values of 15.0%, 17.3% and 17.4% for WP, SS and LFHC treatments respectively. These feeder steers were subsequently fed to a fat constant finished endpoint.

During finishing, the WP steers did not exhibit compensatory growth to make up for the deficit in body fat content caused during backgrounding. To reach the common fatness endpoint the WP steers required a higher fat content in LWG during finishing which translates into a higher energy content of LWG. The WP steers did not exhibit compensatory DMI to meet this added caloric requirement. Consequently ADG and G/F were lower ($P < .05$) for WP steers than for SS and LFHC steers.

The other end of the spectrum may be the comparison of WP with very low ADG (1.5) backgrounding programs. Hersom et al (2004) noted that steers backgrounded on native range (NR) lost more energy to heat production during the finishing phase than steers backgrounded on WP. At feedlot entry the NR steers were lighter and had lower EB fat than the WP steers. Accretion rates for mass and fat were variable across experiments. Sharman et al (2013) observed higher ($P < .05$) omental fat and lower ($P < .05$) fill for steers grown on WP, compared to steers grazing NR that gained 0.42 lb/d. When the ADG of NR steers was 1.0 lb in a second experiment those differences disappeared. Carstens et al (1991) observed that energy restriction had a greater impact on non-carcass fat than carcass fat. If non-carcass fat tends to equilibrate at the end of finishing, the differences in non-carcass fat accretion due to initial mass differences would impact NE_G required to reach a common carcass fat endpoint. It would be one of the inconspicuous effectors of F/G occurring in feedlots.

Sainz et al (1995) implemented three calf feeding strategies. These included immediately starting a high concentrate finishing diet fed ad libitum (AHC); limit feeding a high concentrate diet (LFHC) and ad libitum feeding a forage based diet (AF). The LFHC ration was limited to achieve ADG comparable to the AF diet. The growing phase was scheduled for 520 to 720 lb BW. All 3 groups were fed the AHC diet during the finishing phase from 720 lb to a BW constant endpoint of 1060 lb.

Several important points that intertwine with things previously discussed come together in this experiment. From a production stand point it is noteworthy that diets affected fill at the end of backgrounding (Table 6), but not at the end of finishing. The LFHC diet caused more fill than occurred with the ad libitum high concentrate diet. There were LFHC finishing treatments as well (data not shown here) that also caused more fill than occurred with ad libitum feeding. During finishing, DMI was similar between LFHC and AF grower treatments and both were higher ($P < .05$) than feed AHC during the grower phase.

Backgrounding diets altered ($P < .05$) the finishing phase heat production with values of 258^c, 292^b and 330^a Mcal/kg $W^{.75}$ for AHC, LFHC and AF treatments, respectively. This is opposite the ranking of F/G calculated on an EBW basis (Table 3). We are inclined to think heat production is a loss in efficiency. However in this situation the heat production appears to be a reflection of higher DMI and daily protein gain. Although they are associated with higher heat production, higher DMI and protein gains generally result in improved production/economic efficiency in feedlot cattle.

I took some liberties with the data of Sainz et al (1995) and calculated F/G using their treatment means for DMI, fasted body weight and HCW. The ranking for F/G are similar for the reported EBW basis F/G and Apparent F/G (based on fasted BW). However the magnitude of difference in F/G between LFHC and AF was much greater on an Apparent basis. Since dressing percentage was altered by backgrounding diet, the ranking of F/G based upon HCW was altered. On this HCW basis, the F/G was highest for the AF cattle and the magnitude of differences in F/G is noteworthy (Table 6). The bottom line is that the biological efficiencies diverged from production efficiencies and the production efficiencies depended very much on the marketing method used in my derived calculations.

Implant use should be considered as well when evaluating backgrounding management. Pritchard et al (2003) demonstrated that a comprehensive suckling, backgrounding, finishing production system implant strategy increases HCW ($P < .05$) and lowers finishing phase F/G ($P < .05$). Implants effectively increase the frame size of cattle (Loy et al 1988; Guiroy et al 2002). Prolonged exposure to implants seems to increase frame size more than occurs with shorter periods of implant exposure (Pritchard's closet). Duckett and Andrae (2001) concluded that response to implants used across segments of the cattle production system are additive. If dietary energy appropriate implant potency is used, backgrounding phase implants should increase total LWG and lower F/G in each segment of the production system.

Summary

Backgrounding diets and backgrounding growth rates have obvious as well as inconspicuous impacts on feedlot production. Differences in fill, composition of gain, intake, total LWG and dressing percent can have significant impacts on finishing cattle economics. The dynamics are complex and traditional paradigms do not consistently apply in the current cattle production environment. From a feedlot performance perspective the most appealing system appears to be feeders backgrounded on a limit fed high concentrate diet. On the basis of total LWG and F/G, wheat pasture cattle are the least appealing, although other issues in total system sustainability will continue to make this a viable option. Backgrounding diet substrate (i.e. starch v fiber) seems to have little bearing on final quality grade. Only the very low ADG, extensive systems have much of an impact on marbling of the finished cattle.

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Table 1. Age – Backgrounding effects on steer performance during finishing and carcass traits[1]

Age at Onset, mo	10	15
Initial BW, lb	706	863
Out BW, lb	1179	1313
Days on feed	144	104
ADG, lb	3.29	4.33
DMI, lb	22.14	25.94
F/G	6.74	5.99
HCW, lb	737	792
Ribfat, in	0.60	0.59
Marbling[2]	537	463
YG	3.42	3.31
DMI/MBS[3]	100.6	106.9

[1] Pritchard's closet
[2] 500 = small°; 400 = select°
[3] g DMI/kg $W^{0.75}$

Table 2. Accelerated and Extensive production system influences on finishing phase performance and carcass traits.

	Accelerated	Fall born Extensive	Spring born Extensive
Age at Fdlt entry, mo	6.1	11.8	16.4
BW at Fdlt entry, lb	551	631	838
BW at Fdlt exit, lb	1129[c]	1250[b]	1349[a]
ADG, lb	2.87[b]	3.75[a]	3.97[a]
DMI, lb‡	18.53	23.52	28.86
F/G, lb	6.25[b]	6.25[b]	7.14[a]
Dress, %	60.4[a]	60.1[b]	60.0[b]
HCW, lb	683[c]	739[b]	812[a]
REA, in^2	12.4[b]	12.6[b]	14.0[a]
YG	2.3	2.2	2.4
Marbling[2]	572	561	563

[1] Janovick Guretzky et al (2005)
[2] 400 = Slight°; 500 = Small°
[abc] means differ (P < .05) as noted by authors
‡ Calculated from published means for ADG and G/F

Table 3. Allometric growth in steer calves caused by higher energy grower programs[1]

Grower Diet	Lower Energy	Higher Energy	
1 to 116d			
ADG, lb	2.87[a]	3.48[b]	
BW d116	943[a]	1011[b]	
HCW, lb	532[a]	613[a]	
Carcass fat, %	20.1[a]	23.3[b]	
At 0.4 Ribfat			**Higher Energy[2]**
Total Days	209	165	209
HCW, lb	776	710	800
Carcass protein, lb	95	83	93
Carcass fat, lb	207[a]	207	258[b]
Carcass fat, %	26.7[a]	29.1	32.4[b]

[1] from Jennings et al (2012)
[2] at constant days with Lower Energy treatment
[ab] Means differ (P<0.05)

Table 4. Influence of Grower Phase on Finishing Performance and Carcass Traits of Steers[1]

	Exp 1			Exp 2		
Background phase	**Lower Energy**		**Higher Energy**	**Lower Energy**		**Higher Energy**
days	91		77	112		82
NE_G, Mcal/cwt	40		51	43		56
Initial BW, lb	723		721	717		718
End BW, lb	951		941	977		982
ADG, lb	2.51	*	2.85	2.33	*	3.22
Finishing phase			**Common Diet**			
days	97		85	89		80
Out BW, lb	1337		1285	1245		1265
ADG, lb	3.98	*	4.05	3.01	*	3.54
DMI, lb	25.75	*	24.69	24.69	*	23.85
F/G	6.47	*	6.12	8.25	*	6.77
HCW, lb	836	*	805	777		791
Rib fat, in	0.49	*	0.45	0.40	*	0.45
YG	3.16	*	2.95	3.01		2.94
Marbling[2]	531		527	524		546
Carcass Fat, %[3]	28.1		29.1	27.4		28.0

[1] Pritchard's closet
[2] marbling score 500 = small°, 400 = select°
[3] determined from 9-10-11 rib composition
*means differ (P < .05)

Table 5. The effect of backgrounding calves for 112d on wheat pasture, silage, or a limit fed high concentrate diet on finishing phase performance[1].

Grower Phase Diet	Wheat Pasture	Sorghum Silage/grain	Limit fed High Concentrate
Grower Phase			
Initial BW, lb	558[a]	522[b]	516[c]
Final BW, lb	842	813	831
ADG, lb	2.54[a]	2.42[b]	2.60[a]
EB fat, %	15.0[b]	17.3[a]	17.4[a]
EE in EBW gain, %‡	12.0	18.1	18.5
Finishing Phase		**Common diet**	
Days	123	104	104
Final BW, lb	1287	1281	1260
ADG, lb	3.62[c]	4.45[a]	4.08[b]
DMI, lb	22.93[ab]	24.03[a]	22.27[b]
F/G[2]	6.41[a]	5.38[b]	5.38[c]
EE in EBW gain, %‡	37.6	32.0	33.6

[1] McCurdy et al (2010a)
[2] originally reported as G/F
‡ derived data calculated from published means
[abc] means differ (P < .05)

Table 6. Influence of a limit fed grower program on finishing phase production traits[1]

Grower Phase Diet	Ad libitum (AHC) Finisher	Limit fed (LFHC) Finisher	Ad libitum (AF) Forage based
Initial BW	---	539	---
End of Grower Phase			
days	57	112	112
BW, lb	776[a]	683[b]	701[b]
Empty BW, lb	668[a]	644[b]	624[c]
Fill, % EBW	8.4[c]	11.6[b]	15.1[a]
Carcass fat, %	22.3[a]	15.9[b]	12.2[c]
End of Finish Phase Only			
days	96	89	111
BW, lb	1034[b]	1096[a]	1107[a]
Empty BW, lb	994[b]	990[b]	1003[a]
CarcAdj BW, lb[2]‡	1086	1069	1045
Fill, % EBW	7.4	7.8	6.5
DMI, lb	19.93[b]	24.21[a]	25.86[a]
EBW basis			
ADG	2.69[c]	4.23[a]	3.84[b]
F/G	7.46[a]	5.71[c]	6.80[b]
Apparent basis‡			
ADG, lb	2.69	4.64	3.66
F/G	2.69	4.57	7.07
CarcAdjusted basis[2]‡			
ADG, lb	3.23	4.34	3.10
F/G	6.17	5.58	8.34
Dress, %[3]‡	65.7	61.0	59.0
HCW, lb	679[a]	668[a]	653[b]
Carcass fat, %	28.9	26.7	28.5
Fat gain, g/d	529[b]	774[a]	763[a]
Protein gain, as g/d	162[c]	250[a]	201[b]

[1] From Sainz et al, 1995
‡ derived data calculated from published means
[2] CarcAdj based on final BW = HCW ÷ 0.625
[3]‡ derived from treatment means using equation 100(HCW/fasted BW)
[abc] means differ (P < .05) as noted by authors

Grain Processing: Gain and Efficiency Responses by Feedlot Cattle

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Executive summary

Published information from the past 15 years related to growth performance by feedlot steers and heifers fed various grains processed in different ways (389 diets within 139 trials with a mean of 40 cattle per diet) was compiled. The energy values for these various diets and grains were calculated from performance data and analyzed for this review. A summary of these results comparing dry rolled with steam flaked dent corn grain is presented in Table 1 together with estimates from previous reviews.

Table 1. Compiled information on performance and energy response to flaking of dent corn grain.

Information source	Measurement	Dry rolled corn	Steam flaked corn	Benefit %	Basis
Owens et al., 1997	ADG, kg	1.45	1.43	-1.4	12 paired trials
Zinn et al., 2011	ADG, kg	-	-	6.3	Literature
This review	**ADG, kg**	**1.51**	**1.51**	**-0.1**	**Across all trials**
This review	***ADG, kg***	***1.55***	***1.61***	***3.9***	***17 paired trials***
Zinn et al., 2011	DMI, kg/day	-	-	-4.3	12 paired trials
Owens et al., 1997	DMI, kg/day	9.45	8.35	-11.6	Literature
This review	**DMI, kg/day**	**9.48**	**8.6**	**-9.3**	**Across all trials**
This review	***DMI, kg/day***	***9.22***	***8.87***	***-3.8***	***17 paired trials***
Owens et al., 1997	Gain/Feed	0.152	0.170	11.9	Literature
This review	**Gain/Feed**	**0.16**	**0.176**	**10.0**	**Across all trials**
This review	***Gain/Feed***	***0.167***	***0.181***	***8.4***	***17 paired trials***
Firkins et al., 2001	Ruminal starch digestion %	52.3	56.9	8.8	Ground for cows
Zinn et al., 2011	Ruminal starch digestion %	60.6	84.2	38.9	Across 26 trials
This review	***Ruminal starch digestion %***	***68.3***	***83.9***	***22.8***	***Across all trials***

Table 1 (cont'd). Compiled information on performance and energy response to flaking of dent corn grain.

Information source	Measurement	Dry rolled corn	Steam flaked corn	Benefit %	Basis
Firkins et al., 2001	Total tract starch digestion %	85.0	94.2	10.8	Rolled for cows
Firkins et al., 2001	Total tract starch digestion %	90.7	94.2	3.9	Ground for cows
Zinn et al., 2011	Total tract starch digestion %	89.3	99.1	11.0	Across 26 trials
This review	***Total tract starch digestion %***	***92.5***	***99.1***	***7.1***	***Across 35 trials***
NRC 1996	ME, Mcal/kg	3.18	3.36	5.7	Literature
NRC, 2001	ME, Mcal/kg	3.12	3.24	3.8	Composition
Owens et al., 1997	ME, Mcal/kg	3.21	3.71	15.6	Literature
This review	**ME, Mcal/kg**	**2.61**	**3.12**	**19.5**	**Energy excretion**
This review	**ME, Mcal/kg**	**3.02**	**3.21**	**6.3**	**Across all trials**
This review	**ME, Mcal/kg**	**1.39**	**1.52**	**9.4**	**17 paired trials**
Zinn et al., 2011	NEm, Mcal/kg	2.18	2.40	10.1	12 paired trials
Preston, 2013	NEm, Mcal/kg	2.16	2.29	6.1	Literature
Preston, 2013	NEg, Mcal/kg	1.43	1.56	9.2	Literature
This review	**NEg, Mcal/kg**	**1.39**	**1.52**	**9.4**	**Across all trials**
This review	***NEg, Mcal/kg***	***1.399***	***1.515***	***8.3***	***17 paired trials***

Compiled information for high moisture and dry rolled corn grain based on largely on US trials with dent corn grain are presented in Table 2. Again, processing variables for the rolled or ground grain control and for the high moisture corn (moisture content; rolled or ground into or out of storage) markedly alter feeding value of these grains. Rate of gain was slightly but consistently lower for finishing feedlot cattle fed high moisture rather than dry rolled corn grain and dry matter intake typically was lower. As a consequence, the gain to feed ratio was not consistently greater for high moisture corn even though ruminal and total tract starch digestion were markedly greater for high moisture than dry rolled corn grain. Nevertheless, ME and NE values, particularly when compared within feeding trials, were consistently greater for high moisture than for dry rolled dent corn grain. Higher moisture content, rolling or grinding the grain into storage, and longer storage times all tended to increase the energy availability from high moisture corn grain. Factors beyond enhanced energy can favor high moisture over dry rolled grain. These include earlier harvest of high moisture than dry grain that allows a second crop to be planted earlier, grain yields are greater with harvest at an early stage (but after black layer), costs for processing and storage facilities are low, seasonal and local prices for grain at harvest often are low, and with high moisture harvest, additional roughage (cob and husk) can be harvested readily. However, some energy is lost during fermentation and cost of interest on investment with the longer term grain inventory should be considered. One benefit from processing of grains that seldom is recognized is the reduced variability in rate and extent of digestion among batches of grain. In most feeding trial experiments, only one or a few batches of grain will be used so inconsistency from day to day in grain source and processing is low, much lower than at commercial feedlots. Improved consistency among batches of grain that differ in type and hardness should improve animal performance and health of cattle at commercial feedlots.

Table 2. Compiled information related to performance and energy responses to high moisture dent corn grain.

Information source	Measurement	Dry rolled corn	High moisture corn	Benefit %	Basis
Owens et al., 1997	ADG, kg	1.45	1.37	-5.5	Literature
Zinn et al., 2011	ADG, kg	-	-	-0.6	Literature
This review	**ADG, kg**	**1.51**	**1.5**	**-0.7**	**Across all trials**
This review	***ADG, kg***	***1.55***	***1.54***	***-0.7***	***15 paired trials***
Zinn et al., 2011	DMI, kg/day	-	-	-2.3	Literature
Owens et al., 1997	DMI, kg/day	9.45	8.72	-7.7	Literature
This review	**DMI, kg/day**	**9.48**	**9.67**	**2.0**	**Across all trials**
This review	***DMI, kg/day***	***9.82***	***9.28***	***-5.5***	***15 paired trials***
Owens et al., 1997	Gain/Feed	0.152	0.156	2.2	Literature
This review	**Gain/Feed**	**0.16**	**0.155**	**-3.1**	**Across all trials**
This review	***Gain/Feed***	***0.158***	***0.167***	***5.4***	***15 paired trials***
Firkins et al., 2001	Ruminal starch digestion %	52.3	86.8	66.0	Ground for cows
Zinn et al., 2011	Ruminal starch digestion %	60.6	91	50.2	Across 7 trials
This review	***Ruminal starch digestion %***	***68.3***	***77.5***	***13.5***	***Across 5 trials***
Firkins et al., 2001	Total tract starch digestion %	85.0	94.2	10.8	Rolled for cows
Firkins et al., 2001	Total tract starch digestion %	90.7	98.8	8.9	Ground for cows
Zinn et al., 2011	Total tract starch digestion %	89.3	99.2	11.1	Across 7 trials
This review	***Total tract starch digestion %***	***92.5***	***98.1***	***6.1***	***Across all trials***

Table 2 (cont'd). Compiled information related to performance and energy responses to high moisture dent corn grain.

Information source	Measurement	Dry rolled corn	High moisture corn	Benefit %	Basis
NRC 1996	ME, Mcal/kg	3.18	3.36	5.7	Literature
NRC, 2001	ME, Mcal/kg	3.12	3.23	3.5	Composition
Owens et al., 1997	ME, Mcal/kg	3.21	3.43	6.9	Literature
This review	**ME, Mcal/kg**	**3.02**	**2.96**	**-2.0**	**Across all trials**
This review	***ME, Mcal/kg***	***2.93***	***3.06***	***4.4***	***15 paired trials***
Zinn et al., 2011	NEm, Mcal/kg	2.18	2.23	2.3	Literature
Preston, 2013	NEm, Mcal/kg	2.16	2.29	6.1	Literature
Preston, 2013	NEg, Mcal/kg	1.43	1.56	9.2	Literature
This review	**NEg, Mcal/kg**	**1.39**	**1.34**	**-3.6**	**Across all trials**
This review	***NEg, Mcal/kg***	***1.323***	***1.412***	***6.7***	***15 paired trials***

Introduction

Various aspects concerning effects of grain processing on site and extent of starch digestion and on energy value have been summarized in numerous publications (NRC, 1996; Huntington, 1997; Owens et al., 1997; Rowe et al., 1999**;** Firkins et al., 2001; NRC, 2001; Zinn et al., 2002; Armbruster, 2006; Drouillard and Reinhardt, 2006; Hicks and Lake, 2006; Huntington et al., 2006; Mader and Rust, 2006; McAllister et al., 2006; McLeod et al., 2006; Owens and Soderlund, 2006; **Peters**, 2006; Sindt et al., 2006; Soderlund and Owens, 2006; Zinn and Owens, 2008; Zinn et al., 2011). For additional information and viewpoints, readers can refer to those publications.

How should energy value of grain or diet be calculated?

Net energy (NE) values often are used for feed formulation. Tabular NE values for maintenance, gain, or lactation for feeds generally are calculated from estimates of metabolizable energy (ME) that in turn are estimated from data from trials where total digestible nutrient (TDN) of a feed or diet has been physically measured. Although NE values of individual feeds are not summative to calculate NE of the diet, ME values of individual feeds can be numerically summed to calculate the ME of a mixed diet. Therefore, ME values form the most convenient intermediate basis for estimating energy content of feeds. ME value of a diet in turn can be calculated in two ways – by the factorial approach through measuring energy lost by an animal (similar to TDN) or from the quantity of energy that presumably was used by an animal for maintenance and production. By the factorial method, ME is dietary gross energy minus energy loses in feces, urine, and gas. By the energy retention approach, the amounts of ME used by the animal for energy retention and secretion (NEg and NEL) is added to the ME used for maintenance (NEm) to calculate the total ME that was available to the animal. In either case ME intake divided dry matter intake yields ME per unit of mass (ME/kg) of the diet.

To calculate ME value of a single ingredient in a mixed diet, the ME contributed by other diet components must be subtracted from the ME of the total mixed diet to calculate the amount of ME provided by that single ingredient. Dividing that amount of ME from an ingredient by the proportion of diet DM contributed by that ingredient yields ME/kg of the test ingredient. The factorial approach is quite labor intensive but can help differentiate among various factors causing ME to differ. In contrast, the ME estimates by the energy retention approach should be directly applicable at feed intake levels and environmental conditions used for commercial production. Feeding trials also generate data related to feed or ME intake and gain to feed ratios (directly applicable for economic evaluation) from large groups of animals under a variety of environmental conditions. Although gain to feed ratio can be used directly for calculating economic return from a specific study, a response in gain to feed ratio can differ markedly from the true response in ME of the diet. This is most evident when feed intake or mean weights of cattle fed different diets differ. For example, the gain to feed ratio is improved more than ME value when intakes by cattle fed different test ingredients differs (as with substitution of distillers' products for grain) due to dilution of maintenance. A similar condition exists when groups of cattle are fed for the same number of days but some have slower rates of gain and lower mean feeding weight (as with high forage diets). Furthermore, it is difficult to subdivide gain to feed ratios into the impact of a single diet component of a mixed diet. In contrast, ME or NE values are automatically adjusted for differences in feed intake and mean body weight to help quantify the amount of energy available from the diet that should apply for all trials where that test ingredient is fed.

The energy retention approach inherently includes any differences in efficiency of converting ME to NE. Also, the energy retention approach relies fully on specific equations that have been derived from results of past research trials. Those equations for calculating ME from performance have evolved over time, and can differ with specific dietary (ionophore), animal (type, shrunk and equivalent weights), seasonal and environmental conditions. These factors reduce the precision of estimates of ME from individual trials. However, when two feeds are compared WITHIN a trial, impact of those factors should be minimal. Because all the information needed to calculate ME by the energy retention method can be gathered under commercial production conditions from hundreds of pens of cattle over time, the quantity of data available for calculating ME of a diet or a grain used at a specific feedlot is much greater than by the factorial approach. By comparing ME (or NE values calculated from ME) for a diet with expected values, efficiency of individual sets of cattle or a total feedyard can be generated. This can help in auditing performance, its consistency, and pinpoint specific pens or issues that need attention. Such checks also can be used to evaluate results from published research trials to determine if the reported performance results seem "reasonable and logical" based on diet composition and feed intakes. Both the factorial and the energy retention systems suffer from variability due to 1) the associative effects of feeds, 2) composition differences within a grain or feed source attributable to genetic (e.g., flint versus dent) or growing conditions, 3) inconsistencies in the characteristics of the processed feed or grain (e.g., flake weight, moisture and storage time for high moisture corn, particle size distribution of ground or rolled corn), and 4) environmental factors that can alter nutrient requirements. Because these environmental and processing factors should be more consistent within a feedlot or region than across the diverse locations where research trials are conducted, local estimates for ME should be less variable than literature summaries compiled across diverse locations. Although the ME means for a specific processing method can prove quite variable, the relative differences among means still should be meaningful. Within-trial or "paired" comparisons where a grain from a single source processed by multiple methods is fed within an experiment are preferable to reduce animal and environmental effects. Compared to the total number of feeding trials, the number of such "paired" comparisons is quite limited. Unfortunately, grain processing methods seldom are standardized and factors of importance often are not reported. The objective of this review is to summarize effects of various grain processing methods on site and extent of digestion, on performance, and on ME for corn and other grains, and to evaluate the relative impact of several processing and additional dietary factors on ME estimates.

What factors influence energy value of grain or feed?

Grains typically are fed as a source of net energy, and most of the digested energy from cereal grains is derived from starch. Because starch digestibility is altered by most processing methods, total tract starch digestion often is used as an index and in some cases as a predictor of available energy. However, grain components beyond starch are altered by processing, and processing can alter the site and thereby the products of digestion. For example, the amount of energy lost as gas (methane) can be altered by processing. Such factors are not appropriately credited when evaluating energy availability simply from a difference in starch digestibility.

First and foremost, grain processing usually increases digestibility of specific nutrients, particularly starch, through reducing the amount of starch protected by the kernel's pericarp. And with steam flaking and fermentation of grains, denaturation of proteins that encapsulate starch within the more vitreous grains (corn, sorghum) will increase the accessibility of starch to microbial and animal enzymes. Protein denaturation with steam flaking or fermentation thereby alters ruminal and total tract digestibility of protein. Ruminal and total tract starch digestibility of the less vitreous grains (wheat, barley, oats) is quite high even without processing, so the need for and benefit from extensive processing is lower than with more vitreous grains. Yet, grinding to reduce particle size can increase the rate and extent of ruminal digestion of starch of grains that have a thick or fibrous pericarp when ruminal residence time is short as with lactating cows consuming very high amounts of diets rich in NDF. Simply reducing mean particle size by grinding usually increases starch digestibility of corn grain by lactating cows but has very limited benefit with feedlot cattle fed high concentrate diets. Presumably, this difference is associated with differences either in the degree of mastication during eating or ruminal retention time. Ruminal retention time is decreased at high feed intakes and high dietary NDF concentrations. Consequently, with higher fiber diets, feedlot cattle might benefit from fine grinding of grains. Through increasing accessibility and exposure of fiber and fat to bacterial or enzyme attack, the digestibility of fat and fiber also may be increased by fine grinding and heat treatment. But because fat and fiber content of cereal grains typically is quite low (except for NDF in oats), any digestibility increases associated with fat and fiber will be low relative to benefits with starch and protein.

When rolled or ground, dry grains yield particles strewn across a wide range of particle sizes. This distribution is not reflected by mean particle size or geometric mean diameter alone. Because of their greater surface area, rate and extent of digestion is greater for finer than coarser particles. The prevalence of very small, rapidly fermented particles is greater for floury hybrids than more vitreous, flinty hybrids. This difference in particle size alone between floury and vitreous hybrids following processing may explain much if not all of the difference in digestibility between floury and vitreous hybrids according to Ramos et al. (2009).

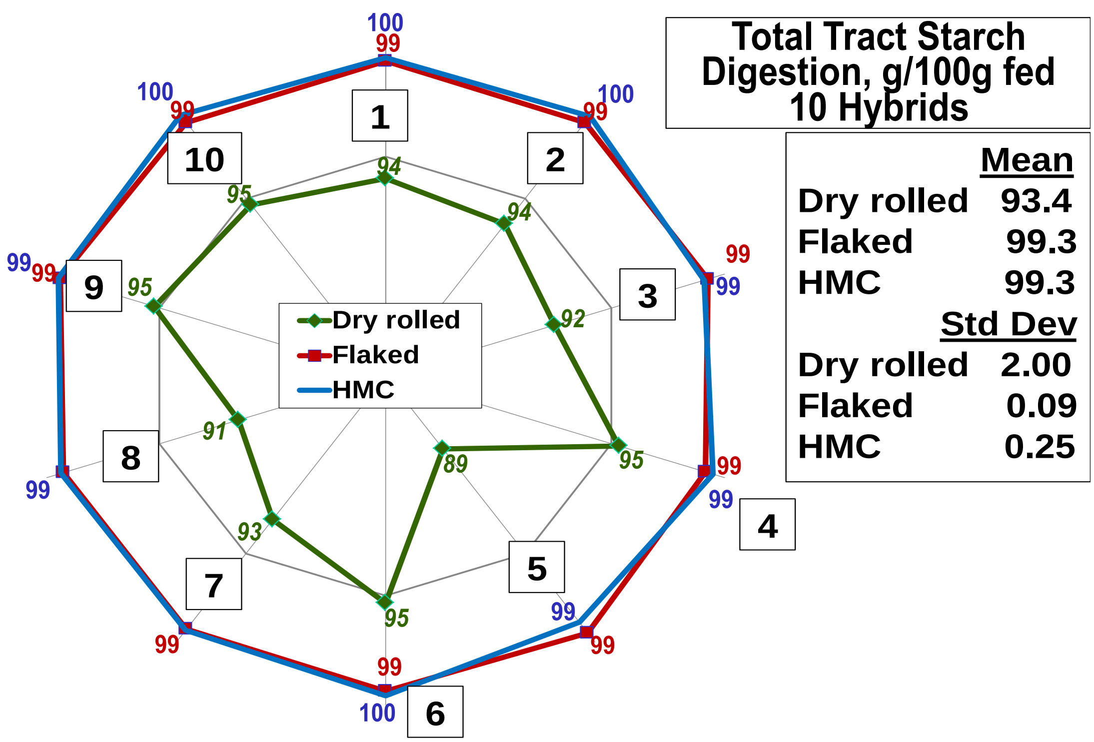
Processing can alter site of digestion even if processing does not alter total tract digestibility. Generally, extent of ruminal digestion of starch is increased by fermenting a feedstuff prior to feeding; in contrast digestibility of the starch reaching the small intestine is increased by steam flaking of cereal grains. Why might an alteration in site of digestion alter the energy value of grain? Fermentation within either the rumen or large intestine involves loss of methane whereas digestion in the small intestine does not. Consequently, flushing more starch to the small intestine should prove beneficial energetically if the additional starch can readily digested within the small intestine and if absorbed nutrients are used productively by the animal.

