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SPRING CONFERENCE**

**APRIL 22-23, 2010
SAN ANTONIO, TEXAS**

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The 2010 Plains Nutrition Council Spring Conference

Thursday, April 22

8:30 – 11:30AM *Intervet/Schering Plough Symposium*

2010 Plains Nutrition Council Spring Conference

- 1:00 PM **Welcome and Introduction** - *Dr. Justin Gleghorn, President Plains Nutrition Council, Brock Thompson Trading, LLC, Amarillo*
- 1:10 PM **Influence of Hedge Funds in Commodity Markets** – *Mr. Jim Green, Rosenthal Collins Group, Chicago*
- 1:40 PM **The Economy and the Ag Sector: What Lies Ahead?** - *Dr. Danny Klinefelter, Texas AgriLife Extension Service-Texas A&M System, College Station*
- 2:15 PM **Break and View Graduate Research Posters**
- 2:45 PM **Caloric Density in Feedlot Diets** – *Dr. Clint Krehbiel, Oklahoma State University, Stillwater*
- 3:30 PM **Using Models to Estimate Feed Efficiency** – *Dr. Luis Tedeschi, Texas AgriLife Research-Texas A&M System, College Station*
- 4:15 PM **Duration of Feeding: Decision Points** - *Dr. Kelly Bruns, South Dakota State University, Brookings*
- 5:00 PM **Recognition of Professional Excellence
View Graduate Research Posters**
- 5:30-7:30PM **Reception - Sponsored by Sweet Bran**

Friday, April 23

- 8:00 AM **PNC Business Meeting**
- 8:15 AM **University Updates** – *Dr. Karla Jenkins, University of Nebraska-Lincoln, Scotts Bluff; Dr. Jim Drouillard, Kansas State University, Manhattan; Dr. Mike Brown, West Texas A&M University, Canyon*
- 9:10 AM **Practical Applications of Genetic Markers in the Cattle Feeding Sector** – *Dr. Mark Allan, Pfizer Animal Genetics, Lincoln, NE*
- 10:00 AM **Break and View Graduate Research Posters**
- 10:30 AM **Nutritional Management Approaches for Receiving and Starting Cattle** - *Dr. Britt Hicks, Oklahoma Cooperative Extension Service – Oklahoma State University, Goodwell
Mr. Keith Hansen, Nutrition Service Associates, Hereford, TX
Dr. Del Miles, Veterinary Research and Consulting Services, Greeley, CO
Dr. Tom Peters, SALT Consulting, Oregon, IL*
- 11:45 AM **Graduate Student Poster Recognition and Awards**
- 12:00PM **Adjourn**



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The Economy and the Ag Sector: What Lies Ahead

*Danny Klinefelter
Texas AgriLife Extension Service/Texas A&M University
College Station*

“In times of change, the learners inherit the earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists.”

--Eric Hoffer

The Economy and the Ag Sector: What Lies Ahead

1. How severe problems become for the agricultural sector as a whole will depend primarily on three factors:
 - How soon net farm income rebounds
 - What happens to land values
 - How soon and how much interest rates increase

The Economy and the Ag Sector: What Lies Ahead

2. Macroeconomics are just as important as microeconomics to the health of the ag sector
 - Interest rates – monetary policy, fiscal policy
 - Value of the dollar – trade, oil prices, interest rates
 - Unemployment rates – 80 percent of total farm household income is now derived from transfer payments and off-farm employment
 - Inflationary expectations – yield curves, land values
 - Global economic conditions – export markets, competitors, investors in U.S. treasuries
 - Taxes
 - Consumer spending – domestic, global, choices
 - Policies and regulations – economic impacts, agencies other than USDA

The Economy and the Ag Sector: What Lies Ahead

3. Markets overact on both the upside and the downside
 - Irrational exuberance/fear: Alan Greenspan, “80 percent of market economics are psychology.”
 - What appreciates can depreciate and quickly
 - The market value debt to asset ratio tends to be a lagging indicator
 - The debt to income ratio is a better leading indicator

The Economy and the Ag Sector: What Lies Ahead

4. Financial regulators

- Regulators and Congress are always more reactive than proactive, but their actions drive how lenders operate
- The administration may be providing liquidity and encouraging lenders to get credit flowing again, but commercial bank and