Do hybrids differ in site of digestion?

Comparisons across hybrids within a trial

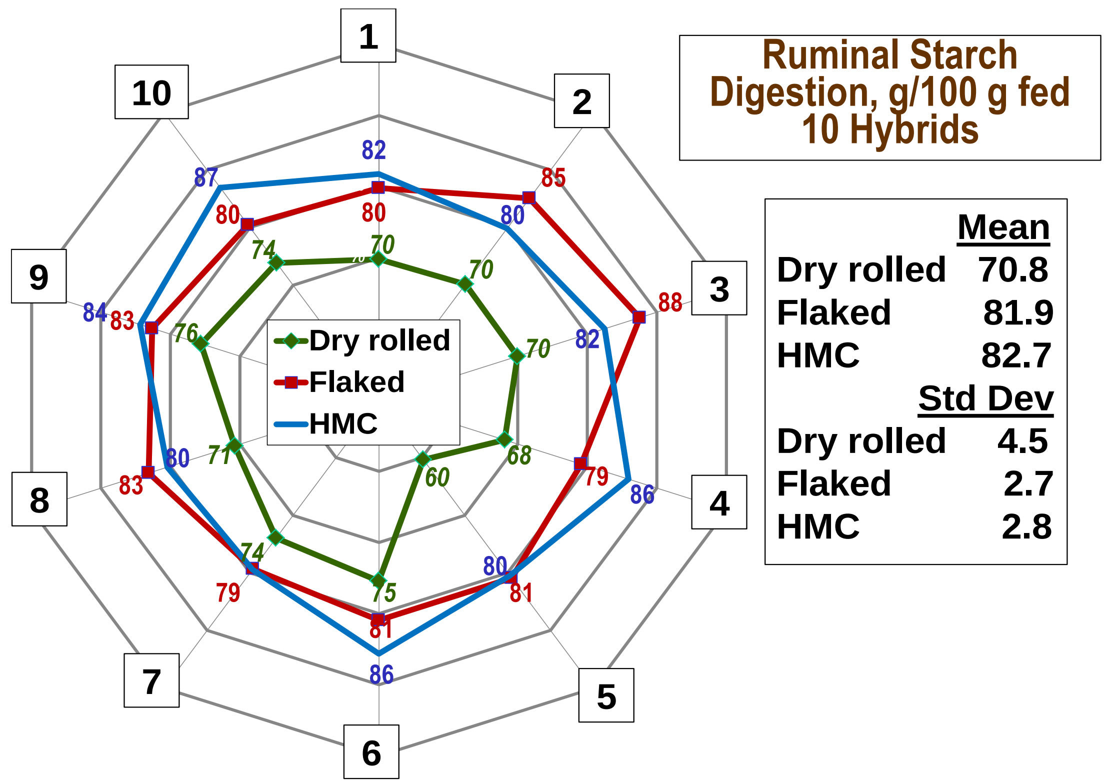
Grain from ten Pioneer hybrids grown in adjacent plots in a single irrigated location in Nebraska that were isolated to avoid the cross-pollination that can alter numerous starch traits within corn kernels. Grain was harvested early as 1) high moisture corn at 28 to 32% moisture and ensiled or 2) harvested later as dry grain. The dry grain thereafter was either 2a) coarsely rolled or 2b) steam flaked at 360 to 410 g/L (28 to 32 pounds per bushel) and fed in rotation to 6 growing Holstein heifers (320 kg) equipped with both duodenal and ileal cannulas. Diets contained 10% roughage and a protein-vitamin-mineral supplement plus chromic oxide to monitor site of digestion. Total tract digestibility of starch from each of the 10 hybrids is illustrated in Figure 1.

Figure 1. Total tract starch digestibility by Holstein heifers fed diets containing 10 different corn grain hybrids in different forms.



Total tract starch digestibility from individual hybrids fed as dry rolled corn ranged from 89% to 95%. In contrast, when fed as steam flaked or high moisture corn (HMC), total tract starch disappearance from these same hybrids was very high and had a very small range (99 to 100%). Hybrids with higher total tract starch digestibility tended to be those hybrids with lower protein content and lower vitreousness of starch. The degree that total tract starch digestibility was increased by processing differed among hybrids ranged from a 10 unit increase in starch digestibility (11% of the initial value) for the hybrid with the lowest digestibility (and was most vitreous) when was fed as dry rolled corn to only a 4 unit increase (4% of the initial value) for the hybrid that had the highest digestibility when fed as dry rolled corn. Thereby, the degree that starch digestibility was increased varied primarily with the baseline value, not with the starch digestibility of the processed grain. Ruminal starch disappearance values from this same trial are shown in Figure 2. Ruminal starch disappearance was less with every hybrid when fed as dry rolled than when fed as high moisture or steam flaked grain. This means that the quantity of starch flowing to the small intestine was considerably greater when the grain was fed as dry rolled than as high moisture or steam flaked corn grain.

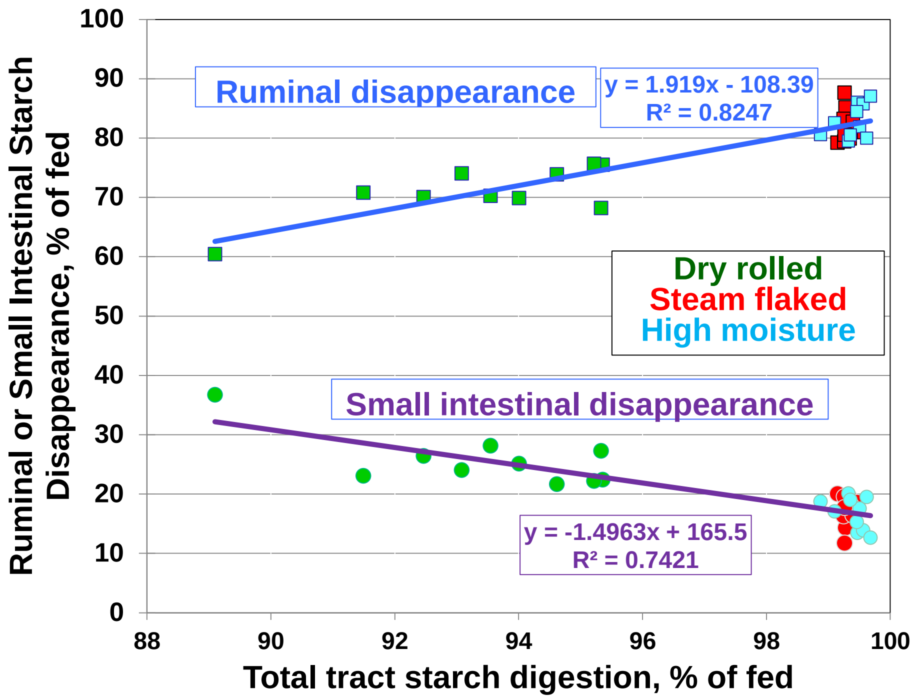
Figure 2. Ruminal starch disappearance as a fraction of starch fed from 10 different corn grain hybrids.



Note that the variability among hybrids in the extent of ruminal starch digested was much greater among the various hybrids fed as dry rolled grain than when fed as flaked or high moisture corn. This would indicate that switching cattle from one grain hybrid or from one batch of grain to another could markedly disrupt the pattern of ruminal fermentation. Abrupt changes in ruminal starch availability of can precipitate acidosis. In research trials where a small number of cattle are fed, only one or a few batches of grain often are processed for the entire feeding trial. In contrast, cattle in commercial feedlots typically receive numerous batches of grain during their feeding period. An improved consistency among batches of grain and of processing should improve the health and performance of feedlot cattle in feedlots, a benefit seldom detected in small feeding trials. Improved consistency among batches of processed grains is an advantage from grain processing that often is not recognized or appreciated.

Despite its lower total tract digestibility, the fraction of dietary starch reaching and digested within the small intestine was greater for hybrids fed as dry rolled than as flaked or high moisture corn grain (Figure 3). Starch influx and its disappearance within the small intestine was greater when extent of ruminal starch digestion was reduced. Variation in the intestinal starch supply also can prove hazardous. Intestinal influx of a large bolus of readily fermented grain might precipitate intestinal acidosis and result in the hemorrhagic bowel syndrome, a perplexing and often fatal malady among high producing lactating cows. This condition often occurs immediately following a sudden or abrupt shift in composition of the diet, in grain processing, or in feed intake or management.

Figure 3. Site of disappearance of starch from 10 hybrids that were dry rolled, steam flaked, or fermented as high moisture corn prior to feeding to intestinally cannulated heifers.



Comparisons across locations and trials

Site of starch disappearance within the digestive tract of steers and heifers has been measured in numerous metabolism trials, but postruminal starch disappearance seldom has been divided between the small versus the large intestine. Published literature values for site of digestion for 5 cereal grains processed by various methods were compiled; results are presented in Table 3. Unfortunately, literature information on the impact of processing on site of intestinal starch digestion is quite limited.

Table 3. Influence of grain source and processing on extent of digestion of starch from grains fed in the dry rolled (DR), steam flaked (SF), steam rolled (SR), or high moisture (HM) forms as a fraction of starch entering specific segments of the digestive tract of steers and heifers from research published in refereed journals. References and data set are available on request.

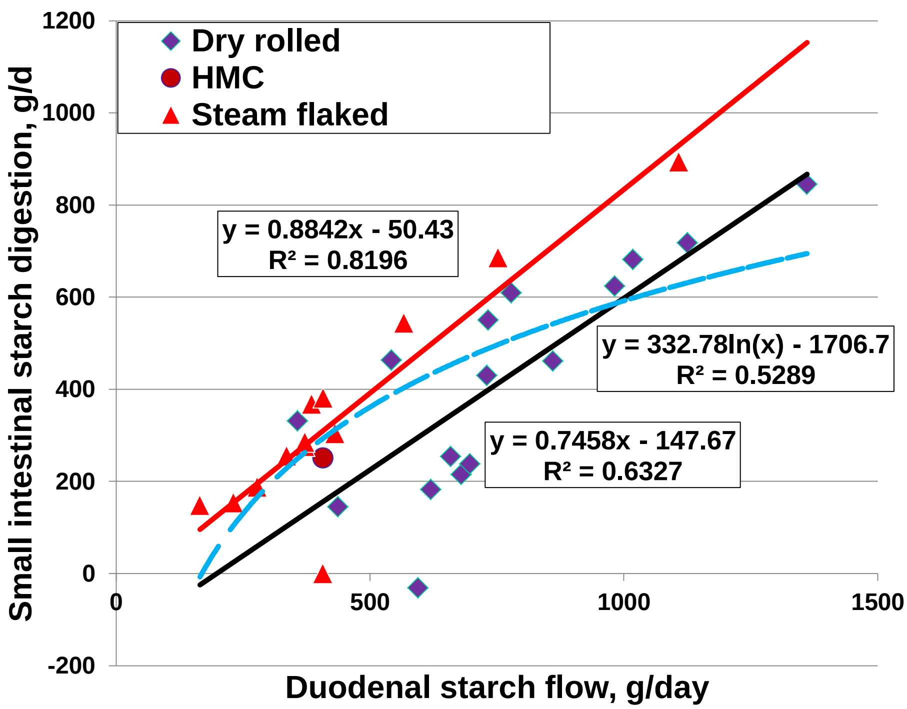
Grain	Process	Diets	Starch digestion, % entering segment				
			Ruminal	Post-ruminal	Total Tract	Small intestine	Large intestine
Barley	DR	7	82.9 [b]	89.1	98.0 [b]	75.6	63.1
Barley	SF	13	90.5 [a]	90.9	99.2 [a]	-	-
Barley	SR	5	90.4 [a]	92.4	99.3 [a]	80.0	62.0
Corn	DR	35	68.3 [b]	71.2 [b]	92.5 [b]	58.0 [b]	43.5 [a]
Corn	HM	5	77.5 [a]	87.2 [a]	98.1 [a]	61.7 [b]	-17.3 [b]
Corn	SF	84	83.9 [a]	93.9 [a]	99.1 [a]	80.2 [a]	65.2 [a]
Corn	W	4	78.1 [b]	57.8 [c]	90.8 [b]	-	-
Oats	DR	1	92.7	76.3	98.3	-	-
Oats	SF	2	94.3	79.0	98.8	-	-
Sorghum	DR	18	70.0 [b]	51.4 [b]	85.9 [b]	31.2 [c]	28.8 [b]
Sorghum	HM	4	75.7 [ab]	82.6 [a]	95.7 [a]	57.4 [b]	59.4 [a]
Sorghum	SF	12	85.0 [a]	92.2 [a]	98.8 [a]	81.4 [a]	53.0 [a]
Wheat	DR	4	81.7	98.6	99.8	95.2	72.0
Wheat	SF	1	91.6	86.2	98.8	-	-

Total tract starch digestibility responses to processing differed with grain, being small and generally not significant for barley, oats and wheat. Ruminal and total tract digestion of starch from these three grains were high even without extensive processing; nevertheless the extent of ruminal digestion often was numerically increased by flaking these grains. Total tract digestion tended to be increased by flaking barley and oats. In contrast with these three grains, total tract digestibility was markedly increased (6 and 13 percentage points) by steam flaking of the two grains with high prolamin content, dent corn and sorghum grain. Although most of the response to processing these two grains can be attributed to an increased ruminal disappearance of starch, disappearance of starch reaching the small intestine also was significantly increased by steam flaking and tended to be increased by fermentation prior to feeding. Surprisingly, ruminal digestion of starch digestion tended to be greater for whole than dry rolled corn grains. High moisture corn grain had significantly greater ruminal digestion than dry rolled corn grain, but the impact of fermentation on ruminal sorghum grain was more muted. Based on the assumption that starch disappearance in the small intestine must exceed about 80% for ruminal starch escape to be preferred (having an energetic advantage for digestion of starch in the small intestine over fermentation in the rumen) as described by McLeod et al. (2006) and Huntington et al. (2006), increasing the extent that starch escapes ruminal fermentation would not prove energetically beneficial when starch digestibility in the small intestine is below 80%. On that basis, increasing flow of starch to the small intestine should prove beneficial only for flaked corn, sorghum grain, and dry rolled wheat. With other grains and other processing methods, ruminal fermentation of starch should be advantageous energetically over postruminal starch digestion.

Is there a ceiling to the amount of starch that can be digested in the small intestine?

Based on infusion studies and extrapolations across a variety of diets, several researchers have proposed that the amount of starch digested in the small intestine is limited to some maximum value. Once this ceiling is exceeded, they propose that the remaining starch simply passes to the large intestine where it is inefficiently fermented. Based on data from trial used to compile Table 3, starch disappearance in the small intestine (duodenal minus ileal starch flow) was calculated and plotted against duodenal starch flow in grams per animal per day (Figure 4) for corn grain processed by various methods. The plots for steam flaked corn and dry rolled corn were different but both remained linear (R^2 > 0.83 and >0.63, respectively) with no plateau in or ceiling to starch disappearance being evident. However, the intercept where intestinal starch digestion would be zero was considerably greater for diets based on dry rolled than on steam flaked corn grain, possibly reflecting lower availability of non-gelatinized or amylose starch.

Figure 4. Small intestinal starch disappearance versus duodenal starch flow from corn-based diets.

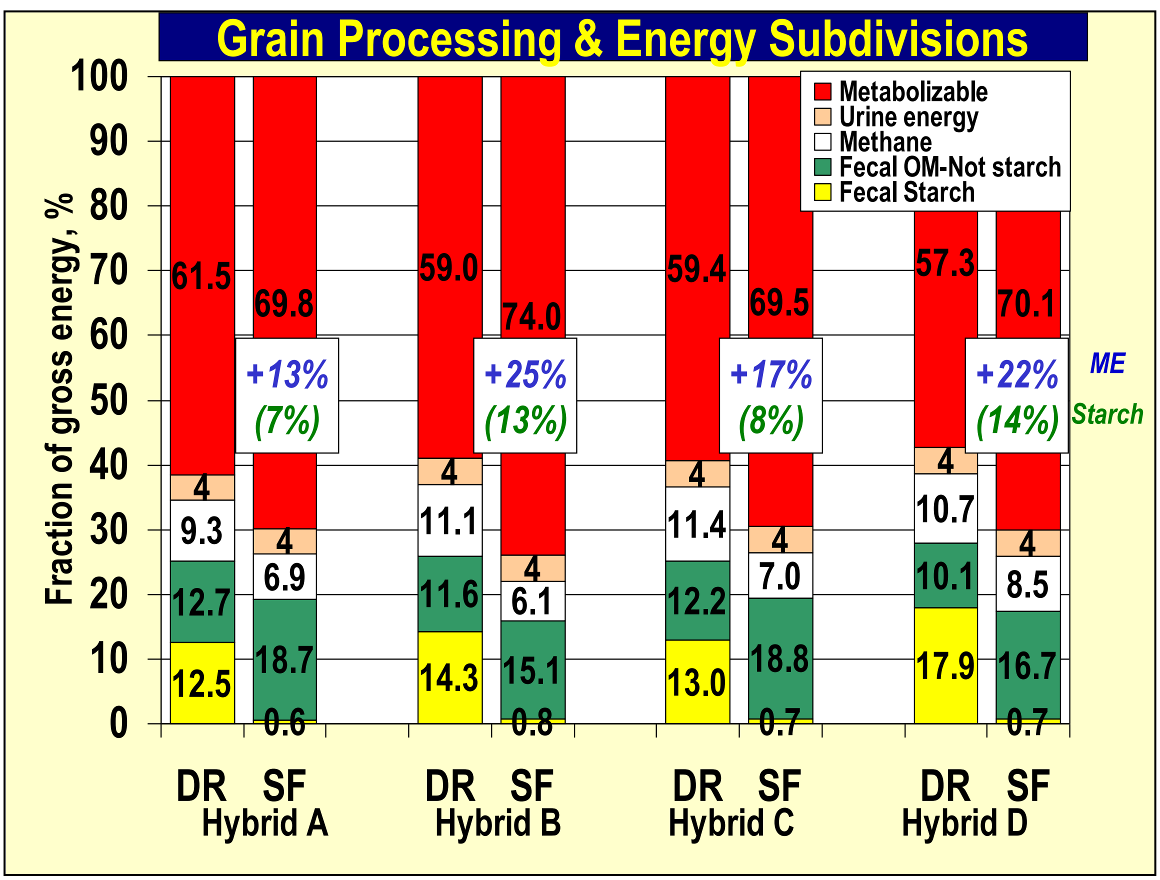


If values for the individual grain processing methods had not been separated and an overall curve were drawn, as is shown in the dashed line of Figure 4, one could conclude that digestibility of starch reaching in the small intestine decreased as starch supply increased and might plateau at some point. The slopes of the regression lines represent estimates of starch digestibility for each unit of added starch flowing to the duodenum. These values are greater than the fractional starch digestion rates shown in Table 3. Had these lines been forced through a zero intercept, estimates of starch digestibility would be 57%, 80%, and 63% for dry rolled, steam flaked, and high moisture corn grain, respectively, and similar to estimates in Table 3. Which values are more appropriate for estimating small intestinal starch digestion is debatable.

Can increased starch digestibility fully explain the energy response of grains to processing?

Corn grain from four individual Pioneer hybrids that differed in vitreousness but grown in the same location the same year were fed after being either dry rolled or steam flaked at 360 g/L (28 pounds per bushel) to 8 steers equipped with ruminal and duodenal cannulas. Energy lost in feces, methane, and urine were measured or estimated as a fraction of total gross energy intake. Methane loss was calculated from ruminal concentrations of various volatile fatty acids and extent of ruminal starch digestion. Metabolizable energy was calculated by difference. Results are presented in Figure 5.

Figure 5. Energy loss from 4 corn grain hybrids fed to ruminally and duodenally cannulated steers.



Energy loss of starch in feces was markedly reduced by flaking each of these grains even though the amount of non-starch organic matter in feces was greater for steers fed flaked grain, probably reflecting decreased ruminal fiber digestion for steers fed flaked corn diets that had a lower ruminal pH. Ruminal methane loss, calculated from ruminal volatile fatty acid concentrations, was substantially lower for steers fed the flaked grain due to higher ruminal concentrations of propionate. Urinary energy loss was similar among all diets. As a result, the metabolizable energy content as a fraction of gross energy was estimated to be 13 to 25% greater from the flaked than from the dry rolled corn diets. The increase in ME from reduced starch excretion across these hybrids alone would be 7 to 14%, only half the observed change in ME. With corn grain at 4.4 kcal/g DM, the calculated ME mean for the dry rolled and for steam flaked corn grain in this trial was 2.61 and 3.12 Mcal/kg, respectively. Why the value for dry rolled corn is slow low is not apparent. Nevertheless, these values indicate that increased digestibility of starch, though correlated with increase ME of the diet, cannot fully explain the alterations in ME associated with the flaking process.

To what degree does grain processing alter cattle performance and net energy value of various grains?

Data from performance trials where high grain diets were fed to finishing steers and heifers were compiled from published trials with complete information on animals and diet compositions. Beta agonists had not been fed within these trials. Because beta agonists alter body composition and weight gain, they will alter calculated energy values for diets, but it seems unlikely that they will alter the relative differences among feedstuffs in their energy values or the responses to grain processing. Maintenance energy requirements used for calculating NEm by the NRC (1996) equations were assumed to be reduced by 12% when an ionophore was being fed. Again, a larger protein mass would be expected to increase maintenance energy requirements so some adjustment in energy requirements for maintenance for based on condition at the beginning as well as the end of a feeding trial probably would be appropriate. ME value for each diet was calculated from rate of gain and feed intake using NRC (1996) empty body weight equations. To calculate equivalent weight, shrunk weight at harvest was assumed to be equal to the weight at which cattle had reached a low choice quality grade. ME values for diets also were calculated based on equations derived by Zinn et al. (2008) based on equivalent weight adjusted shrunk weights but with no adjustment for feeding an ionophore. ME of the grain in each trial was calculated by subtracting the ME provided by the other diet ingredients listed in NRC (1996) tables from the total ME of the diet and dividing the remaining ME by the percentage of grain in diet dry matter. Least squares means for each processing method were calculated. Statistically, values were weighted by the square root of the number of cattle per diet to balance for the relative power of the various trials. Mathematical interconversions among ME, NEg, and NEm that were used followed those described by NRC (1996) and Zinn et al. (2011). Values for barley are shown in Table 4.

Rate of gain for cattle fed barley was greatest for cattle fed unprocessed (whole) barley due to slightly more rapid gain and higher intake as a percentage of body weight. However, diet ME and ME of the grain was greater for rolled, high moisture, and steam flaked barley than for whole barley. Compared with other grains, ME of barley was not markedly altered by grain processing method.   This matches with failure of processing to alter ruminal or total tract starch digestibility from barley grain (Table 3).

Table 4. Performance and energy value for unprocessed and processed barley fed to feedlot steers and heifers across all published trials. Data set and references are available on request.

Grain		**Barley**				
Process	**Basis**	**Dry rolled**	**High moisture**	**Steam flaked**	**Steam rolled**	**Whole**
Diets	Number	49	5	13	10	2
Cattle/diet	Number	33.5	44.8	35.0	30.1	47.5
Grain	% of diet	87.8	83.9	78.8	89.6	81.7
Initial wt	lb	369.1	339.2	361.5	383.2	262.2
Time fed	days	112.1	115.9	100.4	127.9	212.8
Non-grain NDF	% of diet	4.9	7.5	9.8	3.0	2.7
Dressing %	% shrunk wt	57.8	56.2	56.8	57.7	55.9
ADG	kg	1.41	1.33	1.36	1.45	1.51
ADG response	***%***	***-***	***-5.49***	***-3.48***	***3.10***	***7.11***
DMI	kg/d	8.85	8.53	8.89	9.43	8.53
DMI response	**%**	**-**	**-3.69**	**0.38**	**6.54**	**-3.61**
DMI	% BW	1.98	2.05	2.07	2.00	2.07
DMI response	***% BW***	***-***	***3.58***	***4.40***	***1.02***	***4.32***
Gain:Feed	ratio	0.16	0.16	0.15	0.16	0.18
Gain:Feed response	***%***	***-***	***-1.61***	***-3.08***	***-0.95***	***12.58***
ME of diet	Mcal/kg, NRC	2.97	2.91	2.88	2.88	2.89
ME intake	Mcal/d, NRC	26.20	24.70	25.56	27.15	24.56
ME of grain	Mcal/kg, NRC	3.12	3.08	3.06	2.91	2.98
ME of grain	Mcal/kg, Zinn	3.13	3.12	3.09	2.93	2.99
NEg of grain	Mcal/kg, NRC	1.45	1.43	1.41	1.31	1.36
NEg of grain response	***%***	***-***	***-1.57***	***-2.61***	***-9.89***	***-6.59***
NEg of grain	Mcal/kg, Zinn	1.46	1.45	1.44	1.32	1.37
NEg Preston, 2013	Mcal/kg	1.34	-	1.54	1.34	-

Responses to processing oats and wheat are shown in Table 5. The number of feeding trials where these grains comprised the primary or only source of starch in the diet was quite small. Steam flaking had little impact on animal performance or energy values of oats. With wheat, steam flaking depressed daily gain primarily by reducing feed intake substantially so that ME intake was lowered. However, ME of wheat was not altered by steam flaking or rolling. Intake depression was less for steam rolled than steam flaked wheat possibly reflecting greater prevalence of fine particles with flaked wheat diets.

Table 5. Performance and energy value for processed oats and wheat fed to feedlot steers and heifers across all published trials. Data set and references are available on request.

Grain		**Oats**		**Wheat**		
Process	**Basis**	**Dry rolled**	**Steam flaked**	**Dry rolled**	**Steam flaked**	**Steam rolled**
Diets	Number	1	2	4	1	2
Cattle/diet	Number	24.0	24.0	16.2	65.0	26.5
Grain	% of diet	74.2	74.2	87.8	70.2	81.5
Initial wt	lb	311.8	312.5	298.4	323.0	352.2
Time fed	days	118.0	118.0	109.5	121.0	114.9
Non-grain NDF	% of diet	5.8	5.8	3.3	7.4	4.4
Dressing %	% shrunk wt	62.0	62.0	57.7	64.5	63.6
ADG	kg	1.53	1.49	1.50	1.34	1.54
ADG response	***%***	***-***	***-2.94***	***-***	***-10.50***	***2.59***
DMI	kg/d	9.20	9.12	8.88	7.61	9.28
DMI response	%	-	-0.87	-	-14.30	4.51
DMI	% BW	2.29	2.28	2.37	1.89	2.12
DMI response	***% BW***	***-***	***-0.43***	***-***	***-20.44***	***-10.55***
Gain:Feed	ratio	0.17	0.16	0.17	0.18	0.17
Gain:Feed response	***%***	***-***	***-2.40***	***-***	***4.37***	***-1.90***
ME of diet	Mcal/kg, NRC	2.89	2.87	2.92	3.09	2.91
ME intake	Mcal/d, NRC	26.61	26.20	25.94	23.53	26.98
ME of grain	Mcal/kg, NRC	2.94	2.92	3.07	3.05	3.04
ME of grain	**Mcal/kg, Zinn**	**2.92**	**2.91**	**3.06**	**3.09**	**3.04**
NEg of grain	Mcal/kg, Obs	1.33	1.31	1.42	1.41	1.40
Neg of grain	***Response, %***	***-***	***-1.49***	***-***	***-1.01***	***-1.56***
NEg of grain	Mcal/kg, Zinn	1.32	1.31	1.41	1.44	1.40
NEg Preston, 2013	Mcal/kg	1.15	1.43	1.43	1.52	-

Performance and diet energy values from studies in which corn or sorghum grain was the primary or only source of grain in the diet are shown in Table 6.

Table 6. Performance responses and energy values for processed corn and sorghum grain to feedlot steers and heifers based on all published studies. Data set and references are available on request.

Grain		**Corn**					**Sorghum**	
Process	**Basis**	**Dry rolled**	**High moisture**	**Steam flaked**	**Steam rolled**	**Whole**	**Dry rolled**	**Steam flaked**
Diets	Number	75	52	106	6	15	11	27
Cattle/diet	Number	47.7	59.4	48.1	37.5	60.8	39.1	54.0
Grain	% of diet	77.7	78.5	75.3	84.0	82.7	81.6	70.2
Initial wt	lb	344.2	349.6	333.8	358.8	331.0	353.2	346.1
Time fed	days	136.2	118.5	138.3	137.7	134.1	121.0	134.1
Non-grain NDF	% of diet	6.0	5.2	6.4	4.1	4.3	5.3	9.4
Dressing %	% shrunk wt	62.2	62.2	63.2	60.3	60.2	60.0	62.3
ADG	kg	1.51	1.50	1.51	1.42	1.40	1.41	1.45
ADG response	***%***	***-***	***-0.72***	***-0.09***	***-5.71***	***-7.45***	***-***	***2.71***
DMI	kg/d	9.48	9.67	8.60	9.06	8.84	10.74	8.97
DMI response	%	-	1.99	-9.27	-4.44	-6.82	-	-16.49
DMI	% BW	2.13	2.20	1.97	1.99	2.08	2.44	2.02
DMI response	***% BW***	***-***	***3.02***	***-7.48***	***-6.91***	***-2.59***	***-***	***-16.99***
Gain:Feed	ratio	0.160	0.155	0.176	0.157	0.157	0.133	0.162
Gain:Feed response	***%***	***-***	***-2.80***	***10.21***	***-1.70***	***-1.71***	***-***	***21.76***
ME of diet	Mcal/kg, NRC	2.87	2.84	3.03	2.90	2.88	2.61	2.91
ME intake	Mcal/d, NRC	27.16	27.38	26.01	26.25	25.40	27.90	26.05
ME of grain	Mcal/kg, NRC	3.02	2.96	3.21	2.99	2.94	2.66	3.10
ME of grain	Mcal/kg, Zinn	3.02	2.95	3.21	3.01	2.96	2.67	3.11
NEg of grain	Mcal/kg, Obs	1.39	1.34	1.52	1.36	1.33	1.13	1.44
NEg of grain	***Benefit, %***	***-***	***-3.31***	***9.29***	***-1.64***	***-4.18***	***-***	***27.88***
NEg of grain	Mcal/kg, Zinn	1.38	1.34	1.52	1.38	1.34	1.13	1.45
NEg Preston, 2013	Mcal/kg	1.43	1.56	1.56	-	1.43	1.30	1.50

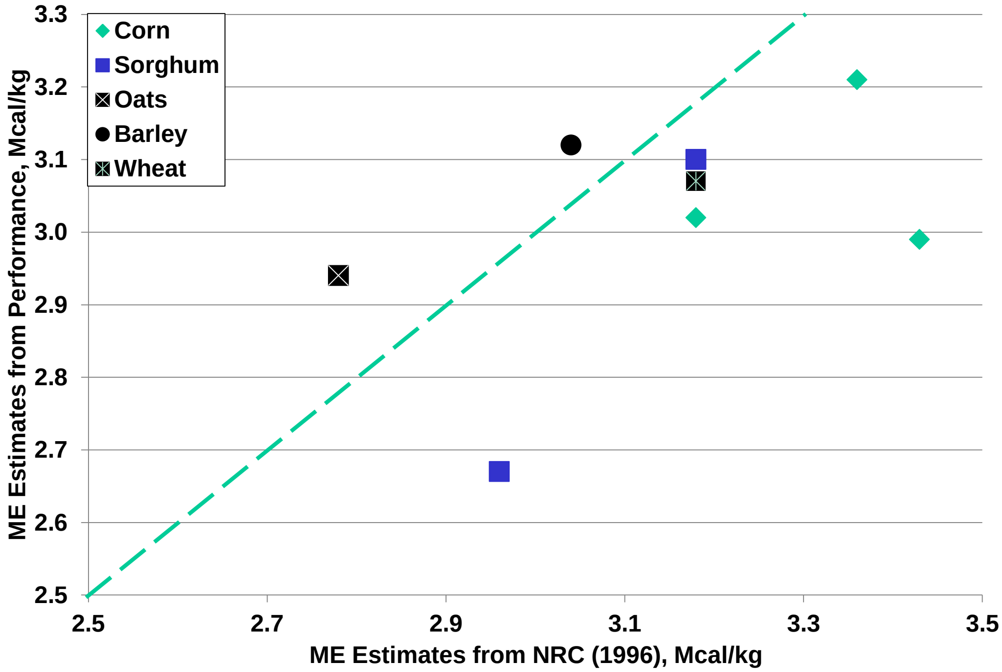
Daily gain tended to be less for steers fed steam rolled or whole corn grain than for steers fed grain in other forms largely due to decreased intake of ME. Dry matter intake of corn was markedly reduced by steam flaking corn, but because rate of gain was not reduced, gain to feed ratio and ME and NEg values were increased markedly (6% and 10%) by steam flaking. This matches with the increased starch digestibility associated with flaked corn grain (Table 3). Although high moisture corn also had increased starch digestibility (Table 3), gain to feed ratio and energy values for corn grain were no greater for high moisture than for dry rolled grain when averaged across all experiments based on the moisture levels and forms of high moisture corn tested. As discussed later, analysis within paired comparison trials rather than across all trials detected a significant energy response to high moisture over dry rolled corn indicating that averages across all trials may yield results that differ from paired comparisons.

Feeding unprocessed (whole) corn grain typically is reserved for calves fed diets containing low amounts of NDF as was apparent in these trials (Table 3). These two factors typically reduce feed intake but increase the gain to feed ratio. However, when ME of the diet is calculated from performance, other diet ingredients and feed intakes should be adjusted appropriately. Based on performance, ME was slightly lower for whole than for dry rolled dent corn across all experiments.

Among all the cereal grains tested, dry rolled sorghum grain had the highest dry matter intake and the lowest ME value even though total ME intake was not markedly different from other grains. Likewise the response in ME to steam flaking was greater for sorghum grain than for the other grains reaching a value among the highest for all grains. This again matches with the marked increases in ruminal and total tract starch digestibility from steam flaking of sorghum grain.

The ME values in tables 4 through 6 were derived from animal performance estimates based on equations relating performance to feed intake. These ME values differ from ME estimates provided by the NRC (1996) as illustrated in Figure 6, being somewhat greater for oats and barley but less than the NRC estimates for corn, wheat, and sorghum grain. As compared with earlier estimates of ME (Owens et al., 1997) the adjustment for ionophore feeding (decreasing the ME requirement for maintenance by 12% according to NRC, 1996) reduces the ME estimates. Yet, ME values from equations developed by Zinn et al. (2011) where maintenance requirements were not adjusted for feeding an ionophore still closely matched values derived from performance using NRC equations. Perhaps other factors that alter requirements such as environmental stress, the assumption that slaughter weight matches weight at 28% body fat, imprecision of measuring initial or final weight, or overestimation of empty body weight from initial shrunk weight through use of a constant empty body percentage (89.1% according to NRC, 1996) are responsible for this difference between the ME estimates derived from these research trials and the ME values reported previously for grains processed by various methods summarized by the NRC (1996).

Figure 6. Metabolizable energy of grains as reported by the NRC (1996) and calculated from feedlot performance studies.



Can more precise estimates of performance and energy responses to grain processing be determined?

Values in Tables 4 through 6 are based on averages across all studies that were located in the published literature. By testing response to grain processing <u>within</u> rather than <u>across</u> studies helps to remove trial differences associated with environmental effects, animal selection, and measurement inconsistencies. Though the impact of these specific factors may be minimized, other factors that remain that are associated with the grain processing method used within each trial (e.g., particle size distribution, rolled versus ground grain, flake weight, moisture content) remain but seldom are quantified in research reports. Nevertheless, pairing of comparisons within each trial markedly increases the statistical and mathematical precision for detecting responses to grain processing.

Results of testing of paired comparisons within trials where steam flaked and dry rolled corn both were fed in the same study are presented in Table 7. Providing steam flaked grain to cattle increased ($P < 0.04$) rate of gain while decreasing feed intake ($P < 0.01$). This resulted in an increased ($P < 0.01$) gain to feed ratio, the ME content of the diet, and the ME content of the grain (by over 5%). ME intake was not different between diets containing dry rolled and steam flaked corn grain. The increases in ME parallel the substantial increases in starch digestion noted with flaking corn grain. Although high moisture and steam flaked corn had similar extents of starch digestion in the rumen and total tract (Table 3), greater ($P < 0.05$) digestion of starch reaching the small intestine for steam flaked than high moisture corn (Table 8) and a decrease in loss of methane (Figure 4) may be responsible for the greater increase in ME over dry rolled corn for steam flaked corn than for high moisture corn (noted later).

Table 7. Paired comparisons within 17 trials where steers or heifers were fed diets based on corn in both the dry rolled and steam flaked form.

Process	Basis	Dry rolled	Steam flaked	Difference	P <
Trials	number	17	17	percent	level
Time fed	days	144.4	144.4	0.0	0.20
Grain level	% of diet	73.1	72.5	-0.82	0.29
Initial wt	kg	325.4	325.5	0.04	0.83
Final wt	kg	547.5	555.1	1.40	0.08
Carcass wt	kg	356.2	361.4	1.48	0.08
Dressing %	% shrunk wt	63.0	63.1	0.19	0.13
ADG	kg	1.55	1.61	3.89	0.04
DMI	kg/day	9.22	8.87	-3.83	0.01
DMI%	kg/100kg BW	2.11	2.01	-4.77	0.01
Gain:Feed	ratio	0.167	0.181	8.40	0.01
Diet ME NRC	Mcal/kg diet	2.92	3.04	4.14	0.01
Diet ME Zinn	Mcal/kg diet	2.91	3.02	3.84	0.01
ME Intake	Mcal/day	26.9	26.9	0.12	0.92
ME Grain NRC	Mcal/kg Obs	3.04	3.21	5.61	0.01
ME Grain Zinn	Mcal/kg Obs	3.03	3.19	5.30	0.01
NEg Grain NRC	Mcal/kg Obs	1.40	1.52	8.57	0.01
NEg Grain Zinn	Mcal/kg Obs	1.39	1.50	7.91	0.01

Results of trials with paired comparisons where high moisture and dry rolled corn both were fed in the same study are presented in Table 8. Dry matter intake in kg per day and as a fraction of mean shrunk body weight were decreased by more than 5% ($P < 0.01$) when high moisture corn replaced dry rolled corn in the diet; rate of gain was not altered. This in turn led to an increase in the gain to feed ratio of about 5%. ME of the grain by both the NRC and by Zinn et al. (2008) equations was about 4% greater for high moisture than for dry rolled corn ($P < 0.02$). Intake of ME was lower for cattle fed high moisture than dry rolled corn, perhaps reflecting more rapid and extensive ruminal metabolism of starch from the fermented than dry rolled grain as noted in Table 3.

What additional animal factors or diet components alter the feeding value of processed corn grain?

The relationships of various trial measurements to ME intake and ME of the diet within each corn processing method were calculated. ME intake of the diet was well correlated with daily gain ($r = 0.84$ to 0.91) and ME of the grain was correlated with gain to feed ratio ($r = 0.67$ to

0.84). Some additional significant correlations that were detected are presented in Table 9. Through altering these conditions in the correct direction, rate of gain and gain to feed ratio might be improved for cattle fed grains processed in a specific manner.

Table 8. Paired comparisons within 19 trials where steers or heifers were fed diets based on corn in both the dry rolled and high moisture form.

Process	Basis	Dry rolled	High moisture	Difference	P <
Trials	number	19	19	percent	level
Time fed	days	129.6	129.6	0.0	1.00
Grain level	% of diet	78.4	78.4	0.01	0.96
Initial wt	kg	325.8	327.0	0.35	0.56
Final wt	kg	529.2	529.1	-0.02	0.98
Carcass wt	kg	368.6	367.9	-0.19	0.90
Dressing %	% shrunk wt	62.3	62.3	0.05	0.66
ADG	kg	1.55	1.54	-0.67	0.78
DMI	kg/day	9.82	9.28	-5.46	0.01
DMI %	kg/100kg BW	2.31	2.17	-5.71	0.01
Gain:Feed	ratio	0.158	0.167	5.36	0.09
Diet ME NRC	Mcal/kg diet	2.82	2.91	3.30	0.03
Diet ME Zinn	Mcal/kg diet	2.80	2.90	3.42	0.02
ME Intake	Mcal/day	27.6	27.0	-2.38	0.04
ME Grain NRC	Mcal/kg Obs	2.93	3.06	4.28	0.02
ME Grain Zinn	Mcal/kg Obs	2.91	3.04	4.42	0.01
NEg Grain NRC	Mcal/kg Obs	1.32	1.42	7.58	0.02
NEg Grain Zinn	Mcal/kg Obs	1.30	1.40	7.69	0.01

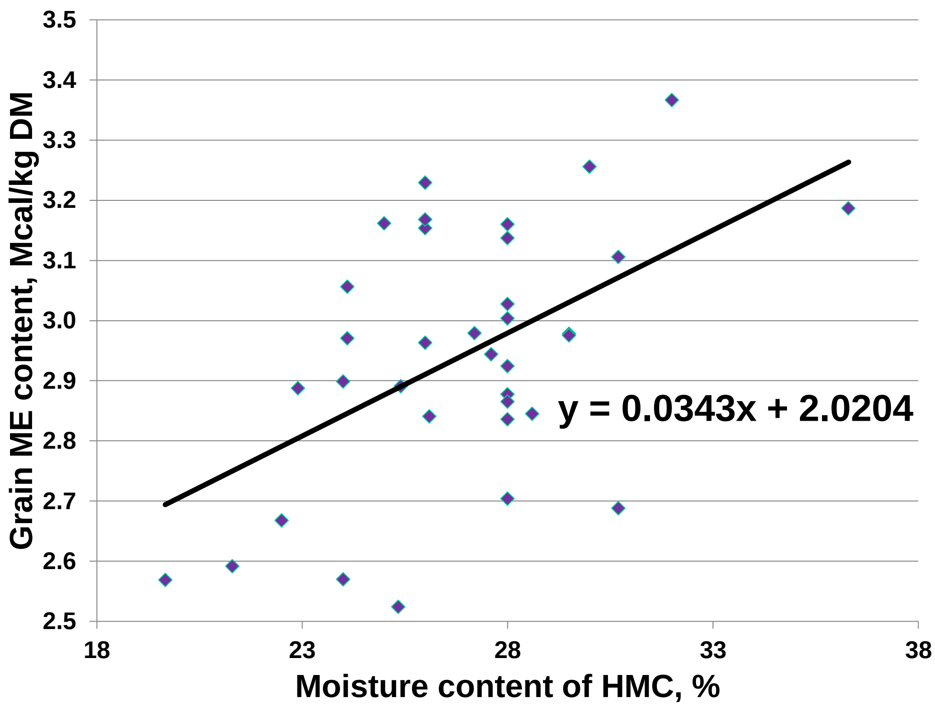
Table 9. Correlations between diet and animal measurements with ME intake and grain ME across trials within a grain form.

Response	Alteration	Dry rolled	Steam flaked	High moisture
ME intake	Initial wt	0.38	-	0.52
ME intake	Non-grain NDF	-0.27	-	0.47
ME intake	Grain % of diet	-	0.38	-0.56
ME intake	Days fed	-0.34	-0.47	-
ME intake	Flake wt	-	0.41	-
Grain ME	Grain moisture	-	-	0.51
Grain ME	Days fed	-	-	0.32

As might be expected based on standard equations used to predict mean feed intake (NRC, 1996), ME intake and rate of gain were greater when the cattle in research trials had a heavier initial weight when they were fed either dry rolled or high moisture grain. The direction of the response to adding more NDF to the diet differed with processing method. Added NDF decreased ME intake when added to dry rolled corn diets but increased ME intake when added to high moisture corn diets. Whether this reflects alleviation of ruminal acidosis, less propionate production from greater ruminal starch escape due to faster ruminal turnover from added NDF, or some other alteration in efficiency related to site or products of digestion is uncertain. The higher the percentage of grain in the diet, the higher the ME intake with steam flaked corn grain but the lower the ME intake with high moisture corn diets. Combined with effects of added NDF, this may indicate that dilution of the diet is more beneficial with high moisture corn grain than with the other forms of corn tested. Longer feeding trials resulted in less ME intake with diets based on dry rolled or steam flaked grain.

With steam flaked grain, higher flake weights increased ME intake. As clearly demonstrated in feeding trials by Zinn and Plasciencia (1996) and summarized across trials by Zinn et al. (2002), flaking corn to produce thinner or lighter test weight flakes increases energy availability but often decreases feed intake and rate of gain. Hence, the optimum flake weight will depend on the relative economic importance of feed efficiency versus rate of gain. ME content of grain increased with moisture content of high moisture grain about 1.2% for every 1% increase in moisture content (Figure 7). Confirming an earlier suggestion (Owens et al., 1997), this indicates that corn fermented at 30% moisture should have about 5% greater feeding value than

Figure 7. Influence of moisture content of HMC on ME content of grain in HMC diets.



high moisture corn at 26% moisture. Research from Nebraska (Benton et al., 2005) and a summary by Soderlund and Owens (2006) have clearly demonstrated that disappearance of ruminal DM increases with time in storage and with moisture content of fermented corn either harvested with high innate moisture or with reconstituted corn where water is added before the grain is ensiled. This indicates that the fermentation process or fermentation products are responsible for the increased energy availability of fermented corn grain. Longer feeding trials also increased the ME of high moisture corn grain, perhaps a longer time for the high moisture corn to ferment and increase in energy availability.

Overview

Comparisons of NEg values calculated from cattle performance using NRC (1996) or Zinn et al. (2008) equations with the NEg values from various publications are presented in Table 10.

Table 10. NEg estimates for various processed grains calculated from performance or literature sources

Grain	Process	Calculated using		Published		
		NRC equations	Zinn equations	NRC Beef 1996	NRC Dairy 2001	Preston 2013
Barley	Dry rolled	1.39	1.38	1.40	1.36	1.34
Barley	High moisture	1.34	1.34	-	-	-
Barley	Steam flaked	1.52	1.52	-	-	1.54
Barley	Steam rolled	1.36	1.38	-	-	1.34
Barley	Whole	1.33	1.34	-	-	-
Corn	Dry rolled	1.39	1.38	1.50**	1.3	1.43
Corn	Steam flaked	1.52	1.52	1.62	1.55	1.56
Corn	High moisture	1.34	1.36	1.62**	1.48**	1.56**
Corn	Whole	1.33	1.34	1.50**	-	1.30
Oats	Dry rolled	1.33	1.32	1.22	1.26	1.15**
Oats	Steam flaked	1.31	1.31	-	-	1.43*
Sorghum	Dry rolled	1.13	1.13	1.35**	1.30**	1.30**
Sorghum	Steam flaked	1.44	1.45	1.50	1.51	1.50
Wheat	Dry rolled	1.42	1.41	1.50	1.47	1.43
Wheat	Steam flaked	1.41	1.44	-	-	-
Wheat	Steam rolled	1.40	1.40	-	-	-

* Differs by more than 5% from calculated values.

**Differs by more than 10% from calculated values.

Values with a star deviate more than 5% from the current estimates of NEg. With dry rolled corn and whole corn grain, the newly derived values are lower than estimated by NRC (1996) as indicated previously by Zinn et al. (2002) but more similar to estimates from NRC (2001) and Preston (2013). The newly derived values for high moisture corn are lower than all previous estimates; this may be associated with insufficient moisture content for adequate fermentation of high moisture corn grain fed in trials published more recently. NEg values for oats were above values indicated by Preston (2013) and were not increased by steam flaking as he suggested. With small grains, starch content and therefore energy values can differ widely with crop growing conditions. New estimates for dry rolled sorghum were substantially lower than all previous estimates. Perhaps a coarser roll or grind size has been used in more recent trials; presence of small berries that are not fractured by rolling or grinding certainly reduce digestibility and energy value of rolled or ground sorghum. In most cases, differences among grain sources reflect differences in starch content or digestibility whereas responses in ME to processing reflect alterations in starch digestibility, site of digestion, and methane loss. The degree that the responses to grain processing differ with either hybrid or growing conditions is uncertain, but greater response to more extensive processing (flaking, high moisture harvest) would be expected with more vitreous samples of grain (corn, sorghum) where starch digestibility is reduced when grain is less extensively processed. Why the absolute ME values in this literature summary for corn grain are lower than often reported and summarized by others is unclear. Selection of hybrids with high test weight for reduced kernel damage during handling or changes and evolution of the equations relating animal performance to energy requirements, especially related to ionophores, may be involved. Responses in digestibility and energy availability to grain processing for feedlot cattle generally parallel those reported for lactating dairy cows, but the shorter time for ruminal fermentation with cows consuming high amounts of diets rich in NDF generally results in lower digestibility for less fully processed grain; this in turn leads to a greater response to grain processing with lactating cows than feedlot steers. As indicated by Preston (2013), cattle use NE for maintenance and gain; for typical feedlot cattle, between 40 and 50% of consumed energy is used for gain. Consequently, when using computerized feed formulation programs, the NEm+g value to employ for an individual feedstuff should be a value midway between NEm and NEg, not NEg alone. The task of the nutrition consultant and advisor is to balance the numerous factors involved with sourcing grain and forage and to optimize and standardize the diet and the processing method for optimum economic return for each specific feedlot. The ultimate task of the feedlot operation is to produce and deliver a consistent, high quality diet for cattle to achieve maximum productivity, economic return, and animal health.

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Feedlot Research at the U.S. Meat Animal Research Center

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Introduction

The U.S. Meat Animal Research Center (U.S. MARC) conducts research in several areas to support the feedlot industry and the U. S. consumer. These areas include

- Determining the nutrient value of emerging coproduct feeds and nutrient requirements of cattle that have diverse genetics
- Defining underlying mechanism associated with enteric greenhouse gas production
- Predicting and mitigating heat stress
- Preharvest food safety
- Developing genomic-based tools for selection for feed efficiency and for making management decisions to improve production efficiency.

Determining the nutrient value of emerging coproduct feeds and nutrient requirements of cattle that have diverse genetics

The metabolizable energy value of steam-flaked rations decrease with increased distillers grains inclusion suggesting that metabolizable energy concentration of distillers grains in not constant and may need to be discounted as inclusion rate increases (Hales et al., 2013a). The decrease in energy value is being driven by an increased loss of methane and fecal energy as distillers concentration is increased.

Wet distillers grains with solubles (WDGS) are relatively high in NDF and average daily gain compared to corn suggesting that lower concentrations of ingredients considered to be high in roughage could be included in diets that replace WDGS for corn. Hales et al. (2013b) determined that final body weight tended to increase as alfalfa hay increased from 2 to 6% but then decreased from 6 to 14% inclusion. Similiarly, average daily gain responded quadratically in which it increased from 2 to 6% and subsequently decreased from 6 to 14% alfalfa hay inclusion. Dry matter intake increased linearly as alfalfa hay inclusion increased in the diet. The Gain:Feed ratio increased from 2 to 6% alfalfa hay inclusion and then decreased linearly from 6 to 14% alfalfa hay inclusion.

Concentration of alfalfa hay in the finishing diet did not affect hot carcass weight, marbling score, or the proportion of cattle grading USDA choice. However, dressing percent and ribeye area did respond in a quadratic manner in which they decreased from 2 to 10% alfalfa hay inclusion and increased from 10 to 14% alfalfa hay in the diet. Yield grade and adjusted 12th rib fat responded quadratically in which both increased from 2 to 6% alfalfa hay inclusion and decreased from 6 to 14% inclusion. Analysis of responses of Gain:Feed and average daily gain on alfalfa hay predict the apex at 3 and 7% for Gain:Feed ratio and average daily gain, respectively, when fed in diets based on dry-rolled corn containing 25% WDGS.

Defining underlying mechanism associated with enteric greenhouse gas production

Methane gas released by cattle is a product of feed fermentation in the digestive tract. Released methane represents both a lost opportunity to capture dietary energy and a source of greenhouse gas. Developing strategies to reduce methane emissions from cattle have the potential to increase production efficiency as well as reducing the impact of cattle on the environment. Numerous factors contribute to the relative methane emissions amongst groups of cattle. In our previous research, we have shown that 3% of intake energy consumed by steers fed a high-corn diet is lost as methane energy (Archibeque et al., 2007). Cattle eating a high-forage diet typically release a greater percentage of their dietary energy as methane and cattle with a lower feed intake emit less methane Flatt et al., 1965; Reynolds et al., 1991; Freetly and Nienaber, 1998). Nkrumah (2006) and Hegarty et al. (2007) found reduced methane emissions from steers that have a low residual feed intake.

Zhou et al. (2010) determined that cattle that differ in feed efficiency also differ in prevalence of methanogenic rumen species which may be a possible mechanism for the reduced CH_4 emissions. In our studies, cattle that had a positive residual gain had higher enteric methane productions compared to cattle that had a negative residual gain at a similar feed intake. The vitro capacity to produce methane and total methanogens in rumen fluid did not differ between groups suggesting an increased methane production with increased feed efficiency. A potential driver of the increased methane production may be the result of more efficient cattle having higher digestion rates of feed resulting in increased nutrient availability to the animal and an increased methane production resulting from increased rates of fermentation.

The primary driver of methane production is the number of days an animal is alive. Reducing the number of days it takes to feed a calf will have the greatest impact on total methane production. The second greatest driver of methane production is the amount of feed the calf consumes. Using selection indexes, such as residual feed intake (RFI), are thought to potentially reduce methane production by decreasing feed intake for a fixed rate of gain. However, if selecting for RFI increases the days on feed to reach a given weight advantages in reduced feed intake will be offset by the increased number of days on feed.

Predicting and mitigating heat stress

Heat waves have been associated with increased mortality of cattle in the feedlot as well as reductions in animal performance. A model has been developed to predict heat events that will result in heat stress in cattle (Eigenberg et al., 2008). The model can be found at the U. S. MARC website (http://www.usmarc.usda.gov). The model is based on a regression equation that predicts respiration rate in cattle. When the ambient temperature is above 25°C and a steer is taking between 74 and 85 breaths per minute (BPM), the condition is considered to be normal. An alert is issued if the predicted BPM is between 85 and 110. When predicted BPM is between 110 and 133, a danger alert is issued. When BPM exceeds 133, an emergency alert is issued. The equation is a function of ambient temperature, relative humidity, wind speed, and solar radiation (estimated from cloud cover). The model uses the predicted data from the National Weather Service to create the extend heat stress forecast.

Animal characteristics are also associated with heat stress. Hide color, history of respiratory pneumonia, body fat, and behavior have been associated with variation in susceptibility to heat stress (Brown-Brandl et al., 2006).

Preharvest food safety

Feedlot soils are a source of *E. coli* O157:H7 and are a potential means of transmission to animals. *Escherichia coli* can be reduced in feedlot soils by solarization. Covering soil with plastic for one week resulted in a two-log decrease in *E. coli*, and a three-log decrease after six weeks (Berry et al., 2012).

Diet can contribute to the level of *E. coli* O157:H7 in feedlot cattle. Cattle fed diets that contained 40 or 70% distiller grains with solubles had more *E. coli* O157:H7 in their feces than calves not fed distillers grains (Wells et al., 2011).

Developing genomic based tools for selection for feed efficiency and for making management decisions to improve production efficiency

The U.S. MARC has long been associated with the evaluation of different breeds of cattle. The historical project has been the Germplasm Evaluation Project (GPE). In GPE, sires within breeds were sampled and bred to a base cow herd at U.S. MARC and the progeny were subsequently evaluated for production traits as well as product quality (Wheeler et al., 1996, 1997, 2001, 2004, 2005, 2010; Casas et al., 2006, 2010). These studies have been pivotal to developing predictions of animal performance and developing nutrient requirements of feedlot cattle.

The difficulty with implementing the information that has been gleaned from these studies is that we rarely know the genetic background of calves when they arrive at the feedlot. Often, the most information we have is the coat color of the calf. In an effort to develop tools that more accurately predict the genetic potential of a calf for feed efficiency and product quality, a new experiment was undertaken to find genetic markers associated with economically relevant traits. The first step was the development of a set of markers across the genome of cattle (Matukumalli et al., 2009) that could be associated with production traits. The second step is collecting production data in cattle that have been evaluated for these genetic markers. The U.S. MARC has undertaken a multiple year project to measure feed intake and growth in fed cattle to identify markers associated with feed efficiency. The goal has been to produce a cost effective test that predicts the genetic potential of a calf to gain weight on a given set of feed resources and the quality of the product at the end of the feeding period. This approach is sometimes referred to as "marker-assisted management." A number of studies have reported associations between genetic markers and production traits (Snelling et al. 2011). However, the ability of genetic markers to predict performance is often reduced when marker-trait relationships are developed in one population and are then applied in a population that is not closely genetically related (Lindholm-Perry et al., 2011). This loss in relationship between markers and traits has resulted in an effort to identify the mutations that lead to differential expression of traits. Initial approaches have been through fine mapping; however, advances in technology have led to an approach that involves sequencing large segments of the genome.

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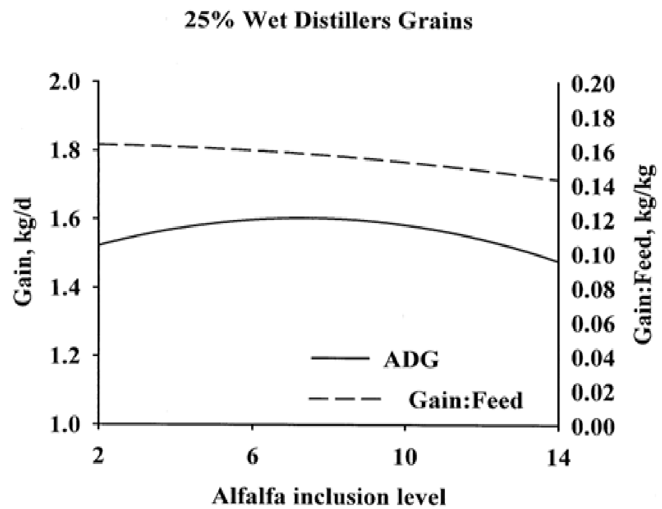

Figure 1. Relationship of inclusion of alfalfa hay and ADG and G:F in a dry-rolled corn-based finishing diet with 25% wet distillers grains and solubles.

Research Update: Kansas State University

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A novel systematic approach to evaluate cattle health and well-being in commercial feedlots. *D.J. Rezac[1], D.U. Thomson[1], F.L. Prouty[2], J.B. Osterstock[2], C.D. Reinhardt[1]. [1]Kansas State University; [2]Pfizer Animal Health.* To evaluate the prevalence and performance affiliation of tissue anomalies, individual carcass and lesion data were collected on 19,229 feeder cattle from 6 commercial feedlots in Kansas and Texas at 2 commercial packing plants in Kansas and Texas from July 2011 through July 2012. Individual pre-harvest health data was also collected on 13,226 head. Data collection methods utilized automated data capture and carcass tracking systems already in place within commercial packing plants. Data captured included HCW, DP%, REA, 12th rib fat thickness, marbling score, quality grade, and yield grade. Individual pre-harvest records included initial weight, sex, days on feed, ADG, and health treatment history. Lesion scoring data included lung lesions (Normal, mild, or severe), liver lesions (0, A-, A0, or A+), and rumen lesions (Normal, mild, or severe). Associations between lesions and outcomes of interest were modeled utilizing Mixed Models (PROC GLIMMIX of SAS, Cary, NC) for each outcome. Comparison of univariate models were used to monitor for confounding among covariates. Covariates of interest where forced into the multivariable model in a stepwise fashion and Bayesian Information Criteria monitored to achieve the best model fit. G-Side random effects included feedyard, feedyard Lot, and Kill Lot; covariates included lesions, initial weight, days on feed, hot carcass weight, sex, metaphylaxsis, BRD treatment, sort group, and initial month placed on feed. Thirty-two percent of lungs had lesions, 9.8% were severe; 20.6% of livers had abscesses, 4.6% were severe; 32% of rumens had lesions, 14% were severe. All comparisons were made vs. normal. Severe rumen lesions were associated ($P<0.05$) with -4.7 lb HCW; mild lesions were associated (P<0.05) with +1.3 lb HCW. Mild and moderate liver abscesses were not associated ($P>0.05$) with changes in HCW, but severe abscesses were associated ($P<0.05$) with -20.0 lb HCW. Severe lung lesions were associated ($P<0.05$) with -13.6 HCW but mild lesions were associated ($P<0.05$) with +1.3 lb HCW.

Implementation of an industry-oriented animal welfare and quality assurance assessment tool in commercial feedlots. *Tera J. Rooney, Daniel U. Thomson, Dan Frese, Shane B. Terrell, D.J. Rezac, Abby C. Jones, and Chris D. Reinhardt, Kansas State University.* Consumer interest in production agriculture has prompted the beef industry to develop tools to increase the accountability and transparency of management practices within the industry. The purpose of this project was to demonstrate the implementation of an industry-oriented animal welfare assessment, while recording data to shed light on current practices within the commercial cattle feeding industry. The NCBA BQA Animal Welfare Self-Assessment Guide was used to objectively evaluate animal handling, antibiotic residue avoidance, cattle comfort, and food safety in 56 commercial feedyards throughout Kansas. The average one-time feeding capacity was 35,455 animals (3,000 to 135,000 animals), representing a total one-time capacity of 1,985,500 animals, or roughly 85% of the one-time cattle feeding capacity of all feedyards in Kansas. The following areas were evaluated and assessed: documentation of 18 best management practices, animal housing, care, and processing facilities, and cattle handling practices. Ten randomly selected pens within each feedyard were inspected for cattle comfort, water tank cleanliness, and feed quality. To evaluate animal handling, processing procedures were observed on a minimum of 100 animals within each feedyard for usage of driving aides, incidences of cattle falling, tripping, vocalizing, or jumping, and accuracy of restraint. All feedyards passed the facilities and cattle comfort portion of the assessment; 98% of pens had acceptable stocking density, mud scores, and feed bunk evaluation, and 83% of all pens had acceptable water tanks with 17% of pens considered unacceptable due to presence of algae or debris accumulation. All feedyards were considered acceptable with respect to cattle handling procedures; a driving aide was required for 3.98% of all cattle observed (benchmark = 10%), 0.2% of cattle fell while exiting the chute (benchmark = 5%); 1.8% of cattle tripped while exiting the chute (benchmark = 10%); 0.9% of cattle vocalized while in the chute before a procedure was performed (benchmark = 5%); 5.9% of cattle jumped when exiting the chute (benchmark = 25%); and 0.2% of cattle were improperly restrained before processing (benchmark = 0%). Seventy-eight percent of feedyards passed all areas assessed; however, only 34% of feedyards maintained complete and current documentation of the 18 best management practices required. Commercial feedyards in Kansas do an excellent job in maintaining cattle comfort and welfare; however, documentation of best management practices is an area which requires additional focus.

Comparison of gamithromycin, tilmicosin, and tulathromysin for control of bovine respiratory disease in feedlot and pasture cattle. *T. Miller[1], D.U. Thomson[1], M. Hubbert[2], and C.D. Reinhardt[1]. [1]Kansas State University; [2]New Mexico State University.* Bovine Respiratory Disease (BRD) continues to be one of the largest animal health concerns in the cattle industry. BRD is a multifaceted group of pathogens, both viral and bacterial, that take advantage of an immune compromised calf to cause disease. This study compared metaphylactic treatments for BRD in both the feedlot and pasture setting. In the feedlot study, heifers (n=579, 403.7 ± 27.4 lbs) from Southwest Texas were identified as being at high risk for BRD and shipped to the Clayton Livestock Research Center in Clayton, NM. Cattle were randomly allocated within truck load lots into 20-head treatment pens (n = 30 pens; 3 treatments; 10 pens per treatment). Cattle were given 1 of 3 metaphylactic treatments based on the randomly assigned treatment for their pen within a replicate: 1) Gamithromycin (6.0 mg/kg), 2) Tilmicosin (13.3 mg/kg), and 3) Tulathromycin (2.5 mg/kg). Cattle were fed a starter diet for the first 56-60 d with a step-up ration change at day 28. At the end of the 60-d feeding period, cattle were weighed. Cattle administered tulathromycin had higher ADG than cattle administered gamithromycin ($P<0.05$) and tended ($P=0.09$) have higher ADG than cattle that received tilmicosin. Tulathromycin-treated cattle tended ($P = 0.12$) to have improved F:G compared to gamithromycin-treated cattle. Cattle that received tulathromycin (5.2%) had lower morbidity rates ($P < 0.05$) than those which received tilmicosin (14.6%) or gamithromycin (12.79%). There were no treatment differences in dry matter intake or mortality. For the wheat pasture study, heifers (n=120, 393.2 ± 28.6 lbs) from the same origin and risk as the feedlot study were processed and trailed to a nearby wheat pasture. Cattle were randomly assigned the same treatments as the feedlot study (3 treatments, 40 animals per treatment). Cattle were allowed to graze on wheat for 54 days with free-choice mineral mixed with lasalocid. The cattle were trailed back to the CLRC facilities and final individual weights were recorded. No differences were identified for ADG ($P=0.98$), morbidity ($P=0.46$) or mortality ($P=0.36$) among the three treatment groups.

Comparison of gamithromycin and tulathromycin for control and treatment of BRD in high-risk calves in commercial feedlots. *S. Torres[1], D.U. Thomson[1], B. Nosky[2], and C.D. Reinhardt[1]. [1] Kansas State University; [2] Merial, Ltd.* To compare the efficacy of gamithromycin with that of tulathromycin for control of undifferentiated bovine respiratory disease complex (BRDC) in feedlot calves, 2,529 weaned crossbred beef calves at 2 commercial feedlots at risk of developing BRDC were administered a single dose of either gamithromycin (6.0 mg/kg, SC; n = 1,263) or tulathromycin (2.5 mg/kg, SC; 1,266) metaphylactically. Health (BRDC morbidity, mortality, case-fatality, and retreatment rates) and performance (ADG, DMI, and F:G) outcomes were compared. Bioequivalence limits for gamithromycin and tulathromycin were established for outcomes for which no significant difference between treatments was detected. Morbidity rate (31.0%) for calves administered gamithromycin was greater than that (22.9%; $P = 0.03$) for calves administered tulathromycin, otherwise health and performance did not differ between treatments. To evaluate the clinical efficacy of the same drugs for the treatment of BRDC in feedlot calves under field conditions, 1,049 calves in six feedlots diagnosed with BRDC were randomly assigned to the same 2 treatments as the control study. Fatality rate, re-treatment rate, average daily gain (ADG), and body weight during 120 days post-enrollment were evaluated; in addition, two sites evaluated clinical scores during 10 days after treatment to determine comparative recovery rates. Re-treatment rate was higher among animals treated with gamithromycin (17.7± 7%) compared with those treated with tulathromycin (9.0±4%). Treatments were bioequivalent ($P < 0.05$) for case fatality rate, and performance (final BW and ADG). Clinical scores during 10 days post-treatment were not significantly different ($P = 0.97$) between treatments. When used for either control or treatment of BRDC, gamithromycin had greater percent pulled for subsequent treatment, but gamithromycin and tulathromycin had similar case fatality rate, mortality, ADG, and final BW. Based on the limits established for this dataset, gamithromycin is considered bioequivalent to tulathromycin.

A survey to describe current feeder calf health and well-being program recommendations made by feedlot veterinary consultants in the United States and Canada. *S.P. Terrell, D.U. Thomson, and C.D. Reinhardt, Kansas State University.* Consulting veterinarians (CV; n=23) representing 11,295,000 head of cattle on feed in the United States and Canada participated in a beef cattle health and well-being recommendation survey. Veterinarians were directed to an online survey to answer feeder cattle husbandry, health and preventative medicine recommendation questions. The CV visited their feedyards 1.7 times per month. All CV train employees on cattle handling and pen riding; only 13% of CV speak Spanish. All CV recommend IBR and BVD vaccination for high-risk (HR) calves at processing; other vaccines were not recommended as frequently by CV. Autogenous bacterins were recommended by 39.1% CV for HR cattle. Metaphylaxis and feed-grade antibiotics were recommended by 95% and 52% of CV, respectively, for HR calves. Banding was recommended with increasing frequency vs. surgical castration for calves with increasing calf body weight. The CV recommended starting HR calves in smaller pens (103 hd/pen) and allowing 13 inches/hd of bunk space. The CV indicated feedlots need to employ one feedlot doctor per 7,083 hd of HR calves and one pen rider per 2,739 hd of HR calves. Ancillary therapy for treating respiratory disease was recommended by 47.8% of CV. Vitamin C was recommended (30.4%) twice as often as any other ancillary therapy. Cattle health risk on arrival, weather patterns and labor availability were the most important factors in predicting feedlot morbidity while metaphylactic antibiotic, therapy antibiotic and brand of vaccine were the least important.

Effects of delayed implanting on feeder cattle health, performance, and carcass quality. *R.D. Munson, D.U. Thomson, D.J. Rezac, and C.D. Reinhardt, Kansas State University*. High-risk feeder calves (n=1,601; 603± 10.5 lb.) were used to examine the effects of delayed administration of the initial steroid implant on health, performance, and carcass characteristics of feedlot cattle. Control steers received a steroid implant (Revalor-XS, 20 mg estradiol and 200 mg trenbolone acetate) as part of normal processing procedures following arrival at the feedyard, and the Delayed Implant group received the same implant at 45 DOF. Delaying the initial implant reduced the percentage of railers (1.8 vs. 3.3%; P = 0.02) and tended to decrease percentage morbidity (24.7 vs. 28.5%; P=0.13), carcass weight (842 vs. 853 lb; P=0.20), and average yield grade (2.10 vs. 2.24; P=0.16). There was little health advantage to delaying the initial implant, and delaying the implant 45 days, even in high risk cattle, could be detrimental to performance and economics.

Comparison of the effects of three different dehorning techniques on behavior and wound healing in feeder cattle in a Western Kansas feedlot. *C.D. Neely[1], D.U. Thomson[1], C.A. Kerr[2], and C.D. Reinhardt[1], [1]Kansas State University; [2]Dodge City Veterinary Clinic, Dodge City, KS.* Cross-bred horned steers and heifers (n = 40; 686 ± 10.3 lb) were used to determine the effect of dehorning methods on pain, cattle behavior, and wound healing. Cattle were blocked by weight and sex and randomly assigned to 1 of 4 treatments: 1) control (CON); 2) banded using high tension elastic rubber (BAND); 3) mechanically removed (MECH); or 4) tipped (TIP). Vocalization and behavior were recorded during the dehorning process. Scores for wound healing, attitude, gait and posture, appetite, and lying were recorded daily. Data were analyzed using the Wilcoxon Rank Sum and mixed model procedures (SAS, Cary, NC). Vocalization scores were highest for MECH cattle and BAND cattle vocalized more than TIP and CON ($P < 0.05$). Attitude, appetite, gait and posture, and lying scores ($P < 0.10$) were higher for BAND cattle across all days following processing compared to MECH, TIP and CON. Wound healing scores (horn bud and bleeding) were greater for BAND cattle than MECH, TIP and CON cattle ($P < 0.05$) 21 days after processing. These data indicate that MECH is a painful procedure for cattle at the time of the procedure, but also that banding adversely affects behavior for an extended period after processing; banding to remove horns from cattle is not recommended based on the data and observations from this study.

Effects of diet energy density on performance and morbidity of newly received beef heifers. *C.J. Redding[1], D. U. Thomson[1], J. S. Schutz[2], S.J. Bartle[1], C. D. Reinhardt[1], and M. E. Hubbert[2]. [1] Kansas State University; [2]New Mexico State University*. Lightweight heifers (n=120; 447± 26.0 lb) were randomly assigned to 1 of 2 treatments and were fed for 56 days. Treatments consisted of either a (1) low starch diet (15% steam flaked corn, SFC) or a (2) moderate starch diet (30% SFC). A 74:26 blend of wet corn gluten feed and dried distillers was included at either 65% or 50% of the low and moderate starch diets, respectively. There were no differences in 56-day body weight, ADG, dry matter intake or feed efficiency across treatments ($P \geq 0.35$). The moderate starch group tended ($P = 0.09$) to have higher dry matter intake in the first 28-day period, but this did not persist through the end of the trial. Additionally, there were no differences observed between treatments for percentage of calves never pulled, pulled once, and pulled twice or more ($P \geq 0.74$). These data suggest that newly received feedlot calves respond similarly to either 15% or 30% SFC diets and increasing the level of SFC to 30% neither compromised nor enhanced the productivity of these calves.

Perception of lameness management, education, and animal welfare implications in the feedlot from consulting nutritionists, veterinarians, and feedlot managers. *S. P. Terrell[1], D. U. Thomson[1], C. D. Reinhardt[1], M. D. Apley[1], K. Stackhouse-Lawson[2]. [1]Kansas State University; [2]National Cattlemen's Beef Association.* The purpose of this survey was to describe perceptions of lameness within the feedlot industry. Consulting nutritionists (CN; n=37), consulting veterinarians (CV; n=47) and feedlot managers (YM; n=63) from the US and Canada participated in the survey. The majority of the participants (98.4%) either manage or consult open air/dirt floor feedyard facilities. Participants were directed to an online survey to answer questions pertaining to management, incidence, perception, and economic impact of lameness. The median response for an estimate of lameness incidence in the feedyard was 2%, with a mode of 1%. Forty-one percent of participants believed that ≥ 50% of feedyard cattle suffering from lameness require treatment. Eighty-one percent estimated the contribution of lameness to total feedyard mortality to be less than 10%. In comparison, 46% of participants estimated the contribution of lameness to the overall chronic/realizer loss in the feedyard to be ≥ 10%. Footrot was measured as the most common cause of lameness by 42% of participants; compared to 35% who considered injury the most common cause. Lameness was considered a welfare concern by 58% of participants, a growing concern by 20% of participants, and not a welfare concern by 22% of participants.

Restricted nutrient intake does not alter serum-mediated measures of implant response in cell culture. *C.D. Reinhardt, T.L. Lee, D.U. Thomson, L.K. Mamedova, and B.J. Bradford. Kansas State University.* Sixteen crossbred steers (293 ± 19.3 kg) were used to evaluate the impact anabolic implants may have on animals in either an adequate or a restricted nutritional state. Steers were trained to individual Calan gates, and then randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement. Treatments consisted of the following: administration or absence of an anabolic growth implant (Revalor-XS, 200 mg TBA and 40 mg estradiol; IMPLANT or CONTROL) and either 2.0 × or 1.0 × maintenance energy (NEM) requirements of a moderate energy, pelleted, starting cattle diet (HIGH or LOW). Animals were weighed on d 0, 14, and 28 of the trial, and total gain, ADG, and feed efficiency were determined for each time point. Blood samples were drawn for each animal at d 0, 14, and 28 of the trial and used to determine serum IGF-1 and plasma urea nitrogen (PUN). Serum (d 0, 14, and 28) was also used for application to satellite cells (previously isolated from a non-study steer and frozen). After treatment with the serum (20% of total media) from the trial cattle, the satellite cells were incubated for 72 hours. Protein abundance of myosin heavy chain (MHC; d 0, 14, and 28), phosphorylated extracellular signal-related kinase (pERK; d 0 and 28), and phosphorylated mammalian target of rapamycin (pmTOR; d 0 and 28) were analyzed to determine the effects of implant, intake, and their interaction (applied via the serum). There was a diet × intake interaction for DMI ($P < 0.01$) and a tendancy ($P \leq 0.10$) for an interaction for d 14 ADG and d 14 G:F; however, there were no interactions ($P \geq 0.38$) for ADG or G:F through d 28. Cattle on the HIGH intake level had greater ($P = 0.05$) IGF-1 concentrations across days and had greater ($P = 0.04$) PUN concentrations on d 28, but implant status did not affect either PUN or IGF-1 ($P \geq 0.55$). Intake had no effect on MHC ($P = 0.82$) but IMPLANT increased ($P < 0.01$) MHC abundance vs. CONTROL across days. Implant status, intake status, and the interaction had no effect on the abundance of pERK ($P \geq 0.41$). Implanting increased pmTOR ($P < 0.01$) but there was no effect ($P \geq 0.44$) of intake or intake × implant. The nearly complete lack of interaction between implant and nutritional status indicates that the signaling molecules measured herein respond to implants and nutritional status independently.

Agreement between observational and necropsy-derived diagnosis for cause of death for cattle in a commercial beef feedlot. *D. Anspaugh[1], D.U. Thomson[1], B. Wileman[1], M. Apley[1], W. Taylor[2], T. Noffsinger[2], and C.D. Reinhardt[1]. [1] Kansas State University; [2] Production Animal Consulting, Oakley, KS.* This study was conducted during the months of June and July 2009 in a feedlot in Western Kansas. Mortalities (n=54) were brought to a designated necropsy area and data pertaining to location (home pen, hospital pen, chronic pen) was recorded. Feedlot health personnel were asked to record the cause of death based only on prior medical history and location where the animal was found. Study investigators, blinded to the pre-necropsy diagnoses, then conducted a thorough necropsy to determine the cause of death. The pre-necropsy and post-necropsy cause of death data were categorized into 7 categories for data analysis: 1) BRD, 2) AIP, 3) tracheal edema, 4) bloat, 5) traumatic injury/buller, 6) peritonitis, and 7) dystocia. A kappa test was performed to estimate the agreement between pre-necropsy and post-necropsy determined cause of death. The overall kappa value of agreement between pre-necropsy and post-necropsy determined cause of death was 0.6039 indicating a moderate level of agreement. However, there was 100% agreement between pre- and post- necropsy cause of death for BRD cases; therefore, a necropsy is not warranted on mortalities previously diagnosed and treated for BRD, especially those found in the hospital or chronic pens. Bloat also had an equal pre- and post-necropsy determined cause of death. All 5 of these animals were found in their home pens and did not have a medical history. This indicates that necropsy of bloat mortalities are not warranted. AIP was under-reported in pre-necropsy determined cause of death (n=12) compared to post-necropsy determined cause of death (n=15), suggesting that animals found in their home pen without symptoms of bloat or history of BRD treatment should receive a necropsy. The poor agreement between pre- and post-necropsy diagnosis for injured animals supporting the concept that for mortalities with a history of severe physical trauma necropsy is not only unwarranted but may also provide misleading evidence contrary to the obvious, primary lesion. Most feedyard mortalities can be accurately diagnosed without the time, expense, and risk of performing necropsy; however, some questionable mortalities should still be investigated.

Time of onset, location, and duration of lameness in beef cattle in a commercial feedyard. *T.M. Green[1], D.U. Thomson[1], B.W. Wileman[1], P.T. Guichon[2], and C.D. Reinhardt[1]; [1] Kansas State University; [2] Guichon Veterinary Services Inc., Okotoks, AB.* A total of 3,243 feedlot steers in a commercial feedlot were observed for lameness prior to processing, immediately following processing, and 1, 2, and 3 weeks post-processing. Calves were observed once weekly while in their respective home pens. Animals were recorded as lame based on the presence of an altered gait. During this study, approximately 90,000 steers were on feed across the entire feedyard. Performance data and medical history were collected through the pre-harvest sort date (approximately 100 DOF). Cattle history factors (age, health risk, region of origin, state of origin, month placed on feed) were included in the analysis as possible contributors to lameness. The proportion of cattle observed lame pre-processing was 1.6% and was less (P=0.02) than the proportion of cattle observed lame after processing (2.5%). Cattle that were lame during weeks 0 and 1 had numerically (P>0.15) lower ADG than sound cattle (3.25 vs. 3.60 lb/d), and cattle observed lame at any time tended (P=0.11) to have lower ADG than cattle that were not lame

(3.41 vs. 3.60 lb/d). Age, risk, region of origin, state of origin, month placed on feed were not significant in predicting prevalence of lameness (*P*>0.05). Of the 3,243 head observed, 0.15% had foot rot, 1.94% were bullers, 1.39% had musculoskeletal injuries, and 0.22% had arthritis. The majority of lameness appears to be associated with handling events; further study is needed to determine if these cases may be reduced by improving facilities or handling technique.

Figure 1. Effects of lung, liver, or rumen lesions on live animal feedlot ADG vs. “normal” animals (no lesions observed). Asterisk (*) indicates a significant (*P* < 0.05) difference (vs. “normal”) within a lesion type. n = 19,229 feeder cattle from 6 commercial feedlots in Kansas and Texas at 2 commercial packing plants in Kansas and Texas slaughtered between July, 2011 – July, 2012.

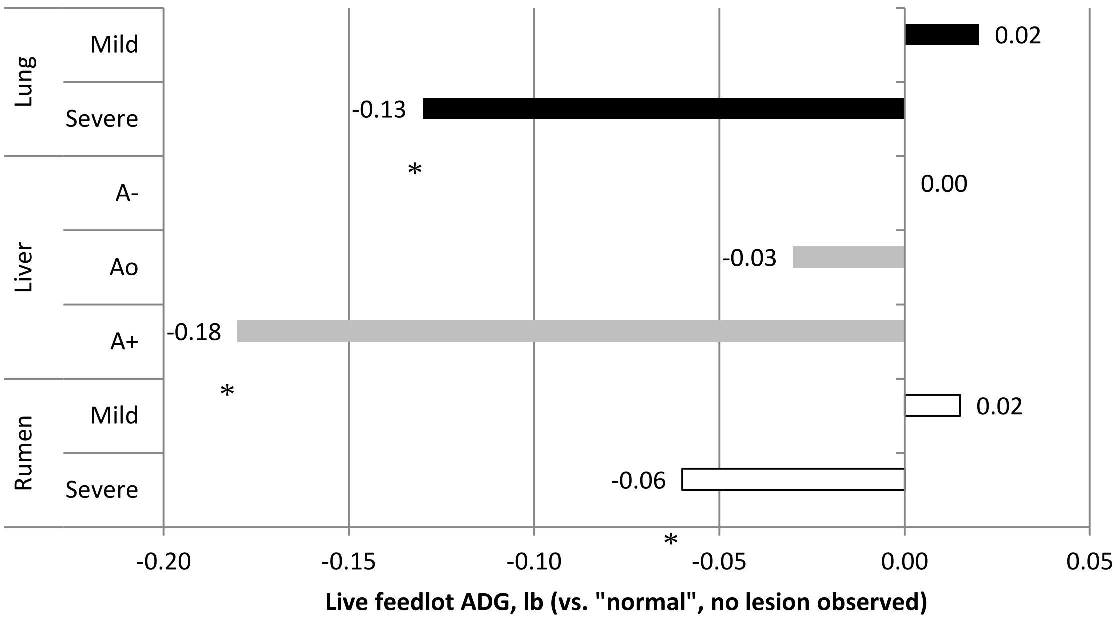


Table 1. Performance and health data for calves given gamithromycin, tilmicosin, or tulathromycin for control of bovine respiratory disease either in starting pens or on wheat pasture.

Treatment	Gamithromycin	Tilmicosin	Tulathromycin	P-value
Feeding pen study:				
n, Pens	10	10	10	
n, Head	190	190	190	
Initial wt, lb	405.1	402.7	403.5	0.73
Final wt, lb	540.1[b]	544.3[ab]	553.0[a]	0.10
DMI, lb	11.99	12.28	12.52	0.20
ADG, lb (deads out)	2.36[b]	2.48[ab]	2.62[a]	0.02
F:G (deads out)	5.10	5.01	4.82	0.27
Mortality, %	1.53	1.55	1.02	0.93
Morbidity, %	12.79[b]	14.62[b]	5.16[a]	0.02
Retreatment, %	1.50	2.56	0.00	0.16
Wheat pasture study:				
Initial wt, lb	392.7	390.6	395.9	0.72
Finalwt, lb	449.7	447.9	452.9	0.90
ADG, lb	1.06	1.08	1.07	0.98
Morbidity, %	12.50%	12.50%	5.13%	0.46
Mortality, %	12.50%	5.00%	5.13%	0.35

Table 2. Effect of gamithromycin vs. tulathromycin for control and for treatment of bovine respiratory disease on performance and health parameters of high-risk feedlot calves in commercial feedlots. Bioequivalence limit indicates the minimum required difference between compounds to conclude a difference for each variable.

Variable	Gamithromycin	Tulathromycin	SEM	Bioequiva-lence limits
Control study:				
Final body weight (lb)	1,165	1,166	13.9	± 20.9
ADG (lb/d)	2.64	2.64	0.022	± 0.22
Feed-to-gain	6.60	6.50	0.594	± 1.32
Retreatment rate (%)	41.5	39.5	4.20	± 10.0
Mortality rate (%)	4.2	3.5	1.7	± 3.5
Treatment study:				
Final BW (lb)	990	1,003	15.4	± 28.6
ADG, (lb/day)	3.34	3.45	0.132	± 0.22
Case fatality rate (%)	3.7	2.4	4.2	± 2.4
				P-value
Initial body weight (lb)	517	519	3.52	0.41
Init. rectal temp. (°F)	104.4	104.4	0.18	0.79
Days on feed at enrollment	3.6	3.7	0.7	0.52
Re-treatment (%)	17.7	9.0	6.7	< 0.01

Table 3. Ranking of seven factors utilized by consulting feedlot veterinarians to predict morbidity and mortality in feeder cattle in commercial feedyards (These items are listed in order of importance by mean and mode with 1 (most predictive) to 7 (least predictive)).

Item	Mean	Mode
Cattle health risk	1.32	1
Weather patterns	3.18	2
Amount and quality of labor	3.41	4
Receiving nutrition program	3.86	3
Class of antibiotic used for metaphylaxis	4.36	5
Class of Antibiotic used of treatment	5.64	6
Brand of Vaccine	6.23	7

Figure 2. Myosin heavy chain abundance in cultured myocytes. Myocytes from a non-study steer were treated with serum (20% of total media) from study steers drawn on d 0, 14, and 28, and myosin heavy chain abundance was measured. In chart A, steers were either implanted (gray bars) or not implanted (open bars) with a long-acting TBA:E_2 implant; in chart B, steers were fed a common diet at either 2.0 (HIGH; gray bars) or 1.0 (LOW; open bars) × maintenance NE requirements. (Effect of day P < 0.01; intake P = 0.82; implant P < 0.01; intake × implant P = 0.41; day × intake P = 0.75; day × implant P = 0.99; day × intake × implant P = 0.52; Error bars represent pooled SEM for treatment means = 0.086.)

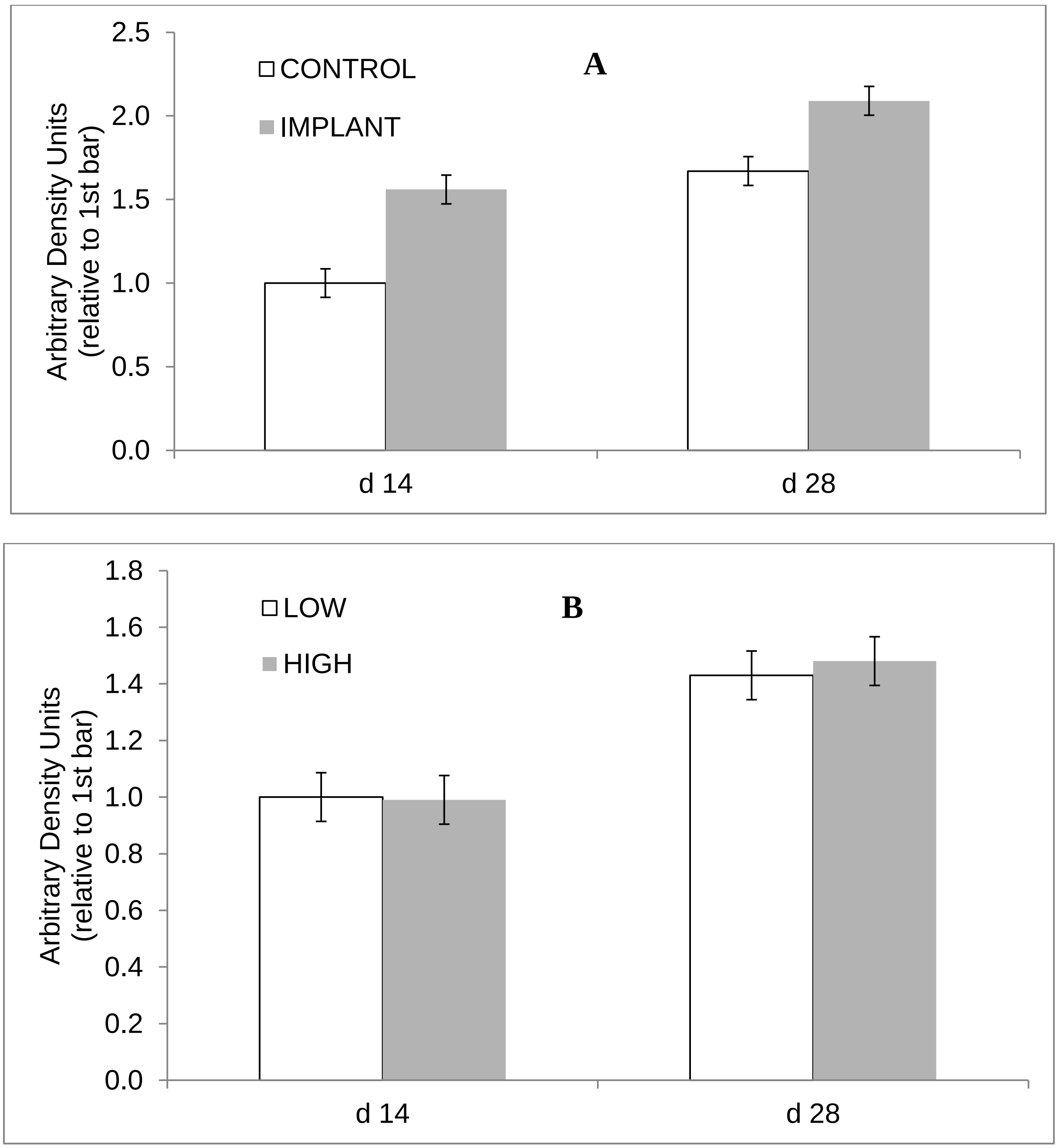


Figure 3. Agreement between identification of cause of death between personnel with only treatment records and location of mortality vs. personnel with only necropsy diagnosis by category. n = 54 mortalities within a single commercial feedyard in Kansas.

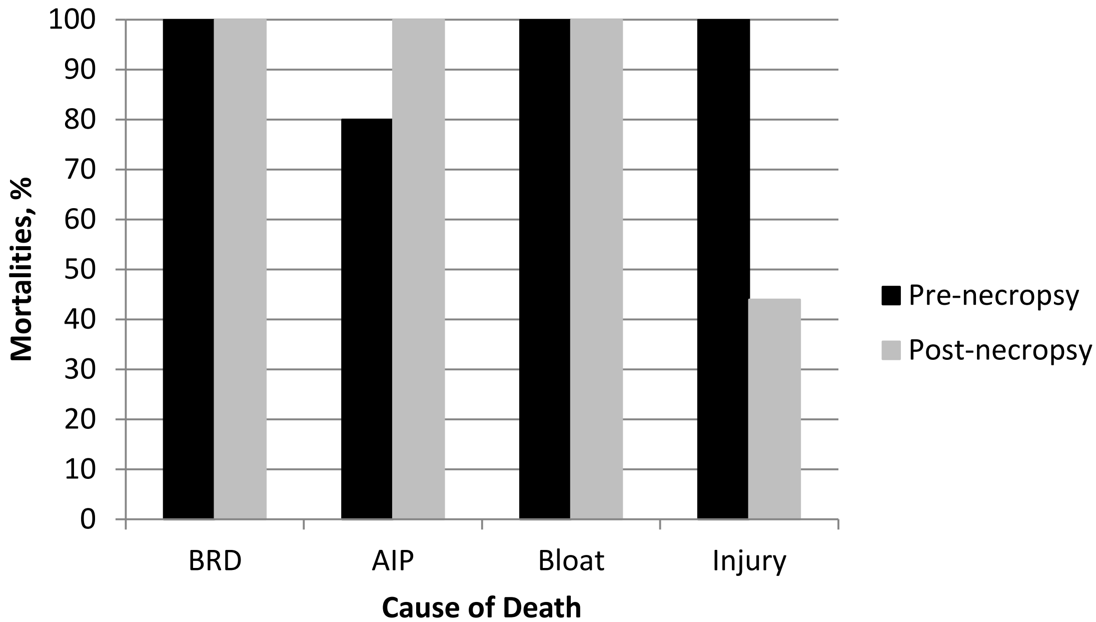


Table 4. Feedlot performance, health data, and carcass traits for steers at high relative risk for BRD that were implanted either immediately upon feedlot arrival (Arrival) or 45 days post-arrival (Delayed). n = 1,601 cattle fed in a commercial feedyard in Kansas.

	Arrival	Delayed	SEM	*P*-Value
Pens, n	10	10		
Animals, n	801	800		
Initial BW, lb	604	603	10.5	0.97
Final BW, lb	1,303	1,296	12.2	0.56
ADG, lb	3.17	3.09	0.59	0.56
DMI, lb	19.45	19.24	0.24	0.40
F:G	6.21	6.30	0.309	0.77
HCW, lb	853	842	8.0	0.20
Choice, %	42.8	44.1	3.00	0.67
Avg. Yield grade	2.24	2.10	0.098	0.16
Morbidity, %	28.5	24.7	2.35	0.13
Retreatment, %	9.4	8.2	1.18	0.31
Respiratory mortality, %	3.3	4.5	1.49	0.43
Pleural adhesions, %	20.1	21.3	2.45	0.63
Lung lesions, %	55.5	58.1	2.94	0.41

Figure 3. Effect of dehorning method (negative control (CON), high-tension banding (BAND), mechanical (MECH), tipping to 1” diameter (TIP)) on average depression score for the entire duration of the trial by treatment. Main effect of treatment, $P = 0.06$; a,b means without a common superscript differ ($P < 0.10$).

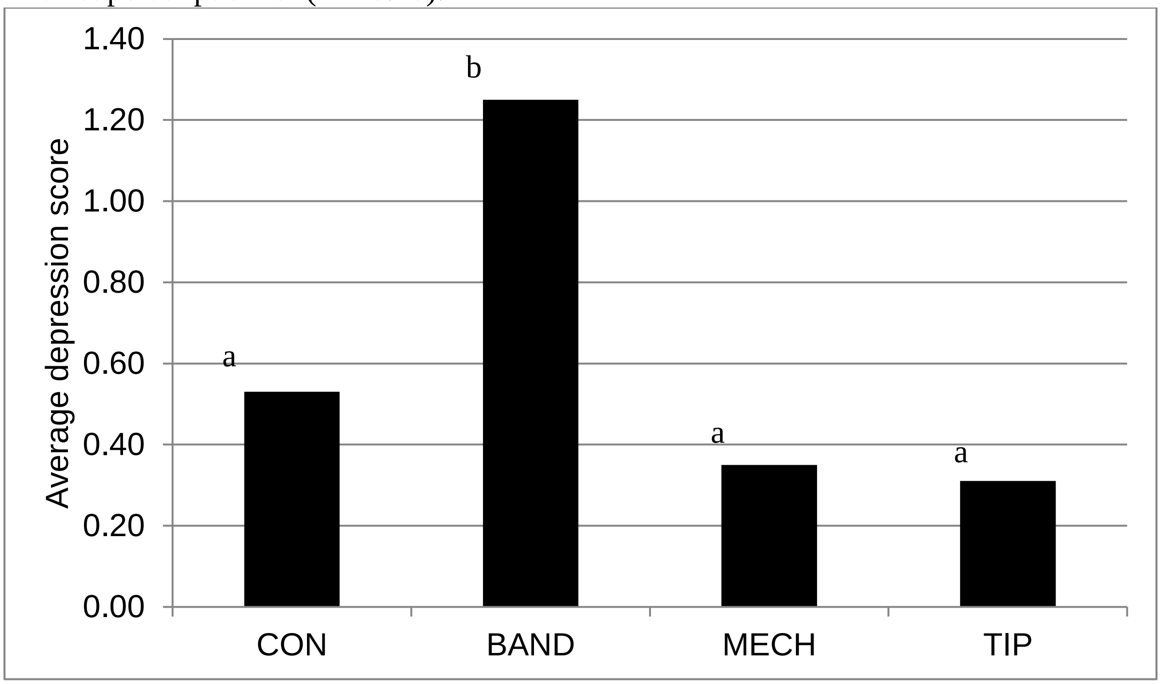
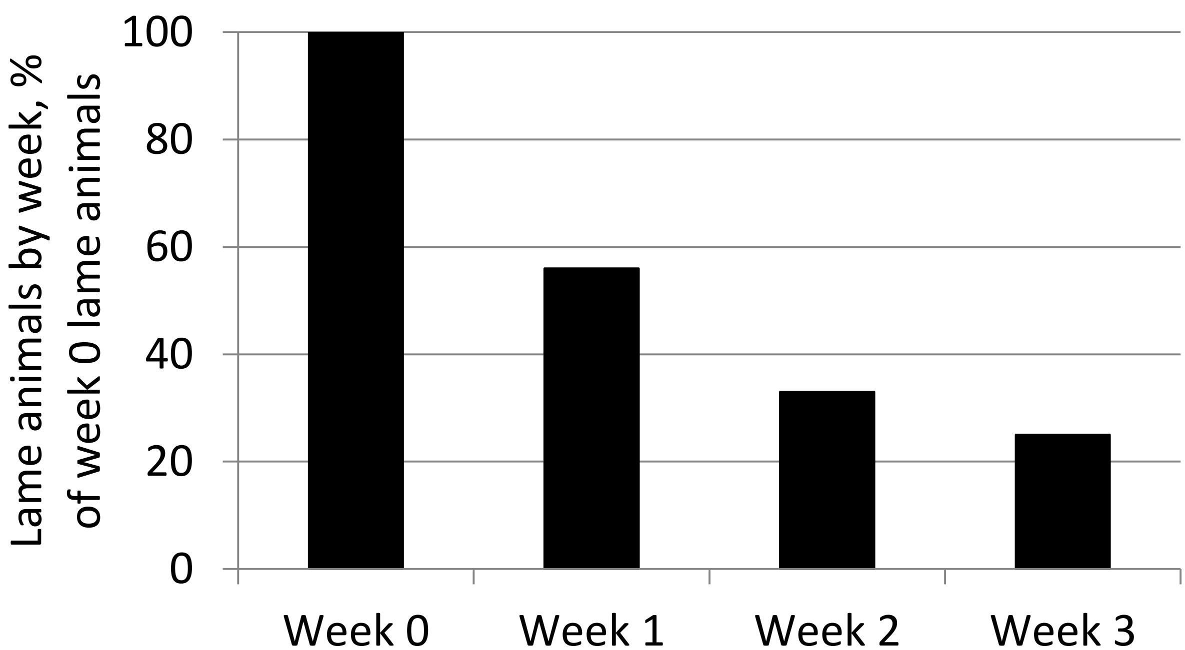


Figure 4. Number of animals observed to be lame, as a percentage of animals observed lame immediately post-processing, by number of weeks post-arrival. n = 3,243 total animals processed and n = 48 lame animals observed immediately post-processing during the summer of 2009 at a commercial feedlot in Nebraska.



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Graduate Student Research Presentations

Co-prilling flaxseed and dolomitic hydrate to decrease ruminal biohydrogenation of polyunsaturated fatty acids *C.A. Alvarado[1], D.O. Sousa[1], E. van Cleef[1], K.A. Miller[1], C.L. Van Bibber-Krueger[1], F. Scarpino[1], D. Klamfoth[2], and J.S. Drouillard[1], [1]Kansas State University, Manhattan, [2]Lhoist North America, Fort Worth, TX*

Three experiments were conducted to evaluate ruminal biohydrogenation of flaxseed embedded in matrices consisting of dolomitic lime hydrate or a blend of hydrate and dolomitic limestone. In Study 1, ground flaxseed (F) and a 50:50 flaxseed:dolomitic hydrate blend (H) were placed into Dacron bags (1 g in duplicate), sealed, suspended in the rumens of fistulated cattle for 16 hours, removed from the rumen, rinsed, and then dried to determine in situ disappearance. Six ruminally fistuled steers were used, 3 of which were fed a 50:50 forage:concentrate diet, and 3 of which were fed a 90:10 concentrate:forage diet. In study 2, steers (n=45, 557±40 lb) were blocked by weight and randomly assigned to individual pens and dietary treatments (15 replicates). Steers were fed for 14 d with a basal diet consisting of 30% corn gluten feed, 25% wheat straw, 25% prairie hay, 12.8% steam-flaked corn, and 3% linseed meal containing either no flaxseed (C); 2.79% ground flaxseed (F); or 8.13% of a flaxseed-dolomitic hydrate blend (H) to provide an amount of alpha-linolenic acid (ALA) equivalent to the F diet. Cattle were fed once daily *ad libitum* and DMI was determined each day. For study 2, heifers (n=40, 604±24 lb) were blocked by weight and allocated randomly to each of 4 diets (10 replicates). The basal diet consisted of 30% corn silage, 27% wet corn gluten feed, 22% steam-flaked corn, and 15% alfalfa hay with either no flaxseed (C); 1 lb/d ground flaxseed (F); 1 lb/d of a 50:50 flaxseed:dolomitic hydrate blend (H); or 1 lb/d of a 50:25:25 flaxseed:dolomitic hydrate:dolomitic carbonate blend (HC). On d 0 and 14 of each study, blood samples were collected, plasma was recovered by centrifugation, and concentrations of fatty acid methyl esters were determined by gas chromatography. In study 1, *in situ* dry matter disappearance was not affected by basal diet ($P >$ 0.05), but we observed greater resistance ($P < 0.05$) to ruminal degradation when flaxseed was encapsulated in a dolomitic hydrate matrix. In studies 2 and 3, plasma fatty acid profiles were similar among treatments on day 0 of each study. By day 14 of each study, plasma ALA concentrations remained low in C, but increased by d 14 for cattle fed all sources of flaxseed (P < 0.01). In study 2, plasma ALA was 2.4-fold greater for H than for F ($P < 0.01$, SEM: 1.69) after 14 d (16, 35, and 85 μg/mL for C, F, and H, respectively). In study 3, embedding flaxseed in dolomitic hydrate-carbonate or dolomitic hydrate matrices resulted in 195 and 339% greater assimilation of ALA, respectively, compared to ground flaxseed (11, 93, 96, and 153 μg/mL for C, F, H, and HC, respectively; $P < 0.01$). These studies indicate that matrices consisting of dolomitic hydrate or dolomitic hydrate and carbonate are effective barriers to ruminal biohydrogenation of unsaturated fats.

Components of this abstract were published previously:

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The effects of Bovamine® Defend^{TM} on prevalence and concentration of *Escherichia coli* O157:H7, non-O157 O types and *Salmonella* in finishing steers *S. N. Aragon[1], F. R. B Ribeiro[1], L. M. Guillen[1], R. A. McDonald[2], D. R. Ware[2], W. M. Kreikemeier[2], R. S. Swingle[3], M. M Brashears[1], G. H. Loneragan[1],and B. J. Johnson[1], [1]Texas Tech University, Lubbock, [2]Nutrition Physiology Company, LLC, Guymon, OK, [3]Cactus Operating, LLC, Amarillo, TX*
Two studies were conducted to determine the effects of Bovamine Defend supplementation as a pre-harvest intervention on performance, carcass characteristics, and prevalence and concentration of *E. coli* O157:H7, non-O175 O types, and *Salmonella* in finishing steers. Treatments were CON (placebo) and BD (Bovamine Defend). Exp.1: A small pen study where steers (n=112; initial BW=877 lb) were blocked by BW and allotted randomly to 28 pens (14 pens/treatment; 4 pens/block; 4 steers/pen) at Texas Tech University's Burnett Center and fed for 117 d. From each steer, rectal fecal samples were collected on d 117 and subiliac lymph node samples were taken at the plant. Exp. 2: A large pen study where steers (n=1800; initial BW=782 lb) were blocked by source and randomly assigned to 24 pens (12 pens/treatment; 75 steers/pen) at Cactus Research Feedyard and fed for 142 d. Fecal floor pads (n=600; 25 pads/pen) were collected on d 140 and subiliac lymph nodes (n=600; 25 samples/pen) were collected at the plant. For both studies, pen was the experimental unit in a randomized block design. Performance and carcass traits were analyzed using the MIXED and GLIMMIX procedures of SAS and microbial data were analyzed using a binomial response model. No significant differences in performance or carcass traits were observed in either study. In Exp. 2, fecal *E. coli* O157:H7 and lymph node *Salmonella* concentrations were reduced by 87% (P<0.03) and 90% (P<0.03), respectively. Fecal *E. coli* O157:H7 prevalence was reduced by 60% in Exp. 1 and 45% in Exp. 2 (P<0.10 and P=0.015, respectively). Prevalence of *Salmonella* in lymph nodes was reduced by 88% (P<0.05) and 25% (P=0.005) in Exp. 1 and Exp. 2, respectively. Prevalence of *E. coli* O26, O45, O103, and O121 in Exp. 2 were reduced by 53% (P=0.02), 41% (P=0.02), 35% (P=0.03) and 47% (P=0.02), respectively. Prevalence of *E. coli* O111 and O145 was too low in both treatments to calculate reduction. There were too few positive samples in Exp. 1 were to compare concentrations of *E. coli* O157:H7 and *Salmonella*, and the prevalence of non-O157 O types was very low. Overall, Bovamine Defend supplementation did not significantly affect performance or carcass characteristics but effectively reduced fecal *E. coli* O157:H7 and lymph node *Salmonella* concentrations and prevalence, and the prevalence of fecal *E. coli* non-O157 O types.
**Bovamine Defend and NPC are trademarks of Nutrition Physiology Co., LLC*
**Each package of Bovamine Defend contains a minimum of $2x10^{13}$ CFU of Propionibacterium freudenreichii and Lactobacillus acidophilus*

Effects of restricted versus conventional dietary adaptation over periods of 9 or 14 days on feedlot of Nellore cattle *R. S. Barducci[1], M. D. B. Arrigoni[1], C. L. Martins[1], São Paulo State University (UNESP), Botucatu, São Paulo, Brazil[1]*
One hundred and twenty, 24-mo-old Nellore bulls (361.3±30.2 kg) were fed in 24 pens for 84-d to determine effects of adaptation protocol and period length on feedlot performance, carcass traits, rumenitis incidence (RI), hepatic abscesses (HA) and rumen wall absorptive surface area (RASA) of Nellore cattle. The experiment was conducted at the Sao Paulo State University feedlot, Botucatu Campus, Brazil, using a completely randomized block design with a 2×2 factorial arrangement, replicated 6 times (5 bulls/pen). Factors include adaptation protocols, restricted finishing diet intake (REST) as a means of dietary adaptation compared with diets increasing in concentrate (STEP) over periods of either nine or 14 d. The STEP program

consisted of ad libitum feeding of 3 adaptation diets over periods of 9-d or 14-d with concentrate level increasing from 55% to 85% of diet DM. The REST program consisted of restricted intake of the finishing diet (85% concentrate) with programmed increases in feed offered until bulls reached ad libitum access over periods of 9-d or 14-d. After adaptation, one animal per pen was slaughtered for rumen papillae evaluations, RI and HA. The remaining 96 animals were harvested at 505 ± 36.4 kg of BW. Days of adaptation did not effect (P>0.05) feedlot performance, carcass traits, RI and HA. Adaptation protocol did not influence (P>0.05) final BW, ADG, carcass traits, RI and HA for the 84 d finishing phase. However, adaptation protocol influenced (P<0.05) 0-28 d DMI (STEP = 9.67 kg, REST = 9.01 kg); 0-28 d DMI, %BW (STEP = 2.52%, REST = 2.36%), and 0-56 d (STEP = 2.58%, REST = 2.47%); 0-84 d G:F ratio (STEP = 0.157, REST = 0.165); and 0-84 d cost to gain 1 kg of BW (STEP = US$1.91, REST = US$1.81). No interaction (P>0.05) between adaptation protocol and period length was observed for performance or carcass traits. REST had larger (P<0.05) mean papillae area (0.59 cm2 vs. 0.52 cm2) than STEP. Number of papillae per cm2 of rumen wall (NOP) interactions was observed (P<0.05) between adaptation period length and feeding phase. Rumen wall absorptive surface area (RASA) in cm2 interactions were observed (P<0.05) between adaptation period length and feeding phase and adaptation protocols and feeding phase. No differences (P > 0.05) in RASA and NOP were observed during the finishing phase; however, NOP was reduced (P < 0.05) for 9-d during the adaptation phase and RASA was reduced (P < 0.05) for STEP and 9-d during the adaptation phase. REST were more feed efficient and exhibited lower cost of gain than STEP, while a 9-d adaptation period did not negatively impact feedlot performance.

Effect of level and source of supplemental protein on rate of ruminal ammonia production and concentrations of amino acid-utilizing and trypticase-metabolizing bacteria in *Bos taurus* and *Bos indicus* steers fed low-quality forage *N. L. Bell[1], R. C. Anderson[2], S. L. Murray[1], J. C. McCann[1], K. K. Weldon[1], and T. A. Wickersham[1] , [1]Texas A&M University, College Station, [2]USDA/ARS, College Station*

Five ruminally cannulated *Bos taurus* (Bt, 303 ± 10 kg initial BW) and five ruminally cannulated *Bos indicus* (Bi, 323 ± 28 kg initial BW) steers were used to quantify differences in source and level of protein on rate of ammonia production and concentrations of amino acid-utilizing and trypticase-metabolizing bacteria in Bt and Bi cattle. *Bos taurus* and Bi steers were assigned to concurrent 5 × 5 Latin squares and fed low-quality forage (4.5% CP). Treatments were a 2 × 2 factorial plus a control: the first factor was level of protein 60 or 120 mg N/kg BW daily; and the second was source DIP (degradable intake protein; 72% DIP) or UIP (undegradable intake protein; 72% UIP). Rumen fluid was collected immediately after feeding and 4h later then processed according to standard laboratory protocols. There were no significant differences between breeds for any of the measured variables ($P \geq 0.21$). There was a main effect of protein supplementation on *in vitro* NH3–producing activity for both Bt ($P = 0.04$) and Bi ($P = 0.03$) steers. In both cases, rates of NH3 production were higher in steers fed 120 mg N/kg BW DIP (0.053 ± 0.02 and 0.048 ± 0.02 μmol NH3/mL per h, respectively) and lower in steers receiving 0 mg N/kg BW (0.031 ± 0.01 and 0.033 ± 0.01 μmol NH3/mL per h, respectively). For Bt steers there was a treatment × time interaction ($P = 0.04$) for most probable number (MPN) of amino acid-utilizing bacteria resulting from decreases in MPN from h 0 to 4 when DIP was supplied at both levels and increases for control and 60 mg N/kg BW UIP. More specifically, steers fed 60 or 120 mg N/kg BW DIP had decreased MPN with time after feeding (0 to 4 h; from 5.96 to 5.37 and 6.41 to 5.85 log10 cells/mL, respectively) versus steers fed 60 mg N/kg BW UIP which increased MPN from 5.74 to 6.07 log10 cells/mL and 120 mg N/kg BW UIP which decreased slightly from 6.0 to 5.8 log10 cells/mL. In Bi steers there was no effect of dietary treatment (*P* = 0.77) or time after feeding (*P* = 0.85) on MPN. There was a main effect of time after feeding on recoverable trypticase-metabolizing bacteria for both Bt ($P \leq 0.01$) and Bi ($P \leq 0.01$) with log10 CFU mL-1 being lower at 4 h after feeding (7.00 ± 0.77 and 7.12 ± 0.64) versus 0 h (7.51 ± 0.88 and 7.53 ± 0.86) for Bt and Bi, respectively. Results indicate that irrespective of breed, microbial N-metabolizing populations responded more rapidly to diets supplemented with DIP than UIP.

Comparison of NRC and industry dietary trace mineral standards for yearling feedlot steers *C.J. Berrett, J.J. Wagner, K.L. Neuhold, E. Caldera, and T.E. Engle, Colorado State University, Department of Animal Science, Fort Collins*
Effect of trace mineral (**TM**) concentration and source on yearling feedlot steer performance, carcass characteristics, and liver TM status, were determined utilizing 360 crossbred steers (initial BW=350 ± 4.0 kg). Steers were blocked by initial BW and randomly assigned to one of 4 treatments (10pens/treatment; 9 hd/pen). Treatments consisted of: 1) negative control (**NC**), no supplemental TM (basal diet contained 7.65 mg Cu/kg DM, 50.5 mg Zn/kg DM, 27.7 mg Mn/kg DM, and 0.12 mg Co/kg DM); 2) basal diet supplemented with 10 mg Cu/kg DM from $CuSO_4$, 30 mg Zn/kg DM from $ZnSO_4$, 20 mg Mn/kg DM from $MnSO_4$, 0.50 mg I/kg DM from EDDI, 0.10 mg Se/kg DM from Na_2O_3Se, and 0.10 mg Co/kg DM from $CoCO_3$ (**NRC**); 3) basal diet supplemented with inorganic forms of Cu, Zn, Mn, EDDI, Se and Co at consulting nutritionist recommendations (**CNI**, 20, 100, 50, 0.50, 0.20, and 0.20 mg of mineral/kg DM, respectively); and 4) basal diet supplemented with 66.6% inorganic and 33.4% organic Cu, Zn, Mn and Co, and inorganic forms of I and Se at iso-concentration to consulting nutritionist recommendations of treatment 3 (**CNO**). All steers were fed a high concentrate steam-flaked corn-based diet for 154 d. Steers were individually weighed on d -1, 0, 35, 121, 153, and 154. Continuous data were analyzed on a pen mean basis using a mixed model appropriate for a randomized block design (fixed effects = treatment and time; random effect = replicate). Categorical data were analyzed utilizing GLIMMIX (fixed effect = treatment; random effect = replicate). Initial and final BW, ADG, DMI, F:G and G:F ratios and calculated net energy recoveries were similar ($P > 0.23$) across treatments. Subcutaneous adipose tissue depth, HCW, KPH, yield grade, marbling score, and quality grade were similar across treatments ($P > 0.17$). Final liver Zn, Mn, Se, and Co concentrations were similar across treatments ($P > 0.37$). Under the conditions of this experiment, it appears that basal dietary concentrations of Cu, Zn, Mn, and Co were adequate for growth and performance of finishing yearling feedlot steers.

Corn Silage: New Thoughts on an Old Ingredient *D. B. Burken, B. L. Nuttelman, J. L. Harding, T. C. Hoegemeyer, T. J. Klopfenstein, and G. E. Erickson, Univ. of Nebraska, Lincoln*
The use of corn silage in beef finishing diets has been shown to be economical in times of high priced corn. Whole corn plant samples were collected from a commercial grain yield research plot to evaluate corn hybrid (season length), plant density, and harvest time effects on whole corn plant quality and yield. There were interactions ($P \leq 0.001$) between hybrid, plant density, and harvest time for variables tested; however interactions were ignored due to replication and for data interpretation clarity. There was a quadratic response to harvest time for DM yield and TDN yield per acre ($P \leq 0.01$), with yield increasing between first two harvest dates and then decreasing thereafter. There was a quadratic increase for DM yield ($P \leq 0.01$) with increased plant density. There was an increase in DM yield ($P \leq 0.01$) for longer season in comparison to

shorter season hybrids. Data from this experiment illustrate that corn hybrid, plant density, and harvest time affect corn silage yield and quality characteristics. A finishing experiment evaluated substitution of corn with corn silage in diets with modified distillers grains with solubles (MDGS). Steers (n=324; BW=714 ± 37 lb) were separated into two BW blocks and assigned randomly to one of 36 pens (9 steers/pen). Dietary treatments fed were 15, 30, 45, or 55% corn silage in diets with 40% MDGS. Two other treatments were tested with 30% corn silage and 65% MDGS and 45% corn silage and 0% MDGS. All steers were on feed for 173 days. Performance measures were calculated from HCW adjusted to a common dressing percentage (63%). As corn silage inclusion increased in diets containing 40% MDGS, DMI and ADG (4.04 and 3.53 lb for steers consuming 15% and 55% corn silage, respectively) linearly decreased ($P < 0.05$), which equated to a linear decrease in F:G ($P < 0.01$) with the steers on the 15% corn silage treatment being 1.5%, 5.0%, and 7.7% more efficient than steers on treatments containing 30%, 45%, and 55% corn silage, respectively. Cattle fed 45% corn silage with 40% MDGS instead of 0% MDGS had increased DMI and ADG ($P < 0.05$) with no difference in F:G ($P = 0.30$). For steers fed 30% dietary corn silage, the addition of 65% MDGS (compared to 40% MDGS) resulted in decreases in DMI and ADG ($P < 0.01$) with no difference in F:G ($P = 0.12$). Dressing percentage, HCW, 12th rib fat, and calculated YG decreased linearly ($P < 0.01$) with increasing corn silage inclusion in diets containing 40% MDGS. Even with modest performance depressions and the assumption of additional DOF for cattle fed elevated levels of corn silage, there is an economic incentive to feeding higher levels of corn silage in diets containing MDGS.

Effect of zinc concentration and source on performance and carcass characteristics of feedlot steers *E. Caldera, J. J. Wagner K. L. Neuhold, G. I. Zanton, K. Sellins, and T. E. Engle, Colorado State University, Department of Animal Sciences, Fort Collins*
Three-hundred and sixty cross-bred steers (348.1 kg ± 28.9) were utilized to investigate the effects of zinc (Zn) concentration on performance and carcass characteristics of feedlot steers. Steers were blocked by weight and randomly assigned to one of the 5 supplemental Zn treatments (8 pens per treatment; 9 steers per pen). Treatments consisted of: 1) **Control-50 (CON-50**; 50 mg of supplemental Zn/kg DM from $ZnSO_4$); 2) **Methionine control** [**MetCON-50**; 50 mg of supplemental Zn/kg DM from $ZnSO_4$ plus MHA to equalize HMTBa concentrations across treatments; 3**) Organic-50 (ORG-50;** Control diet supplemented with 50 mg of Zn/kg DM from Mintrex Zn plus MHA to equalize HMTBa intake across treatments); 4) **Organic-100** (**ORG-100**; Control diet supplemented with 100 mg of Zn/kg DM from MINTREX Zn plus MHA to equalize HMTBa intake across treatments 2-5); and 5) **Organic-150** (**ORG-150**; Control diet supplemented with 150 mg of Zn/kg DM from Mintrex Zn). All steers were fed a typical high concentrate steam-flaked corn based finishing diet twice daily. Steers were individually weighed on d −1, 0, 144, and 145 and pen weighed on d 28, 56, 84, and 111. Ractopamine HCl was fed for the final 29 d of the finishing period to all treatments. On d 145, all steers were transported to a commercial abattoir for slaughter. Initial and final body weights, overall ADG, DMI, and feed efficiency (g/f), were similar across treatments. Fat thickness, internal fat, hot carcass weight, KPH, marbling score, and dressing percentage were similar across treatments. Steers receiving ORG-150 had a greater ($P < 0.03$) yield grade compared to steers receiving ORG-50 (2.99 vs. 2.76 ± 0.08; respectively). Steers receiving 1080 Zn also had greater ($P < 0.01$) yield grades compared to steers receiving ORG-100 (2.99 vs. 2.68 ± 0.08; respectively). There was a trend ($P < 0.07$) for steers receiving MetCON to have a greater yield grade compared to CON-50 (2.82 vs. 2.67 ± 0.08; respectively). In addition, liver biopsies

and blood samples were analyzed for Zn, Cu, and Fe concentrations. Blood samples were also analyzed for alkaline phosphatase activity. Initial liver biopsy Cu and Fe concentrations were similar across treatments. Whereas, the Zn concentrations were greater ($P < 0.01$) in the CON-50 group compared to the Methionine treatment group (218.7 vs. 170.2 ± 12.9). Day 111 liver Zn concentrations tended ($P < 0.05$) to be lower for CON-50 and MetCON-50 treatments compared to ORG-50 treatment, while no other differences were noted among treatments (117.8, 123.7 vs. 158.0 ± 16.1). Initial and final plasma concentrations of Zn, Cu, and Fe and alkaline phosphatase activity were similar across treatments. These data indicate that under conditions of this trial, increasing Zn concentration in the diet above NRC recommendations has little impact on performance, however, may impact lipid partitioning in steers.

Effect of urea inclusion in diets containing dried distillers grains on total tract digestibility and ruminal fermentation in feedlot cattle *I. Ceconi[1], M. Ruiz-Moreno[2], A. DiCostanzo[1], and G. I. Crawford[1], [1]University of Minnesota, Saint Paul, [2]University of Florida, Marianna*
A high proportion of CP in distillers grains (DG) is undegradable in de rumen. Therefore, addition of degradable intake protein (DIP) to feedlot rations containing DG may be beneficial. An experiment was conducted to evaluate the effect of DIP supplementation in feedlot cattle finishing diets on total tract digestibility and ruminal fermentation. Four ruminally cannulated Holstein steers (765 ± 40 lb initial BW) were assigned randomly to a duplicated 2 x 2 Latin square design. Each period consisted of a 16-d adaptation and a 5-d collection phase. Steers were fed *ad libitum* once daily one of two dietary treatments containing (DM basis) 52% dry-rolled corn, 20% dried corn DG with solubles, 12% high-moisture corn, 10% ryegrass haylage, mineral-vitamin supplement, and 0% (CON) or 0.6% (U) urea. Energy, CP, and DIP concentrations were 0.60 or 0.59 Mcal NEg/lb, 14 or 15.6%, and 6.4 or 8.0% for CON or U, respectively. Steers were intra-ruminally dosed every 12 h with 7.5 g of chromic oxide from d 11 to 21 and fecal grab samples collected from d 17 to 21 to determine OM digestibility. Ruminal VFA and ammonia-N (NH_3-N) concentrations were measured in ruminal fluid samples collected on d 21 at multiple time points after feeding. Ruminal pH was continuously recorded by probes residing in the rumen for 5 d. Organic matter intake (21.8 ± 0.2 lb) and ruminal pH (5.86 ± 0.02) were not affected by treatment ($P \geq 0.13$). Ruminal VFA and NH_3-N concentration, and OM digestibility were higher for U than CON (119.1 and 89.3 ± 5.9 m*M*, 8.5 and 3.9 ± 1.1 mg/dL, and 72.3 and 69.1 ± 2.9% for U and CON, respectively; $P \leq 0.04$). Results from this experiment agree with those from a concurrent feedlot finishing experiment by these authors where ADG and feed efficiency were improved by 11% and 7%, respectively, for U compared with CON. Increasing DIP through the inclusion of urea to dry-rolled and high-moisture corn-based feedlot diets containing 20% dried DG resulted in increased OM digestibility and concentration of NH_3-N and total VFA without affecting feed intake and ruminal pH.
Similar abstract previously published:
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Immunogenic inhibition of prominent ruminal bacteria as a means to reduce lipolysis and biohydrogenation *in vitro* *H. D. Edwards[1], R. C. Anderson[2], W. L. Shelver[3], N. A. Krueger[2], D. J. Nisbet[2] and S. B. Smith[1], [1]Texas A&M University, College Station, [2]USDA/ARS, College Station, [3]USDA/ARS, Fargo, ND*

Biohydrogenation is a ruminal process that almost quantitatively saturates free fatty acids, thus limiting the availability of unsaturated fatty acids for absorption and assimilation. In order for biohydrogenation to occur, free fatty acids must first be hydrolyzed from their triacylglycerol precursor, a process known as lipolysis. Ruminants saturate up to 80% or more of their dietary unsaturated fatty acids through the microbial processes of lipolysis and biohydrogenation, therefore promoting the accumulation of saturated fatty acids in their meat and milk. *Anaerovibrio lipolyticus 5s, Butyrivibrio fibrisolvens H17C, Propionibacterium avidum* and *acnes* are prominent ruminal bacteria that have been identified as active contributors to lipolytic activity in the rumen. For this study, antibodies generated against these bacteria were tested as a means to inhibit lipolysis. Additionally, an antibody was also generated against a *Pseudomonas* lipase to determine if an antibody specific against a purified lipase would be more effective than an antibody against whole cells. *Butyrivibrio fibrisolvens* uniquely participates in both lipolysis and biohydrogenation processes and thus the anti-*B. fibrisolvens* antibody also was tested to determine its effectiveness at reducing biohydrogenation against itself in pure culture. Each bacterium was cultured in anaerobic medium until late log phase and 4 ml of culture was transferred to tubes containing 2 ml anaerobic assay buffer and a bed of glass beads. Tubes were treated without (controls) or with antibody (0.6 mL). To determine cross-reactivity of the antibodies on lipolysis, each antibody was tested against each bacterium. Tubes were supplemented with either 0.3 ml olive oil to measure lipolysis or 6 mg linoleic (18:2*n*-6) or α-linolenic acid (18:3*n*-3) to measure biohydrogenation. Tubes containing olive oil were incubated for 12 h and tubes containing linoleic or α-linolenic acid were incubated for 1 and 3 h at 39°C. Lipolysis was measured colorimetrically to determine the accumulation of free fatty acids and biohydrogenation was determined by measuring fatty acid products by gas chromatography. All five antibodies were effective at reducing lipolysis. The anti-*Pseudomonas* lipase was the most effective, averaging a 77% reduction in free fatty acid accumulation. A reduction in lipolytic activity was caused by each antibody for nearly all bacteria, suggesting that the lipases for these bacteria are likely genetically similar. Thus, an antibody generated against a single lipase may be universally effective in reducing lipolytic activity for any lipase-producing bacteria. Biohydrogenation of α-linolenic acid was depressed by 22% at 3 h compared to controls (50 ± 13 nmol ml^{-1} h^{-1}). Biohydrogenation was not affected in the presence of the antibody with linoleic acid as substrate, likely a result of it not being unsaturated to the extent that α-linolenic acid is. This study demonstrated that a prominent ruminal bacterium responsible for freeing and hydrogenating ruminal fatty acids can be immulogically inhibited *in vitro*.

Case Study: Arrival Bovine Respiratory Disease titers and subsequent morbidity and performance of newly received cattle from New Mexico ranches and south Texas livestock auctions *J. R. Graves[1], M. E. Hubbert[2], J. S. Schutz[2], C. A. Löest[1], and E. J. Scholljegerdes[1], [1]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, [2]Clayton Livestock and Research Center, New Mexico State University, Clayton*

This study was designed to evaluate titer levels for three major precursors to Bovine Respiratory Disease (BRD), Infectious Bovine Rhinotracheitis (IBR), Bovine Virus Diarrhea (BVD), and Parainfluenza-3 (PI-3), over the course of a 56 d feeding period. Five hundred and thirty-three crossbred steer calves (Initial BW = 555 ± 3.0 lb) were used in a completely randomized design. Four loads of approximately 90 head of cattle per load were obtained from New Mexico ranches with differing calf health management protocols and two loads (n = 90/load) of cattle originating from Texas livestock auctions with unknown calf health management programs. On d 0, cattle were weighed, bled and administered metaphylaxis and vaccinated for IBR, BVD, and PI-3. Cattle were randomly assigned to one of six pens within load. Cattle were then bled and weighed on d 28 and 56. Cattle were accessed daily for symptoms of BRD and treated accordingly. At the conclusion of the study, a subset of animals not treated (Healthy; n = 46) were selected to serve as a control group for comparative analysis to treated cattle (Morbid; n = 44). Serum was analyzed for BRD antibody titers. Overall morbidity was 8.3%. Average daily gain for healthy cattle was greater ($P < 0.001$) than morbid between d 0 and 28 and d 0 and 56. Irrespective of health status 87.8% and 28.5% ($P < 0.01$) of cattle arrived with no serum titer for IBR and PI-3, respectively. Arrival (d 0) antibody titers for IBR and BVD did not differ ($P \geq 0.15$) across morbid and healthy cattle. However, d 0 serum antibody titers for PI-3 were lower ($P = 0.08$) in morbid cattle and varied across sources of cattle ($P < 0.001$), which was likely due to differences in calf management at the ranch. Day 28 serum IBR antibody titers were greater ($P = 0.09$) for morbid cattle than healthy with no differences being observed for BVD or PI-3 ($P \geq 0.26$). Serum antibody titers on arrival for IBR and PI-3 differed ($P = 0.07$) and did not differ ($P = 0.54$) for BVD between healthy and morbid cattle. Specifically, serum antibody titers were lower for PI-3 in morbid cattle than healthy. Conversely, serum antibody titers were greater for IBR in morbid cattle when compared to healthy. Serum antibody titers differed ($P \leq 0.02$) across loads of cattle. Due to the variation in management of cattle from New Mexico it is difficult to identify one overarching factor that may influence arrival antibody titers. Nonetheless, cattle from ranch 4, which were considered well-managed by receiving mineral, vaccinations at branding and weaning, and preconditioned at the ranch after weaning, had the highest antibody titers for PI-3 only ($P < 0.001$) but were intermediate or lower for IBR and BVD compared to other loads of cattle coming from New Mexico ranches and Texas livestock auctions. Interestingly, arrival serum antibody titers for BVD were greater for ranches whose calves were not vaccinated or preconditioned ($P < 0.001$). Health and nutritional management of calves at the ranch may have an influence on arrival antibody titers to viruses involved in the BRD complex; however, due to the low number of cattle and relatively low incidence of morbidity in this experiment, it is difficult to identify one factor that may influence calf health in the feedlot. Therefore, future work is needed to further elucidate the management factors on the ranch that may predispose cattle to BRD in the feedlot. This will allow for the development of predictive tools or management recommendations for cow/calf producers to reduce morbidity as it relates to BRD in the feedlot.

Effect of Rumensin and Amaferm on performance of heifers fed high roughage mixed diets in dry lot and grazed on high quality forage *H. C. Gray, P. Beck, K. Glaubius, and B. Stewart, Department of Animal Science, University of Arkansas, Fayetteville*
Previous studies have found adding Rumensin to diets will increase cattle performance by improving ruminal efficiency. Previous research has also shown that by adding Amaferm to the diet, fungal activity in the rumen increases, allowing more surface area for bacteria to attach to and maximize the digestion of high fiber forages. The objective of this research was designed to test the effects of adding Rumensin and Amaferm on performance of growing beef heifers fed high roughage mixed diets in dry lot over two yr and while grazing wheat pasture in yr 1. Angus

influenced cross-bred heifers (n = 72 yr 1 and 60 yr 2; BW = 484 ± 12.1 lb yr 1 and 519 ±16.3 lb yr 2) were placed in twelve (99' x 21') dry lot pens located in Hope, AR. In yr 1 of the study, calves were fed a diet of corn stalk hay (50% as fed) and corn distiller's grains, and corn as the primary concentrate energy sources for 83-d beginning in early November. Heifers were then placed on 12, 2 acre cool-season annual pastures keeping heifers within their original feeding groups, feeding Amaferm and/or Rumensin in two lbs corn per heifer daily. In yr 2 of the study, calves were fed a diet of mature ryegrass hay (50% as fed) using corn as primary concentrate energy source and cottonseed meal and urea were added as primary protein source for 66-d. Dry lot data were analyzed as a randomized complete block design with 2x2 factorial arrangement of treatments and the grazing period performance was analyzed as a completely randomized design using mixed procedure of SAS. Pen (or Pasture) treatment was the experimental unit and heifer the sampling unit. There was no year by treatment interaction for dry lot ($P \geq 0.75$) so data were pooled across YR for analysis. Total BW gain and ADG tended ($P = 0.07$) to be increased with the addition of Rumensin (153 vs 161 ± 8.1 and 1.62 vs 1.73 ± 0.11, for control vs Rumensin, respectively). There, however, was no effect ($P = 0.95$) of Amaferm on BW performance or an Amaferm by Rumensin interaction ($P = 0.80$). Treatment did not affect DMI ($P \geq 0.11$) or feed efficiency ($P \geq 0.43$). These results indicate Rumensin may increase performance of these high roughage low energy diets but Amaferm inclusion had no effect on performance in dry lot. On pasture, however, there was a tendency ($P = 0.10$) for Amaferm to increase BW gain by 18 lbs and ADG by 0.2 lb/d. These results indicate Amaferm did not affect performance of heifers fed these high roughage low energy diets in dry lot but Amaferm inclusion provided improved performance on high-quality pasture.

Evaluation of near-infrared reflectance spectroscopy for nutrient prediction of wheat and barley entering feedlots in western Canada *A. R. Harding[1], C. F. O'Neill[1], M. L. May[2], L. O. Burciaga-Robles[2], and C. R. Krehbiel[1], [1]Department of Animal Science, Oklahoma State University, Stillwater, [2]Feedlot Health Management Services Ltd., Okotoks, Alberta, Canada*
Near infrared reflectance spectroscopy (NIRS) has been used to predict nutrient composition of feed commodities. Barley and wheat grains are commonly used in the cattle feeding industry in western Canada, and feedlots are challenged with large variation in nutrient composition of these commodities. The objective of this study was to evaluate the use of NIRS for nutrient prediction of barley and wheat grains. Barley (n = 98) and wheat (n = 75) samples were selected from seven feedlots in western Canada from September, 2011 to August, 2012, representing a range in nutrient compositions as predicted by commercially available NIRS prediction equations (InfraXact, FOSS North America, Eden Prairie, MN). Based on nutrient distributions for each grain, samples were selected for HIGH, MED, or LOW nutrient composition of dry matter (DM), starch, and crude protein (CP). In addition, random samples of each commodity were selected to make up a majority of the respective study populations. Laboratory analysis was completed on all samples. PROC REG of SAS 9.3 (SAS Institute, Cary, N.C.) was used to determine correlations between laboratory assayed and NIRS values across the ranges (HIGH, MED, and LOW samples) for each constituent. Correlation of NIRS predictions and lab assayed values for DM was poor for wheat ($R^2 = 0.20$, $P = 0.09$, n = 15) but strong for barley ($R^2 = 0.86$, $P < 0.05$, n = 21.) When comparing NIRS and lab predictions of CP for barley and wheat samples, strong correlations were observed ($R^2 = 0.63$, $P < 0.05$, n = 24, and $R^2 = 0.92$, $P < 0.01$, n = 15, respectively.) Poor correlations were observed when comparing NIRS predictions and lab assayed values for starch content of barley ($R^2 = 0.17$, $P < 0.05$, n = 23) and wheat ($R^2 = 0.27$, P

≤ 0.05, n=15), respectively. NIRS technology can adequately predict CP of barley and wheat grain and accurately predict DM of barley grain. Additional research must be done to improve current calibrations evaluating DM of wheat and starch content of barley and wheat grain.

Interactive effects of zinc and ractopamine hydrochloride on the β-adrenergic receptor
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β-adrenergic receptor (βAR) agonists are commonly used in the beef cattle industry in the United States to improve carcass characteristics, growth rate, and feed efficiency. A commonly used growth promotant, ractopamine hydrochloride (RH), has been shown to increase muscle hypertrophy by binding to the βAR. When activated, the βAR signals intracellularly beginning with an increase in cAMP production. Zinc has been shown to have an allosteric binding site on the βAR and previous studies have indicated that zinc may increase βAR affinity for agonists such as isoproterenol. The objective of this study was to determine if zinc (Zn), when used in combination with RH, would stabilize the interaction of RH with the βAR, indicated by altered cAMP production, mRNA quantity, or protein abundance. Cultures of bovine satellite cells were established and treated at 120 h for 6, 24, and 96 additional h. Preliminary data was collected from dose titrations of Zn and RH to establish the optimum biological effect of each molecule. Treatments were applied in a 2 X 2 factorial arrangement with two levels of zinc (0 μM or 1 μM) and two levels of RH (0 μM or 10 μM) in differentiation media. cAMP was measured at 6, 24, and 96 h, while mRNA and protein were measured at 24 and 96 h. At 6 h, no differences (P >0.05) were detected in cAMP production between any of the treatments. However, at 24 h the 10 μM RH, 1 μM zinc treatment had a greater concentration of cAMP (P <0.05) compared to all other treatments. At 96 h the 10 μM RH, 0 μM zinc treatment had a lower concentration of cAMP (P =0.05) compared to the control. A tendency for an interaction of Zn and RH (P <0.10) was determined at 96. Using RT-QPCR analysis, no differences were detected in mRNA abundance between any of the treatments for the genes evaluated. Genes of interest included, β1 adrenergic receptor, β2 adrenergic receptor, AMPKα, myosin heavy chain I, myosin heavy chain IIA, and myosin heavy chain IIX. Protein quantification was performed via western blotting procedures to assess the abundance of the β1 adrenergic receptor, β2 adrenergic receptor, and AMPKα; However, no differences were detected in protein abundance between treatments.. These results indicate that zinc in combination with a β-agonist, may help to sustain the response during prolonged exposure. These changes in cAMP response may prolong the biological response in skeletal muscle to β-adrenergic agonists.

Comparing condensed distillers solubles concentration in steam-flaked and dry-rolled corn finishing diets on cattle performance and carcass characteristics *M. E. Harris[1], A. H. Titlow[1], A. L. Shreck[1], S. A. Furman[2], G. E. Erickson[1], K. H. Jenkins[2], and M. K. Luebbe[2], [1]Department of Animal Science, University of Nebraska, Lincoln, [2]University of Nebraska, Lincoln, Panhandle Research and Extension Center, Scottsbluff*
Two experiments were conducted to 1) determine if a corn processing by condensed distillers solubles (CCDS) concentration interaction exists, and 2) determine the optimum concentration of CCDS in steam-flaked corn (SFC) based diets. Experiment 1 was arranged in a 2x3 factorial with factors including corn processing method [dry-rolled (DRC) or SFC] and level of CCDS (0, 15, or 30% diet DM). The objective of Exp. 2 was to determine the optimum concentration of CCDS

(0, 9, 18, 27, or 36% diet DM) in SFC-based diets. Urea and soybean meal were included in all diets to meet or exceed NRC requirements for MP. In both experiments, crossbred steers were utilized in a randomized block design, blocked by BW, stratified by BW within block, and assigned randomly to pens. Pens were assigned randomly to treatments within BW block. Experiment 1 consisted of 42 pens with 7 pens/treatment and 11 steers/pen. Experiment 2 used 40 pens with 8 pens/treatment and 11 steers/pen. In Exp. 1, DMI decreased quadratically (P<0.04) as CCDS level increased for both SFC and DRC based diets. No differences (P=0.30) in DMI were observed between corn processing method, although numeric differences exist. For DRC-based diets, final BW, and ADG increased quadratically (P<0.01) as solubles concentration increased. There was a quadratic improvement (P<0.03) in F:G as CCDS increased in the DRC-based diets. With SFC-based diets, final BW and ADG increased linearly (P=0.01), while F:G showed a quadratic improvement (P=0.07). Steam-flaked corn diets had greater (P=0.02) 12^{th} rib fat thickness compared to DRC diets. Diets with SFC tended (P=0.09) to have greater yield grade than DRC-based diets. Dry matter intake for Exp. 2 also decreased quadratically (P<0.01) as CCDS concentration increased. Average daily gain increased quadratically (P<0.01) with greatest gains observed at 27%. There was a quadratic improvement (P<0.01) in F:G, with optimum F:G observed at 27% before slightly increasing at 36% CCDS. Hot carcass weight increased quadratically (P<0.01), and peaked at 27% CCDS. Calculated YG and marbling score increased quadratically (P=0.06 and 0.08, respectively). Fat thickness and LM area also tended to quadratically increase (P=0.13 and 0.07, respectively) as CCDS concentration increased. Dressing percent increased linearly (P=0.01) as CCDS increased in the diet. For Exp. 1, these results demonstrate a positive interaction when a more intensely processed corn (SFC) source is used with CCDS. These results disagree with previous work when feeding wet distillers grains plus solubles and SFC-based diets. In Exp. 2, the optimum inclusion of CCDS was 17.5% and 25% for gain and efficiency, respectively. Distillers solubles can replace SFC up to 36% of the diet DM, while maintaining or improving performance.

Effects of corn processing methods on fermentation/digestion characteristics and feedlot performance of steers fed no-roughage diets *R. M. Harvey, J. Sexten, and M. S. Kerley, Animal Sciences, University of Missouri, Columbia*

Two experiments were conducted to evaluate the effect of corn processing on fermentation/ digestion characteristics and feedlot performance in steers. Experiment 1 was a site and extent study that used five Hereford steers with rumen fistula and duodenal “T”-type cannula in a 5x5 Latin square design to evaluate the effect of corn processing method on rumen digestion and microbial growth when fed with or without roughage. Diets were whole-shelled corn (WC), cracked corn (CC), CC with 8% hay (CC+H), steam-flaked corn (SF:CC) and SF with 8% hay (SF:CC+H). Each of five periods consisted of four days for diet adaption and three days for sample collection. All diets were fed at 1.8% BW DMI and were balanced to meet or exceed NRC (2000) nutrient requirements. Data were analyzed using the GLM procedure in SAS version 9.3 (2011). MOEFF was not significantly different across treatments (P > 0.10). Treatment diet did not affect pH (P > 0.10). OM digestibility did not differ between treatment diets (P > 0.10). There was no difference in ruminal crude protein digestibility across treatments (P > 0.10). Microbial N flow post-ruminally was not significantly different (P > 0.10) between treatments but was numerically highest for both the WC and SF:CC+H treatments (97.70 and 99.80 g, respectively). Experiment 2 consisted of 80 head of crossbred steers (441.8 ± 10.86 kg) assigned to a completely randomized design to determine the effect of feeding high concentrate diets with or without roughage on feedlot performance. Four high concentrate diets were fed at 2.0 % BWDMI for 55 days. Diets consisted of (WC), WC with 8% fescue hay (WC+H), (CC) and CC with 8% fescue hay (CC+H). Treatments were randomly assigned to pen with 4 steers/pen and 5 replicates/treatment. Diets were fed once daily into GrowSafe bunks (1 bunk/pen) to measure individual steer intake. Individual body weights were captured on two consecutive days at the initiation and end of the study with an interim 27 day weight. Data were analyzed using GLM procedure in SAS. There was no difference in initial, d27 or final BW between treatments ($P > 0.10$). Average daily gain was different among treatments ($P < 0.02$). Steers fed WC+H and CC+H had greater gains compared to the WC and CC treatment diets (1.52 and 1.67 vs 1.49 and 1.35 kg, respectively). Individual steer intake was different across treatment diets ($P < 0.01$). CC+H had the greatest intake (13.54 kg/d) with steers fed the WC and CC diets eating the least (10.40 and 10.47 kg/d, respectively). Feed conversion ratio (FCR) was not statistically significant ($P > 0.10$) but did numerically improve with WC inclusion in treatment diet compared to CC treatment diets (7.57 and 8.13, respectively). Overall, WC diets with no roughage have yet to be studied. The site and extent study showed that pH change over time was more consistent and ammonia concentration was increased with the WC compared to the other diets. We concluded from our growth study that roughage removal reduced intake without concomitant from reduced ADG, so that FCR was improved. Though not statistically significant, numerical differences in the site and extent study paralleled the growth study indicating that when diets are balanced for RDP/RDN along with post-ruminal amino acids, improvements in digestibility and feedlot performance do occur.

Effect of high dosage ractopamine hydrochloride on growth performance and carcass characteristics of Holstein steers *J. E. Hergenreder[1], J. L. Beckett[2], J. Homm[3], and B. J. Johnson[1], [1]Department of Animal and Food Science, Texas Tech University, Lubbock, [2]Beckett Consulting Services, Fallbrook, CA , [3]Elanco Animal Health, Greenfield, IN*

Objectives were to evaluate the effects of feeding ractopamine HCl at 400 mg/hd/d for the last 28 d of the feeding period on growth performance and carcass characteristics of Holstein steers. Steers (n = 1,498; initial BW = 547 kg) were randomly assigned to pens (10 pens/treatment) and to a treatment: 1) no ractopamine HCl (C); 2) Ractopamine HCl fed at 400mg/hd/d (RH). Treatment period averaged 28 d. Steers were fed a conventional finishing diet based on steam-flaked corn and alfalfa hay with monensin (33.3 g/ton; 100% DMB: Rumensin: Elanco, Greenfield, IN) added. Dry matter intake decreased ($P < 0.05$), while ADG was greater ($P < 0.05$), and F:G was lower ($P < 0.05$) in RH steers. Ractopamine HCL fed steers had heavier final BW and HCW ($P < 0.05$), and higher DP ($P < 0.05$). Control steers had a smaller loin eye area ($P < 0.05$), and tended to have more back fat ($P = 0.07$) than RH steers. Ractopamine HCl fed cattle had lower calculated yield grades ($P < 0.05$), a higher percentage of yield grade 1 ($P < 0.05$), and a lower percentage of yield grade 3 ($P < 0.05$) cattle. Marbling score did not differ between treatments ($P > 0.10$), however RH steers had a lower percentage of cattle grading Choice ($P < 0.05$), and a higher percent grading Select ($P < 0.05$). These data indicate that 400 mg/hd/d of ractopamine HCl fed to Holstein steers can improve feedlot performance, dressing percentage, hot carcass weight, and LM area while having a minimal impact on quality grade.

Effects of a terminal sorting system with zilpaterol hydrochloride on feedlot performance and carcass characteristics of yearling steers *F.H. Hilscher[1], G.E. Erickson[1], D. B. Burken[1], B.L. Nuttelman[1], K. J. Vander Pol[2] , and J.P. Hutcheson[2], [1]University of Nebraska-Lincoln, [2]Merck Animal Health, De Soto, KS*

Crossbred yearling steers (n=1400, 829 ± 64 lb) were used to evaluate the effects of Zilpaterol hydrochloride (ZH) and terminal sorting 50 d prior to harvest on feedlot performance and carcass characteristics. Steers were blocked by arrival group (25 steers/pen, 56 pens) and assigned randomly to pen to receive 1 of 4 treatments: 1) unsorted non-ZH negative control (-CON); 2) unsorted ZH fed positive control (+CON); 3) early weight sort fed ZH (1-Sort) with heaviest 20% identified at d 1 and sorted 50 d from harvest and marketed 14 d prior to –CON and +CON, with the remaining 80% of the pen fed 7 d longer than –CON and +CON; and 4) four-way sort 50 d from harvest fed ZH (4-sort) with steers sorted into a heavy, mid-heavy, mid-light, and light group, marketed -14 d, 0 d, +7 d, and +21 d from the –CON and +CON, respectively. Because the heaviest steers were sorted early, the remaining steers in the sorted treatments were fed longer than the –CON and +CON as a treatment. All steers fed ZH were fed 7.56 g/ton of DM for 20 d followed by 3 d withdrawal. Dry matter intake was lower (P<0.01) for 4-sort cattle when compared to the unsorted controls, but was not different compared to 1-sort. Carcass weight for +CON (948 lb) was 33 lb heavier (P<0.01) than –CON (915 lb), and HCW for 4-sort was numerically greater than +CON (957 lb; P0.12). Carcass weight SD was not different (P>0.95) between +CON and –CON, while carcass weight SD of 4-sort was reduced (P<0.01) compared to unsorted controls. Steers fed ZH had a greater percentage of carcasses over 1000 lb than –CON (P<0.01). Although not statistically different, % of carcasses over 1000 lb were reduced by 22% for 4-sort compared to +CON. The percentage of carcasses over 1050 lb was significantly lower (P <0.05) for 4-sort compared to all other treatments. Longissimus muscle area was greater in +CON and sorted treatments (P<0.01) than –CON, and 4-sort had increased (P<0.05) LM area vs. +CON. Fat depth was lower (P<0.05) in +CON than –CON, but did not differ in ZH treatments. Marbling was lower (P<0.04) for; 1-sort, 4-sort, and +CON when compared to -CON. Feeding ZH increases carcass weight, but sorting reduces variation and increases carcass weight further due to greater days on feed.

Effects of supplemental lysine and methionine with zilpaterol hydrochloride on feedlot performance, carcass characteristics, and tenderness in finishing feedlot cattle *A.D. Hosford[1], W. Rounds[2], and B. J. Johnson[1], [1]Department of Animal and Food Science, Texas Tech University, Lubbock, [2]Kemin Industries, Inc., North America, Des Moines, IA*

Feeding rumen protected (RP) amino acids (**AA**) with zilpaterol hydrochloride (**ZH**) was evaluated in a small-pen feeding trial. Crossbred steers (n = 180; initial BW = 366 kg) were blocked by weight and then randomly assigned to treatments (45 pens; 9 pens/treatment). Treatment groups consisted of a RP lysine supplement (**Lys**) LysiPEARL™ and ZH, a RP methionine supplement (**Met**), MetiPearl™ and ZH, a RP lysine and methionine (**Lys+Met**) and ZH, no AA and no ZH (**Cont-**), and no AA and ZH (**Cont+**). Zilpaterol hydrochloride (8.3 mg/kg DM) was fed for the last 20 d of the finishing period with a 3 d withdrawal. Lysine and Met were top dressed daily for the 134 d feeding trial to provide 12 or 4 $g{\cdot}hd^{-1}{\cdot}d^{-1}$, respectively to the small intestine. Carcass characteristics and striploins were collected following harvest at a commercial facility. Steaks from each animal were aged for 7, 14, 21 and 28 days, and Warner Bratzler shear force (**WBSF**) was determined as an indicator of tenderness. Cattle fed supplemental Met and Lys+Met had increased final BW (P = 0.02 and 0.03), and ADG (P <

0.05) compared to Cont-. Supplementation of Lys, Met, and Lys+Met improved G:F ($P < 0.05$) compared to Cont- during the ZH feeding period (d 111 to 134) as well as the entire feeding period ($P < 0.05$). Zilpaterol hydrochloride increased carcass ADG ($P < 0.05$) when compared to non-ZH fed cattle. Methionine and Lys+Met treatments had heavier hot carcass weights (**HCW**: $P < 0.05$) as compared to Cont-. Yield grade was decreased ($P < 0.05$) for Cont+ cattle compared to Lys, Lys+Met, and Cont- treated cattle. Quality grade distribution was unaffected between treatments. Tenderness was reduced ($P < 0.05$) with ZH regardless of AA supplementation. Lysine, Met, Lys+Met, and Cont+ had less tender steaks ($P < 0.05$) throughout all aging groups as compared to Cont-. Steaks from Lys treated cattle were less tender ($P < 0.05$) than Cont+ during the 7 and 14 d aging periods. After 21 d of aging, all steaks from AA supplemented steers had similar WBS ($P > 0.05$) as Cont+. Control- had the highest percentage of tender steaks after 21 days of aging ($P < 0.05$). Supplementation of AA, in conjunction with ZH feeding increased ADG and HCW. These findings indicated that cattle fed ZH may require additional AA absorbed from the small intestine in order to maximize performance.

Effects of wet distillers grains and condensed distillers solubles on growth performance and carcass characteristics of finishing steers *H.D. Hughes, M.S. Brown, K.J. Kraich, J. Simroth-Rodriguez, and J.O. Wallace, West Texas A&M University, Canyon*
Few data exist describing the feeding value of condensed distillers solubles (CDS) in diets typical of the southern High Plains. Crossbred steers (n=384) were adapted to a common finishing diet, blocked by BW, implanted with Revalor-IS (80 mg trenbolone acetate and 16 mg estradiol) and assigned to treatments of CDS concentration (0, 7.5, or 15% of diet DM) in diets containing 15% wet distillers grains with solubles (WDGS; represented by 0/15, 7.5/15, and 15/15, respectively) or to a control treatment containing 0% CDS and 0% WDGS. Cattle were housed in 36 soil-surfaced pens (9 pens/treatment). Diets contained equal fat and crude protein content across treatments. The WDGS and CDS replaced portions of steam-flaked corn, cottonseed meal, yellow grease, and urea. Cattle were fed twice daily for 167 days (initial BW = 794 ± 24 lb). Dry matter intake tended to increase (P=0.12) with increasing CDS concentration (19.9, 20.0, and 20.4 +/- 0.4 lb/d for 0/15, 7.5/15, and 15/15, respectively), but DMI was not different between the control (19.6 lb/d) and the average of remaining treatments (P=0.58). Steer ADG on a live basis was 7.3% greater by cattle fed WDGS and CDS diets (3.37, 3.31, and 3.36 +/- 0.06 lb/d for 0/15, 7.5/15, and 15/15, respectively) compared to cattle fed the control diet (3.14 lb/d; P=0.007), but ADG was not different among CDS concentrations (P>0.43). Cattle fed the control were 4.2% less efficient on either a live or carcass basis than the average of those fed CDS (P=0.005), while no differences in F:G were observed as CDS concentration increased. Hot carcass weight (P=0.02) and 12th rib fat thickness (P=0.09) were both greater for cattle fed WDGS and CDS compared to the control. No differences (P > 0.10) were observed for remaining carcass measurements among treatments. Based on cattle performance, the NEg of WDGS and CDS were 100 and 85%, respectively, of the NEg of steam-flaked corn. Results suggest that WDGS is an effective replacement for steam-flaked corn in finishing rations at 15% inclusion rates. Results also suggest that including CDS up to 15% of ration DM in equal fat diets, in combination with WDGS, will not have a negative impact on performance or carcass characteristics.

Effects of corn processing method and dietary inclusion of corn wet distillers grains with solubles (WDGS) on nutrient metabolism and enteric gas production in finishing steers

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Dry rolled (DRC) and high moisture (HMC) corn are common corn processing methods used by feedlots in the Upper Midwest. Research is limited on higher inclusion rates of wet distillers grains with soluble (WDGS). Therefore, the effects of increasing the concentrations of WDGS in dry rolled and high moisture corn-based diets on energy metabolism and enteric methane (CH4) production were evaluated in eight MARC III (initial BW = 394 kg) steers using respiration calorimetry head boxes. A 4 x 4 replicated Latin square with 2 x 2 factorial arrangement of treatments was used with the following dietary treatments: 1) DRC-based diet with 25% WDGS (DRC-25); 2) DRC-based diet with 45% WDGS (DRC-45); 3) HMC-based diet with 25%WDGS (HMC-25); 4) HMC-based diet with 45% WDGS (HMC-45). Density of dry rolled and high moisture corn used in treatment diets were 678.4 and 605.1 kg/L respectively. Dry matter intake tended to decrease ($P = 0.10$) and CH4 production was reduced ($P < 0.01$) as WDGS concentration increased in the diet. The CO2 to CH4 ratio increased ($P = 0.02$) and RQ decreased ($P < 0.01$) when WDGS increased in the diet. Retained energy tended to be greater ($P = 0.07$) for DRC vs HMC. Urinary N excretion as proportion of N intake was not affected by corn processing method or WDGS inclusion rate, while feces was increase ($P = 0.01$ and < 0.01; respectively) for HMC and 25% WDGS diets. However, as a proportion of N intake, urinary N excretion was increased ($P < 0.01$), whereas, fecal N excretion was decreased ($P < 0.01$) when WDGS concentration increased in the diet. As a percent of intake, ether extract apparent digestibility was greater ($P < 0.01$) for WDGS at 45 than 25% of DM. Diets containing 25% WDGS or HMC had a lower ($P < 0.01$) NDF digestibility. Starch apparent digestibility as percent of intake was increased ($P < 0.01$) for diets containing DRC, while it was not affected ($P = 0.29$) for WDGS concentrations in diet. Retained energy as a percentage of GE intake was similar ($P = 0.21$) using 25 and 45% WDGS diets, while retained N as a percentage of N intake was greater ($P = 0.02$) for 45% diets.

Impact of postweaning residual feed intake in heifers on efficiency of forage utilization, heart rate and physical activity of pregnant cows *A.N. Hafla, J.R. Johnson, G.E. Carstens, T.D.A. Forbes, L.O. Tedeschi, J.C. Bailey, J.T. Walter, and J.G. Moreno, Department of Animal Science, Texas A&M University, College Station*

Residual feed intake (**RFI**) of growing cattle has been shown to be positively associated with biological processes (e.g., energy expenditures, digestibility) that affect efficiency of feed utilization. However, few studies have examined the association between RFI in growing animals, and life-cycle efficiency of integrated beef production systems. The objectives of this study were to determine if RFI classification of beef heifers is associated with efficiency of forage utilization, body composition, feeding behavior, heart rate and physical activity of mid-gestation females. Postweaning RFI was measured in growing Bonsmara heifers for 2 consecutive yr (N = 115) while fed a high-roughage diet (2.04 Mcal ME/kg DM). RFI was calculated as the residual from the linear regression of DMI on mid-test $BW^{0.75}$ and ADG, and heifers with the lowest (n = 24) and highest (n = 24) RFI were retained for breeding. During the postweaning trial, heifers with low RFI (more efficient) consumed 20% less ($P < 0.001$) DMI,

but had similar BW and ADG compared to high-RFI heifers. First-parity (N =23) and 2nd-parity (N =19) females were subsequently fed a diet consisting of 30% alfalfa and 70% sorghum hay (2.11 Mcal ME/kg DM), and DMI and feeding behavior traits measured with a GrowSafe® system. Body condition scores and ultrasound measurements of rump-fat depth and LM area were obtained on days 0 and 77 of the study. Heart rate was measured using Polar® monitors, and physical activity measured using IceTag® accelerometers. Interactions between heifer RFI classification and age (1st vs 2nd parity) were non-significant ($P > 0.10$). Pregnant females with low RFI as heifers consumed less ($P < 0.001$) hay (9.0 vs 11.6 ± 0.6 kg/d), spent less ($P < 0.001$) time consuming hay (149 vs 198 ± 13 min/d), and had lower ($P < 0.05$) meal eating rates (27.4 vs 33.3 ± 1.8 g/min) than pregnant females with high RFI as heifers. However, BW, ADG, BCS, rump-fat depth and physical activity (step count, lying bout frequency and duration) were similar in pregnant females with divergent RFI as heifers. Heart rates were lower ($P < 0.05$; 66.1 vs 71.1 ± 1.7 beats/min) for pregnant females with low RFI. Mid-gestation 1st-parity females had lower ($P < 0.05$) initial BW and ADG, but similar DMI, rump-fat depth and BCS compared to mid-gestation 2nd-parity females. First-parity females had 53% higher frequency of bunk visits, 31% more daily step counts, 9% more lying bouts and 8% higher heart rates then 2nd-parity females. Females with low RFI as growing heifers consumed 23% less forage and had 7% lower heart rates, while maintaining the same BW and BCS during the 2nd trimester of gestation compared to females with high RFI as heifers. Results from this study suggest that a strong association exist between RFI in growing heifers and efficiency of forage utilization in pregnant cows.

The effects of corn oil removal from distillers grains plus solubles on finishing performance and carcass characteristics *M. L. Jolly, B. L. Nuttelman, D. B. Burken, C. J. Schneider, G. E. Erickson, and T. J. Klopfenstein, University of Nebraska, Lincoln*

Two studies evaluated the effects of corn oil removal from distillers byproducts on finishing performance and carcass characteristics. Oil is removed from thin stillage using centrifugation which is the new process used by most plants, but different than previous work. In Exp. 1, a 180-d finishing study was conducted utilizing 225 calf fed steers (659 ± 20 kg) in a randomized block design. Treatments consisted of 27% inclusion of condensed distillers solubles (CDS) with de-oiled (6.0%) and normal (21.1%) fat, 40% inclusion of modified distillers grains plus solubles (MDGS) with de-oiled (9.2%) fat and normal (11.8%) fat, and a corn based control (CON). Dietary fat was 4.7% for de-oiled CDS, 8.8% for normal CDS, 6.1% for de-oiled MDGS, and 7.2% for normal MDGS compared to 4.4% for CON. There were no fat x by-product type interactions observed ($P > 0.34$) and no differences in DMI, ADG, or F:G between de-oiled and normal CDS ($P > 0.25$) or de-oiled and normal MDGS ($P > 0.44$). However, when compared to CON, feeding CDS decreased DMI ($P < 0.01$) and improved F:G ($P < 0.01$), regardless of fat. Feeding MDGS resulted in similar DMI ($P > 0.48$), greater ADG (P < 0.01), and improved F:G (P < 0.01) compared to CON, regardless of fat. No differences ($P > 0.20$) were observed in carcass characteristics due to fat content of CDS and MDGS. In Exp. 2, a 147-d finishing study was conducted utilizing 336 yearling steers (774 ± 42 kg) to evaluate increasing inclusions of de-oiled wet distillers grains plus solubles (WDGS). Treatments consisted of 35, 50, and 65% dietary inclusion of WDGS with de-oiled (7.9%) and normal (12.4%) fat and a corn based control (CON). Dietary fat was 5.6% for de-oiled 35%, 7.2% for normal 35%, 6.2% for de-oiled 50%, 8.5% for normal 50%, 6.7 for de-oiled 65%, and 9.8% for normal 65% WDGS compared to 4.3% for CON. An inclusion x fat interaction was observed for DMI ($P < 0.10$). Dry matter intake was greater for normal 35%, de-oiled 35%, and de-oiled 50%, intermediate for normal

50% and de-oiled 65%, and lowest for normal 65% (*P* < 0.01). Fat content had no effect on final BW, ADG, and F:G (*P* > 0.20). Level of WDGS had no effect on FBW or ADG (*P* > 0.88) but was significant for F:G (*P* < 0.01). Feed conversion decreased linearly (*P* < 0.01) with increasing inclusion of WDGS, regardless of fat content (*P* > 0.20). No differences (*P* ≥ 0.29) were observed in carcass characteristics due to fat content or level of WDGS. Overall, these data suggest that removal of fat had no impact on finishing performance or carcass characteristics by centrifuging distillers solubles.

Effects of postruminal amino acid supply on dietary protein flow from the rumen of a forage-based diet using a continuous culture system *M. M. Masiero, J. H. Porter, M. S. Kerley, and W. J. Sexten, University of Missouri, Columbia*

Three diets with increasing ruminal undegraded protein level (**LO**, **MID** and **HI**) were fed (50g/d) to continuous culture fermenters (**FER**) to characterize RUP (porcine blood meal and Aminoplus) supplementation effect on post-ruminal amino acid flow in a forage-based diet. We hypothesized that increasing diet RUP concentration would increase RUP flow from the rumen without influencing microbial fermentation. Diets were randomly distributed over FER (*N=24*), acclimated for 4d, and sampled over 3d. FER content was monitored at 0h and 4h post feeding for pH and analyzed for VFA (mM) and ammonia concentration (**AM**) (mM/dL). Diets, FER content and bacteria were used to measure amino acid digestibilities (g of digested AA/g AA fed). The pH was greater (P = 0.005 and 0.0008) for HI, 6.46 and 6.42, compared to MID, 6.34 and 6.27, and LO, 6.32 and 6.24, for 0h and 4h, respectively. AM increased as RUP increased (LO 3.18; MID 5.30; HI 8.79) at 0h, however at 4h AM was greater (P < 0.0001) for HI (10.58) compared to MID (6.10) and LO (4.26). Acetic, propionic, valeric, total VFA and acetic:proponic did not differ (P = 0.44) at 0h and 4h. Butyric did not differ (P = 0.37) at 0h. At 4h butyric was greater (P = 0.036) for LO (16.9) compared to HI (15.4), however MID (16.5) did not differ between treatments. Isobutyric was greater (P < 0.0001) for HI (1.5) compare to MID (1.2) and LO (1.1) at 0h. At 4h, isobutiric increased as RUP increased (LO 1.2; MID 1.4; HI 1.6; P < 0.0001). Isovaleric was greater (P < 0.0001) for HI, 2.9 and 3.0, compared to MID, 2.5 and 2.6, and LO, 2.2 and 2.4, for 0h and 4h, respectively. OM, NDF and ADF digestibility, microbial efficiency and g of Bacterial N/d did not differ (P = 0.4). Protein digestibility (%) was greater (P = 0.042) for LO (47.2) and HI (46.0) compared to MID (38.3). Threonine (P = 0.175) and methionine (P = 0.55) digestibility did not differ. Lysine digestibility was greater (P = 0.041) for LO (0.5) compared to MID (0.38), however HI (0.46) did not differ between treatments. Arginine digestibility was greater (P = 0.014) for LO (0.59) compared to MID (0.48), however HI (0.54) did not differ between treatments. Histidine digestibility was greater (P = 0.002) for LO (0.56) compared to MID (0.38) and HI (0.44). Total AA digestibility was greater (P = 0.056) for LO (0.53) compared to MID (0.43), however HI (0.49) did not differ between treatments. At the lower RUP inclusion level (MID) RUP was recovered in total from effluent flow. At the higher RUP inclusion level (HI) less than half of supplemental RUP was recovered in effluent flow. In conclusion, RUP supplementation in forage-based diets increased RUP flow from the rumen without negatively influencing microbial fermentation. RUP fraction of rumen-stable proteins may be influenced by supplemental protein level.

Advantages of technology enhanced beef production systems *C. L. Maxwell[1], B. K. Wilson[1], B. T. Johnson[1], B. C. Bernhard[1], D. L. VanOverbeke[1], D. L. Step[2], C. J. Richards[1], and C. R. Krehbiel[1], [1]Department of Animal Science, [2]Department of Veterinary Clinical Sciences, Oklahoma State University, Stillwater*

The objective of this study was to evaluate conventional and natural production systems through annual pasture and finishing with 2 roughage levels. Beef steers (n = 180; initial BW = 250 ± 19.1 kg) from a single ranch in Oklahoma were randomized to one of two treatments in the pasture phase. Steers were implanted with 40 mg of TBA, 8 mg estradiol, and 29 mg tylosin tartrate (Conventional; CONV) or received no implant (Natural; NAT). The 2 treatments were comingled and grazed winter annual pasture for 109 d. During pasture grazing, CONV steers had an 18.5% improvement in ADG (1.22 vs. 1.03 kg/d; $P < 0.01$), and a heavier final BW (385 vs. 366 kg, $P < 0.01$), compared with NAT steers. Steers (160 steers; 5 steers/pen; 8 pens/trt) were assigned to a 2 x 2 factorial RCBD in the feedlot phase. The first factor was production program (NAT vs. CONV), and the second factor was 7 vs. 12% roughage (DM basis; LOW vs. HIGH). During finishing, CONV steers were given 120 mg of TBA, 25 mg estradiol and 29 mg tylosin tartrate at processing, were fed monensin and tylosin for the entire feeding period, and fed zilpaterol hydrochloride for the last 20 d of the trial. Both groups were fed 135 d. At harvest, 17-18 strip loins/treatment were collected for retail meat analysis. There were no system x roughage level interactions ($P \geq 0.07$). Conventional steers ate 6.9% more fed (11.8 vs. 11.0 kg/d; $P < 0.01$), gained 28.4% faster (1.90 vs. 1.48 kg/d; $P < 0.01$), and were 24.2% more efficient (0.164 vs. 0.132; $P < 0.01$), compared with NAT. There was a trend for LOW steers to eat less feed (11.3 vs. 11.5 kg/d; $P = 0.13$) and gain faster (1.73 vs. 1.66 kg/d; $P = 0.09$), resulting in an improvement in feed efficiency (0.153 vs. 0.144; $P < 0.01$) compared with HIGH. There was a 26% improvement in estimated daily carcass weight gain (1.55 vs. 1.23 kg/d), 17.8% improvement in carcass efficiency (0.132 vs. 0.112; $P < 0.01$), and 14.9% improvement (1.31 vs. 1.14 Mcal/kg; $P < 0.01$) in calculated NE_g retained for CONV vs. NAT. There were no effects of treatment on 12th rib-fat thickness ($P \geq 0.16$). Hot carcass weight was increased by 62 kg (424 vs. 362 kg; $P < 0.01$), dressing percentage increased 1.6% units (64.9 vs. 63.3%; $P < 0.01$), and ribeye area was increased by 16.9 cm^2 (100.9 vs. 84.0 cm^2; $P < 0.01$), decreasing USDA Yield Grade (3.09 vs. 3.54; $P < 0.01$) for CONV compared with NAT. Natural steers had a higher percentage grading Premium Choice (48.7 vs. 18.7%; $P < 0.01$), a higher percentage of USDA Yield Grade 4 and 5 (25.4 vs. 9.3%; $P < 0.01$), and a higher percentage of abscessed livers (39.6 vs. 10.5%; $P < 0.01$) compared with CONV. Conventional had increased Warner-Bratzler shear force values (3.89 vs. 3.40, kg; $P < 0.01$) compared with NAT, resulting in lower overall tenderness scores in a trained taste panel (6.8 vs. 6.4; $P < 0.01$). Conventional cattle had lower feedlot cost of gains, resulting in $203.69/steer greater net returns ($P < 0.01$) compared with NAT. The results of these data show that the technologies used in CONV production result in significant improvement in efficiency, performance and profitability with minimal effects on carcass and retail meat quality, regardless of roughage level.

Effects of cottonseed meal and dried distillers grains supplementation on rice straw utilization by Brahman steers *J. C. McCann, J. E. Sawyer, and T. A. Wickersham, Texas A&M University, College Station*

Seven ruminally cannulated Brahman steers were used in a 7 × 4 incomplete block design to determine the effects of cottonseed meal (CSM; 43.9% CP, 82.9% degradable protein) or dried distiller's grain (DDG; 27.5% CP, 43.6% degradable protein) supplementation on rice straw utilization. Treatments consisted of a control (no supplement) and three levels (60, 120, and 180 mg N/kg BW) of either CSM or DDG. Periods were 14 d with 9 d for adaptation and 5 d for data collection. Steers had ad libitum access to rice straw (4.7% CP, 68% NDF) and were fed supplements at 0630 daily. Increased supplementation resulted in a linear increase ($P \leq 0.06$) in forage OM intake from 13.5 g/kg BW (control) to 16.1 and 15.5 g/kg BW for 180 mg N/ kg BW of CSM and DDG respectively, with no difference between sources ($P = 0.84$). Total digestible OM intake was increased by supplementation (linear, $P < 0.01$) from 8.0 g/kg BW (control) to 11.7 and 12.9 g/kg BW for 180 mg N/ kg BW of CSM and DDG respectively. A greater response was observed for DDG ($P = 0.05$) due to greater provision of supplement (g DM/d) to achieve isonitrogenous treatment levels. Total tract OM digestion was linearly increased ($P < 0.01$) by CSM and DDG supplementation. Although CSM and DDG improved NDF digestibility (linear, $P \leq 0.06$) from 49.6% (control) to 53.7% and 54.9% at 180 mg N/kg BW respectively, estimated forage NDF digestibility was not significantly increased ($P > 0.10$). Ruminal ammonia concentrations peaked 4 h after supplementation with the greatest concentration (4.0 mM) observed for 180 mg N/kg BW of CSM and the lowest concentration observed in the control (0.8 mM). Provision of CSM resulted in a linear increase ($P < 0.01$) in ruminal ammonia in contrast to the quadratic response ($P = 0.02$) observed with DDG supplementation. Total VFA production followed a similar trend with a linear increase for CSM and DDG supplementation, respectively ($P = 0.09$, $P = 0.01$). Protein supplements containing high and low levels of degradable intake protein were effective at improving intake and utilization of rice straw.

Lactipro improves performance and health of high-risk calves after feedlot arrival
Kevin Miller, Cadra Van Bibber-Krueger, and Jim Drouillard, Kansas State University Manhattan
Two experiments were conducted to determine the effect of a 100-mL oral dose of the *Megasphaera elsdenii*-containing product, Lactipro®, at initial processing, on the health and performance of high-risk calves during the receiving period. In Exp. 1, 1294 crossbred steers (BW = 262 ± 1.3 lb) were received from Mexico over a 13-d period in November and December of 2011. Steers were provided hay upon arrival and processed approximately 24 h later. At processing steers were assigned to a Control group (no Lactipro®) or a Lactipro® treatment group (100-mL oral dose of Lactipro®) based on alternating order through the chute. Steers were housed in 10 concrete-surfaced pens with 15 or 16 steers/pen or 28 dirt-surfaced pens with 39 to 42 steers/pen. All steers were fed a 55% concentrate receiving diet *ad libitum*. Steers were observed daily for signs of bovine respiratory disease (BRD). Steers determined to be sick with BRD were taken to the processing area and given antibiotic therapy (1st antibiotic therapy, Micotil; 2nd antibiotic therapy, Baytril; 3rd antibiotic therapy, LA-200). There were no differences between treatments for DMI, ADG, feed efficiency, overall morbidity, or mortality ($P \geq 0.53$). Incidence of 1st- and 3rd-time antibiotic therapy were not different between Control and Lactipro® steers ($P \geq 0.16$); however, Lactipro® steers tended to have a lower incidence of 2nd -time antibiotic therapies ($P = 0.06$). In Exp. 2, crossbred calves (504 bulls, 141 steers; BW = 443 ± 10.8 lb) were received from Texas over a 2-wk period in January, 2012. Bulls were castrated at processing and treatments and allocation to treatment were the same as Exp. 1. Calves were housed in 24 dirt-surfaced pens with 25 to 30 calves/pen, fed a 55% concentrate receiving diet, observed daily for clinical signs of respiratory disease and treated for BRD as described for Exp. 1. Calves dosed with Lactipro® had greater DMI, ADG, and improved feed efficiency ($P \leq 0.05$) compared Control calves. Instances of 1st- and 2nd-time therapeutic

treatments for BRD were 31% and 33% less for calves given Lactipro® compared to the control group ($P < 0.05$). Third-time antibiotic therapy for BRD and mortalities were not different between treatments ($P > 0.10$), but BRD therapeutic treatment cost per calf was decreased by 13% ($P < 0.05$) for calves in the Lactipro® treatment. Dosing calves with Lactipro® at processing was effective as a method for improving performance and decreasing clinical signs of BRD.

Prediction of barley silage dry matter by near infrared reflectance spectroscopy
C. F. O'Neill[1], A. R. Harding[1], S. E. Murray[1], M. L. May[3], L. O. Burciaga-Robles[3], O. R. Rasmussen[2], and C. R. Krehbiel[1] , [1]Department of Animal Science, Oklahoma State University, Stillwater, FOSS North America, Eden Prairie, MN, [3]Feedlot Health Management Services Ltd, Alberta, Canada
Near infrared reflectance spectroscopy (NIR) has been shown to accurately predict the nutrient composition of various feedstuffs, including forages. For this study, the use of NIR for the prediction of barley silage DM was examined and NIR equations were developed using commodity specific or broad based calibration sets. Fifteen fresh samples of both barley silage and barley straw were split into two groups: water added (WTR) and fresh. Water was added to WTR samples to ensure a broad range of DM values were represented in the equations. Samples were split, weighed and scanned using NIR technology (InfraXact, FOSS North America, Eden Prairie, MN). Samples were dried in a forced air oven at 55°C, in twelve 4 hour intervals. At each interval the samples were weighed and scanned. For each sample DM was calculated and correlated to NIR spectra at each interval using WINISI software (FOSS North America). Data from barley silage samples were blocked by calculated DM and randomized to either the validation set (n = 128) or calibration set (n = 639). A commodity specific barley silage NIR equation (SIL) was developed from the silage calibration set data (SE of calibration (SEC) = 3.77, $R^2 = 0.98$). A second calibration set (n = 1406) was developed with the addition of data from barley straw samples (n = 767) to the barley silage calibration set data and a broad based barley silage NIR equation (SIL-STR) was derived (SEC = 2.93, $R^2 = 0.98$). The SIL and SIL-STR equations for DM of barley silage were validated using the independent barley silage validation set. The R^2 and SE of prediction (SEP) for the validation of SIL and SIL-STR equations were 0.98 and 3.78 and 0.98 and 3.96, respectively. The DM content of barley silage can be accurately predicted using NIR technology. The use of a broad based barley silage calibration provides comparable results to a commodity specific calibration while increasing the robustness of a NIR equation.

Effect of skeletal muscle fiber heterogeneity on development of intramuscular fat in growing beef cattle *S.L. Roberts, P.A. Lancaster, U. DeSilva, G.W. Horn, and C.R. Krehbiel, Department of Animal Science, Oklahoma State University, Stillwater*
Previous research indicates that metabolism and fiber type of skeletal muscle is related to intramuscular lipid content. The objective of this study was to determine differences in metabolism, angiogenesis, and intercellular signaling of skeletal muscle fibers within the same muscle group that could be responsible for the initiation of intramuscular adipose tissue development and differentiation. Longissimus dorsi (LD) muscle samples were collected from steers (n = 12; 385 days of age; 378 kg) grazing wheat pasture. LD samples were dissected under magnification and sorted into 3 categories based on visual stage of development: immature (MM), intermediate (ME) and mature (MA) intramuscular fat (IM). In addition, muscle fibers

lying adjacent to each IM category and those not associated with IM tissue were collected and stored separately. Quantitative RTPCR was used to determine relative fold change in genes involved in metabolism, angiogenesis, and intercellular signaling pathways in both LD and IM samples. Gene expression data were analyzed using a general linear model that included the fixed effect of tissue. Pearson correlation coefficients were also computed between gene expression in LD and IM tissue samples that were at the same stage of development. Fatty acid binding protein 4 and *PPARγ* expression were greater (P<0.05) in more mature IM while *PREF-1* expression was less (P<0.01) indicating successful separation into different maturity categories. Genes associated with metabolism and angiogenesis in LD tissue showed no differences among stages of development. Myostatin expression did not change in LD tissue, but mysotatin receptor and follistatin expression decreased (P<0.01) as IM matured. Angiogenic growth factors in MM IM tissue had a strong positive correlation (r>0.88) with angiogenic growth factors in LD associated with MM IM; however, no correlation was observed in ME or MA IM. These data indicate a coordinated effort between LD and IM in early stages of IM development.

Wet distillers grain and solubles vs. wet corn gluten feed for newly received and growing cattle *E.R. Schlegel[1], S.P. Montgomery[2], C.I. Vahl[1], B.E. Oleen[1], W.R. Hollenbeck[1], and D.A. Blasi[1], [1]Kansas State University, [2]Corn Belt Livestock Services, Cedar Rapids, IA*
In many instances, due in part to price per unit of energy and proximity to production, Kansas beef producers have the opportunity to incorporate grain processing industry byproducts such as wet distillers grains and solubles (WDGS) and wet corn gluten feed (WCGF) into newly arrived and growing cattle diets. While a number of previous studies have compared these two byproducts for use in finishing diets, little information is available for receiving and growing cattle diets. Therefore, the objective of this study was to compare the performance outcomes of newly arrived and growing calves fed either WDGS or WCGF relative to a standard corn – based diet. Over a 7-day period (May 15 through 23, 2012), 280 steers and bulls (30% bulls; 518 lb initial body weight) were assembled through sale-barn market facilities in Tennessee and transported to the Kansas State University Beef Stocker Unit. Upon arrival, all calves were weighed, tagged, mass medicated with Draxxin® (1.1 mL/100 lb), and palpated for sex (bull or steer). Calves were given ad libitum access to long-stem prairie hay and water overnight. The following day, calves were vaccinated against clostridial and respiratory diseases and dewormed, and bulls were surgically castrated. Each load (three total) was then blocked by arrival date and randomly assigned to one of three treatments for a total of 24 pens. Castrated bulls were equally distributed among the eight pens within each string. Experimental treatments consisted of feeding a diet that did not contain any corn byproducts (Control) or diets containing either 30% WCGF or 30% WDGS on a dry matter basis. Feed bunks were checked twice daily, and feed was delivered in amounts sufficient to result in clean feed bunks both morning and afternoon. Calves were fed their respective diets at approximately 7:00 a.m. and 3:00 p.m. daily for 58 days. Calves were then fed a common diet for an additional 14 days to equalize gut fill after which time cattle were weighed to determine a final body weight. Daily dry matter intake, gains, and feed efficiencies were determined for each pen of calves. Growth performance and feed intake data was analyzed as a randomized complete block design using SAS. Health data was analyzed using Pearson’s chi-square using the FREQ procedure. Feeding WDGS during the receiving period increased dry matter intake (P<0.04) but did not improve growth performance compared to cattle fed the Control and WCGF diets. Feeding WDGS during the growing period provided

for increased ADG (*P*<0.01) and improved feed efficiency (*P*<0.05) compared to cattle fed the Control or WCGF diets. Based on Pearson's residual, it appears there is a reduction for 1st treatments for BRD for those calves fed WDGS.

Using RAMP to eliminate grain adaptation diets *C.J. Schneider, B.L. Nuttelman, A.L. Shreck, D.B. Burken, T.J. Klopfenstein, and G.E. Erickson***,** *University of Nebraska, Lincoln* Three experiments evaluated transitioning cattle from RAMP, a complete starter feed (Cargill Corn Milling, Blair, NE), to a finishing diet to determine if adaptation diets can be eliminated when using RAMP for grain adaptation. In Exp. 1, 300 steers (BW=638±48 lb) were assigned to 30 pens resulting in10 steers/pen. The control adaptation treatment involved a 4-step system (4-STEP) which gradually decreased RAMP inclusion (100 to 0%) while increasing finishing ration which contained 47.5% Sweet Bran (0 to 100%) equally over 4 periods (4, 6, 6, and 6 d) by mixing RAMP with a finishing ration. Additional treatments involved either a 2-step system (2-STEP) which fed RAMP for 10 d followed by a 50:50 blend of RAMP and finisher for 4 d before feeding the finishing diet on d 15, or a 1 step adaptation system (1-STEP) which involved feeding RAMP for 10 d and switching directly to a finishing diet on d 11. From d 29 until slaughter a common finishing diet was fed. Daily gain, DMI, and G:F were not different (P > 0.20) among treatments on d 39 or over the entire feeding period. Adaptation treatment did not affect carcass traits (P > 0.30) or the incidence of liver abscesses (P > 0.61). Liver abscess prevalence was very low at 3% overall which may suggest that acidosis was minimal in this trial. In Exp.2, individually fed yearling steers (n=60; BW=844 ± 33 lb) were assigned randomly to 1 of 3 adaptation treatments. Adaptation treatments included 4-STEP and 1-STEP from Exp. 1 and a traditional adaptation program (TRD) which decreased alfalfa hay inclusion (45 to 7.5%) while corn inclusion increased (25 to 62.5%) over 4 periods (4, 6, 6, and 6 d). On d 28, all cattle were switched to a common finishing diet and remained on a common diet for the entire 138 d finishing period. During grain adaptation, 1-STEP cattle had greater ADG (P=0.02) and G:F (P=0.04) compared to TRD and tended to have greater ADG compared to 4-STEP (P=0.10). Feed intake variance among d for animals was greater for TRD compared to 4-STEP and 1-STEP (P < 0.04), but DMI were not different (P = 0.50) during the adaptation period. Feedlot performance over the 138 d period and carcass traits were not affected (P>0.15) by adaptation treatment. In Exp. 3, ruminally fistulated steers (n=12; BW = 877 ± 66 lb) were used to evaluate the effects of using the same adaptation programs used in Exp. 2 on ruminal pH and DMI. Intakes were similar for all treatments during the 28 d adaptation period (P = 0.53) or during the 14 d period when cattle were fed a common finishing diet. (P = 0.77). Cattle on the 4-STEP treatment cattle spent more time eating when compared to 1-STEP (P = 0.02) or TRD (P < 0.01) during the adaptation period and compared to TRD (P = 0.04) while on a common finishing diet. During the adaptation system, average ruminal pH was greater for 1-STEP (P = 0.04) and 4-STEP (P = 0.10) and time below pH of 5.6 was lower for 1-STEP (P = 0.03) when compared to TRD. While cattle were fed a common finishing diet, there were no differences among treatments for average ruminal pH, pH variance, or time and area below pH 5.6 (P > 0.16). Regardless of adaptation period length, RAMP treatments increased eating time and average ruminal pH during the adaptation period which may suggest less risk of acidosis when using RAMP to start cattle on feed. Cattle fed RAMP for 10 d can be transitioned directly to a finishing diet containing 47.5% Sweet Bran without affecting performance.

Effects of exchanging supplemental N with condensed distillers solubles on growth performance and carcass characteristics of feedlot *steers* *J. Simroth-Rodriguez[1], M. S. Brown[1], J. Kawas[2], J. Wallace[1], B. Coufal[1], R. Butler[1], H. Hughes[1], K. Kraich[1], and B. Mendonca[1], [1]Feedlot Research Group, West Texas A&M University, Canyon, [2]Facultad de Agronomía, Universidad Autónoma de Nuevo Leon, Monterrey, Nuevo Leon, Mexico*
Further assessment of the feeding value of condensed distillers solubles (CDS) is needed. Crossbred steers (initial BW = 827 +/- 24 lb) previously adapted to a finishing diet were blocked by BW and randomly assigned to treatments in a 2 x 2 + 1. Diets contained equal fat. The control diet was based on steam-flaked corn, with urea and cottonseed meal (CSM) providing supplemental N. In remaining diets, N from CDS replaced urea N or CSM N, with CDS included at either 10 or 20% of DM (11 pens/treatment). Composite samples for each diet were assayed and contained 13.45, 13.65, 13.90, 14,55, and 14.60% CP for the control, 10% CDS replacing urea N, 10% CDS replacing CSM N, 20% CDS replacing urea N, and 20% CDS replacing CSM N, respectively. The effects of CDS concentration and source of N replaced did not interact for growth performance or carcass measures ($P>0.12$). Steer DMI was 3.8% lower ($P=0.07$) for the control than when CDS N replaced a portion of urea N. Steer DMI was 3.4% higher and ADG was 3.7% greater ($P<0.06$) when CDS N replaced urea N than when CSM N was replaced. Steer DMI and ADG were not altered by CDS concentration. Steer ADG and feed efficiency were not different between the control and when CDS N replaced a portion of urea N nor when CDS N replaced urea or CSM N. However, feed efficiency was 3.0% poorer ($P=0.02$) when 20% CDS was fed compared to 10% CDS. Carcass measures were not different between the control and when CDS N replaced a portion of urea N ($P>0.49$). Hot carcass weight was lighter and LMA was larger ($P<0.08$) when CDS N replaced CSM N. Fat thickness, average yield grade, and calculated empty body fat were also lower ($P<0.03$) when CDS N replaced CSM N, whereas 20% CDS increased marbling score compared to 10% CDS ($P=0.03$). Results suggest that CDS N is a more effective replacement of urea N than cottonseed meal N. Replacing CSM N reduced ADG and carcass weight, and produced leaner carcasses, whereas carcass quality was slightly improved when more CDS was fed.

Non-protein nitrogen supplements to enhance low-quality forage utilization *C.C. Stefan, J.E. Sawyer, and T.A. Wickersham, Texas A&M University, College Station*
Efficacy of four NPN-based protein supplements for stimulating intake and digestion in cattle consuming low-quality forage (6.8% CP) was evaluated. Five ruminally-cannulated steers (238 kg ± 9.1 kg) were used in a 5 × 5 Latin square consisting of four supplements and a negative control (CON). Supplements were infused directly into the rumen, prior to feeding and included a 40% CP mineral mix (40MM; 100% of CP from biuret), 60% CP mineral mix (60MM; 100% of CP from biuret), 25% CP liquid (25L; 61% of CP from slow-release N source; RumaPro™, Anipro/Xtraformance Feeds), or 35% CP liquid (35L; 74% of CP from RumaPro™). Mineral mixes were provided at 114 g/d and liquids at 310 g/d. Periods were 14 d; 8 d adaptation to treatment and 6 d sample collection. Forage OM intake tended to be greater for 25L (5.56 kg/d; $P = 0.06$) and 35L (5.53 kg/d; $P = 0.08$) than CON (5.20 kg/d), but was similar to CON for 40MM (5.34 kg/d; $P = 0.44$) and 60MM (5.13 kg/d; $P = 0.71$). Total OM intake was greater ($P < 0.01$) for both liquid supplements (5.81 and 5.79 kg/d; 25L and 35L, respectively) than CON (5.20 kg/d), but 40MM (5.38 kg/d; $P = 0.33$) and 60MM (5.18 kg/d; $P = 0.92$) were comparable to CON. There were no differences ($P \geq 0.11$) between supplements and CON for total tract OM digestion, which ranged from 56.0 – 58.6%. Total digestible OM intake was greater ($P < 0.01$)

for 25L (3.4 kg/d) and 35L (3.36 kg/d) compared to CON (2.94 kg/d), but not for 40MM (3.03 kg/d; *P* = 0.43) or 60MM (3.06 kg/d; *P* = 0.27). Average ruminal NH_3 concentrations were greater (*P* < 0.01) with supplementation, 0.33 m*M* (CON) versus 1.06, 1.96, 1.71, and 2.09 m*M*, for 40MM, 60MM, 25L, and 35L; respectively. Ruminal VFA concentrations were greater (84.7 vs 98.7 m*M*) with supplementation (*P* < 0.06). Supplementation with liquids increased intake of digestible OM. In contrast, delivery of the mineral mixes did not significantly impact digestible OM intake. These data suggest a potential benefit to providing readily fermentable OM when delivering supplemental NPN to cattle consuming forage near the 7% CP thresh-hold, below which protein supplementation typically stimulates forage utilization.
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Relationship between chemical intramuscular fat percent measured by FOSS with ultrasound, carcass, and camera marbling scores *A. J. Thompson, F. R. B. Ribeiro, S. N. Aragon, W. C. Burson, J. Baggerman, A. Romano, A. D. Hosford, J. E. Hergenreder, and B. J. Johnson, Department of Animal and Food Sciences, Texas Tech University, Lubbock*
The objective of this study was to determine the relationship between intramuscular fat percentage measured by FOSS with marbling scores from real-time ultrasound (**RTU**), carcass and camera data to determine body composition in feedlot steers (n = 72). The RTU, camera and carcass data were collected on 72 crossbred feedlot steers within a 76 h period. Measurements of RTU were taken by a certified ultrasound technician approximately 24 h prior to slaughter using an Aloka 500-V instrument with a 17-cm 3.5 MHz transducer. Hair was clipped to less than 0.64 cm and vegetable oil was applied to enhance image quality. The RTU measured traits consisted of 12-13th rib backfat thickness (**uBF,** mean = 1.04 cm), 12-13th LM area (**uREA**, mean = 102.7 cm^2), and marbling score (**uMARB,** mean = 4.6). Intramuscular fat was converted to **uMARB** by using the equation: uMARB = ((769.7 + (56.69×uIMF))/100) – 5. Overall means for 48 h chill carcass data were 12-13th rib backfat thickness (**cBF**, 0.97 cm), 12-13th LM area (**cREA**, 103.5 cm^2), and marbling score (**cMARB**, 5.0). Marbling scores were converted to a numeric cMARB (Slight^{00} = 4, Small^{00} = 5, and Modest^{00} = 6). Carcass camera data consisted of 12-13th rib backfat thickness (**camBF**, 0.99 cm), 12-13th LM area (**camREA**, 103.8 cm^2), and marbling score (**camMARB**, 4.5). A face steak was collected from the 12-13th rib LM, trimmed of all excess fat to isolate the muscle, and chemical fat percentage was determined using a FOSS FoodScan near-infrared spectrophotometer. Data were analyzed using the PROC REG, MEANS and CORR procedures of SAS. Results show that all three carcass data collection methods were highly correlated to each other. Correlations ranged from 0.79 to 0.82, 0.68 to 0.95 and 0.57 to 0.87 for BF, REA, and MARB, respectively. Chemical measurement of IMF percent by FOSS was highly correlated to **uMARB** (0.62), **cMARB** (0.86), and **camMARB** (0.86). Ultrasound marbling scores overpredicted IMF (0.22%), while cMARB and camMARB under predicted IMF (-0.34 and -1.11% respectively). Carcass BF and camBF were over predicted by RTU (0.07 and 0.06 cm, respectively), however, REA was under predicted by RTU when compared to cREA and camREA (-0.78 and -1.13 cm^2, respectively). Camera MARB was over predicted by uMARB (0.17) and cMARB was under predicted (-0.32). These results show that linear measurements of carcass traits can be more accurately predicted by RTU when compared to a non-linear measurement (MARB). Validation through FOSS near-infrared spectrophotometry shows that we can also predict percent IMF from RTU, carcass and camera marbling scores.

The effect of calf age at weaning on cow and calf performance and efficiency in a drylot/confinement production system *J. M. Warner, K. H. Jenkins, R. J. Rasby, M. K. Luebbe, G. E. Erickson, and T. J. Klopfenstein, University of Nebraska, Lincoln*
Recent changes in production economics have impacted the long-term sustainability of the beef cow-calf industry. Confinement of beef cows may be an alternative to improve production efficiency and reduce the land base needed for cow-calf production. Therefore, the objectives of this research were to evaluate the effect of calf age at weaning on cow and calf performance and the efficiency of producing a weaned calf to 205 d of age in a total confinement production system. Multiparous, crossbred (Red Angus x Red Poll x Tarentaise x South Devon x Devon), lactating beef cows (n = 84) with summer-born calves at side were blocked by prebreeding BW (H, M, L), stratified by calf age, and randomly assigned to 1 of 4 treatments within strata. The experiment was a randomized complete block design with a 2 x 2 factorial arrangement of treatments. Cow-calf pairs managed at 1 of 2 research feedlots (ARDC or PREC) were weaned at 90 (EW) or 205 (NW) d of calf age. Early weaning coincided with the onset of the breeding season. Regardless of location, EW calves and cows and NW pairs were fed a common diet (60:40 distillers grains:crop residue, DM) from the time of early to normal weaning. EW cows were limit-fed (15.0 lb DM/cow/d) while EW calves were fed *ad libitum*. NW pairs were limit-fed the equivalent amount of DM consumed by EW cows and calves. All cow-calf pairs were managed in earthen feedlot pens throughout the experiment. Pen was considered the experimental unit. Cow BW and BCS prebreeding were similar ($P = 0.56$) between EW and NW cows. At normal weaning, EW cows had greater ($P = 0.05$) BW than NW cows. Body weight change from early to normal weaning was 46 lb greater ($P \leq 0.01$) for EW than NW. Cow BCS at normal weaning was not impacted ($P = 0.23$) by weaning regimen or location. Calf BW at early weaning was not different ($P = 0.85$) between EW or NW calves. EW calves gained 22 lb less than NW from early to normal weaning. EW cows and calves consumed 23.5 lb DM total/d while NW pairs consumed 22.8 lb/pair/d. Final pregnancy rates were similar ($P = 0.74$) between EW and NW cows. Early weaning has minimal impact on cow or calf performance or cow reproduction when pairs are limit-fed in confinement.

Effect of supplemental protein amount and degradability on intake and digestion in *Bos indicus* and *Bos taurus* steers fed rice straw *K.K. Weldon, J.C. McCann, J.E. Sawyer, and T.A. Wickersham, Texas A&M University, College Station*
We evaluated effects of amount and degradability of supplemental protein on utilization of low-quality forage in 5 Angus steers (*Bos taurus*- **Bt**, BW = 303 ± 10 kg) and 5 Brahman steers (*Bos indicus*- **Bi**, BW = 323 ± 28 kg). Steers fitted with ruminal and duodenal cannulas were used in concurrent 5 × 5 Latin squares. Treatments were arranged as a 2 × 2 factorial plus a control (CON; no supplementation). Isonitrogenous (27% CP) supplements were formulated to provide different proportions of ruminally degradable protein (**DIP**; **L** = 28% DIP or **H** = 72% DIP). Each type of supplement was fed to deliver 60 or 120 mg of N/kg BW. Steers had ad libitum access to rice straw (4.4% CP, 72.8% NDF). Experimental periods were 15 d; 9 d adaptation and 6 d sample collection. Forage OM intake (**FOMI**) was greater for Bt than Bi ($P = 0.05$). Supplementation increased FOMI in both Bt and Bi ($P < 0.05$); Bi FOMI was increased from 13.5 g/(kg BW·d) to 14.8 g/(kg BW·d) and Bt from 16.5 g/(kg BW·d) (CON) to 17.6 g/(kg BW·d). Neither protein source, amount, nor their interaction affected FOMI within Bi or Bt ($P > 0.20$). OM digestibility (**OMD**) was greater in Bi than Bt ($P < 0.01$). Supplementation did not affect OMD in Bt ($P = 0.53$; 54.4% vs. 53.6% for CON vs. supplement), but increased OMD for

Bi (P = 0.02) from 53.4% (CON) to 57.0% (supplemented). There were no source, amount, or source × amount effects (P > 0.37) within Bi or Bt for OMD. Total digestible OM intake (**TDOMI**) was similar between breeds (P = 0.12), and increased (P < 0.01) with supplementation. A 14% increase in TDOMI was observed from CON for Bt (P = 0.04); TDOMI increased 29% from CON for Bi (P = 0.05). There were no source, amount, or source × amount effects (P > 0.22) within either breed for TDOMI. While Bt had significantly higher FOMI, an increase in OMD for Bi with supplementation resulted in similar overall TDOMI between breeds.

Effects of Next Enhance 300 on *in vitro* fermentation, feedlot performance, carcass characteristics, meat quality, and consumer sensory characteristics of Longissimus steaks of beef steers *M.C. Westerhold[1], Z.D. Callahan[1], M.S. Kerley[1], C.L. Lorenzen[1], W.J. Sexten[1], B.R. Wiegand[1], and T.J. Wistuba[2], [1]Division of Animal Sciences, University of Missouri, Columbia, [2]Novus International Inc., St. Charles, MO*
Three experiments were conducted to evaluate how feeding Next Enhance 300 (**NE**) affects *in vitro* fermentation, feedlot performance, carcass traits, meat quality, and consumer sensory characteristics of LM steaks from beef steers. Dual-flow continuous culture (**CC**) fermenters were used to assess the fermentation characteristics of rumen microbiota in CC with increasing NE levels (**EXP1**). A feedlot trial (**EXP2**) was conducted using crossbred steers (n=98) to evaluate the effect of NE on growth performance and carcass characteristics. At harvest, the heaviest steer/pen (five steers/treatment; **TRT**) was sent to the University of Missouri abattoir. LM steaks from these steers were used to evaluate meat quality and consumer sensory characteristics (**EXP3**). In EXP1 two CC fermentation runs were conducted using a corn based diet with treatment (**TRT**) levels of 0, 15, 30, 60, 120, and 240 mg·kg^{-1} DM. Microbial efficiency, pH, ammonia, and VFA concentrations were not affected by NE (P>0.10). OM (P=0.05) and CP (P=0.02) digestibility quadratically increased, with 30 and 60 mg·kg^{-1} DM being the highest. In EXP2, TRT consisted of 0 (**CON**, n=25), **150** (n=24), **300** (n=25), and **600** (n=24) mg·hd^{-1}·d^{-1} NE. NE caused a linear decrease (P<0.05) in DMI at d 28, 56, and 84. However, overall DMI did not differ (P=0.19). ADG of steers fed the 150 diet was the highest at d 28 (P=0.05) and 56 (P=0.10). However, due to the decreased performance of steers fed the 300 and 600 diets, a linear decrease (P<0.05) was observed for d 28, 56, and overall ADG. D 28 G:F of steers fed the 150 diet did not differ from CON but was improved (P<0.05) when compared to 300 and 600 steers. There was a linear decrease (P=0.01) in overall G:F due to decreased efficiency of steers fed the 600 diet. A quadratic increase (P=0.01) in dressing percent (**DP**) and a quadratic decrease (P=0.05) in 12th rib backfat (**BF**) were observed, with CON steers having the lowest DP and the most BF. NE tended to cause a quadratic increase (P=0.10) in LM area (**LMA**) and LMA/45.4 kg. Consequently, there was a quadratic decrease (P=0.04) in calculated USDA yield grade in response to NE. HCW and marbling score did not differ (P>0.05) among TRT. In EXP3, NE inclusion did not affect a* or b* color values at 96 h post mortem (d 0) or d 14. NE linearly decreased (P=0.05) L* values a d 0, but did not affect d 14 L* values. NE caused a linear decrease (P=0.07) in cook loss. A consumer sensory panel (n=55) was performed on one steak/steer, with 4-5 panelists evaluating each sample. There was no difference (P>0.05) among TRT for Warner-Bratzler Shear Force, drip loss, percent moisture, percent fat, consumer opinion of overall like, or liking and level of tenderness, juiciness, and flavor. Including NE at 30 and 60 mg·kg^{-1} diet DM increased digestion *in vitro*. When fed to feedlot steers at 150 and 300 mg·hd^{-}

$^{1}\cdot d^{-1}$ (levels similar to those eliciting a response in EXP1) NE improved ADG, DP, BF, LMA, and yield grade, and had no effect on sensory characteristics of LM steaks from beef steers.

The effect of *Aspergillus oryzae* extract on feedlot performance and carcass merit in yearling steers fed steam-flaked corn based finishing diets *K.A. White[1], J.J. Wagner[2], T.E. Engle[1], D.R. Woerner[1], R.K. Peel[1], T.C. Bryant[2], J.S. Jennings[3], and K.M. Brennan[3], [1]Animal Sciences Department, Colorado State University, Fort Collins, [2]JBS Five Rivers Cattle Feeding, Greeley, CO, [3]Alltech, Inc. Nicholasville, KY*
Crossbred yearling steers (n = 540) averaging 319.8 ± 7.11 kg initial BW were utilized in a randomized block design experiment to evaluate the effects of supplementing a steam-flaked corn based finishing diet with *Aspergillus oryzae* extract containing α-amylase activity on feedlot performance and carcass characteristics. Within each of 2 years, steers were ranked by weight and allocated into 15 weight block replicates. Within each weight block replicate, steers were randomly assigned to 1 of 2 treatments resulting in 9 steers per pen. Treatments consisted of: 1. Amaize® (AMZ; 5 g/head daily providing 750 fungal α-amylase units/g, Alltech Inc. Nicholasville, KY) and 2. Control (CON; providing 5 g/head daily of a corn meal placebo). Cattle were fed for 152 d in year 1 and 149 d in year 2. Initiation of treatment diets was on d 0 in year 1 and on d 21 in year 2. Initial and final BW were the average of 2 individual weights obtained on study d -1 and 0 and on 2 consecutive days immediately prior to harvest, respectively. Feedlot performance and continuous carcass data were analyzed using PROC MIXED of SAS. Fixed classification variables in the model included treatment, year, and treatment*year. Random variables included weight block replicate and weight block replicate within year. Initial BW was included in the model as a covariate when ($P < 0.10$). Categorical carcass data were analyzed using PROC GLIMMIX of SAS using the same model as for continuous data but assuming a binomial distribution. Final BW ($P = 0.71$), DMI ($P = 0.80$), ADG ($P = 0.78$), gain efficiency ($P = 0.54$), and net energy for maintenance ($P = 0.57$) and gain ($P = 0.58$) calculated from performance were similar across treatments. Dressing percentage ($P = 0.01$) and hot carcass weight ($P < 0.10$) was increased for steers fed AMZ as compared with CON (63.4 vs 62.9% ± 0.13 and 365.6 vs 361.5 kg ± 1.95, respectively). Carcass maturity, marbling score, and the distribution of USDA quality grade was not influenced ($P > 0.15$) by treatment. Longissimus muscle area ($P = 0.10$) was increased for the AMZ treatment as compared with CON. Remaining carcass variable were not impacted by treatment ($P > 0.15$). The year by treatment interaction was significant ($P < 0.01$) for liver abscess rate suggesting that AMZ reduced liver abscesses in year 1 but increased the percentage of abscessed livers in year 2. The results of this study suggest that feeding AMZ had minimal impact on feedlot performance but did increase dressing percentage, LM area, and hot carcass weight.

Evaluation of multiple ancillary therapies utilized in combination with an antimicrobial in newly received, high-risk calves treated for bovine respiratory disease *B. K. Wilson[1], C. L. Maxwell[1], D. L. Step[2], C. J. Richards[1], and C. R. Krehbiel[1], [1]Department of Animal Science, Oklahoma State University, Stillwater, [2]Department of Veterinary Clinical Sciences, Oklahoma State University, Stillwater*
Bovine respiratory disease (BRD) is the leading cause of morbidity, mortality, and decreased production in feedlots, with estimated annual economic losses in excess of $1 billion. The standard protocol when treating for BRD or undifferentiated fever in feedlot cattle is to administer some class of injectable antimicrobial. However, it is common to provide some form

of additional treatment, or ancillary therapy, in conjunction with an antimicrobial when treating for suspected BRD in feedlot cattle. The goal of ancillary therapy is to improve the response to a BRD challenge in calves treated with antimicrobials, not to replace antimicrobial treatment. This can be accomplished by relieving the harmful effects of inflammation, blocking histamine activity, or boosting immune system function to aid in the defense against infectious pathogens (Apley, 1994). The objective of this experiment was to evaluate the effects of 3 commonly used ancillary therapies in combination with an antimicrobial in newly received, high-risk calves treated for bovine respiratory disease (BRD). Crossbred steers (n = 516; initial BW = 217 ± 20 kg) were monitored daily by trained personnel for clinical signs of BRD. Calves that met treatment criteria (n = 320) were given an antimicrobial and then randomly assigned to 1 of 4 experimental treatment groups: intravenous flunixin meglumine injection (NSAID), intranasal viral vaccination (VACC), intramuscular vitamin C injection (VITC), or no ancillary therapy (NOAC). First treatment morbidity was 66.5% and mortality attributed to BRD was 12.6%. Steers receiving VACC tended ($P = 0.10$) to require a second BRD treatment less frequently than steers receiving NSAID or NOAC. Calves receiving NSAID or VITC tended ($P = 0.09$) to require a third BRD treatment less often than calves receiving NOAC. Of calves treated 3 times for BRD, those receiving NOAC had lower ($P = 0.05$) severity scores than those receiving VACC or VITC and heavier ($P = 0.02$) BW than those receiving NSAID, VACC, or VITC at the time of third treatment. Between the second and third BRD treatments, calves receiving NOAC also had greater ($P = 0.03$) ADG than those receiving VACC or VITC and tended ($P = 0.06$) to have greater ADG than those receiving NSAID. Calves receiving NOAC tended ($P = 0.07$) to have heavier BW on d 28 than NSAID, VACC, or VITC with mortalities and removals excluded. When contrasted with the average of NSAID, VACC, and VITC calves, NOAC calves tended ($P < 0.10$) to have heavier BW on d 56, greater ADG and DMI from first BRD treatment through d 28, greater DMI from d 28 through d 56, and had greater ($P = 0.05$) DMI from first BRD treatment through d 56 with mortalities and removals excluded. Responses to the 3 ancillary therapies used in this experiment were negligible. The use of NSAID, VACC, and VITC appears to have minimal benefits and could potentially be detrimental to animal performance in severely challenged calves.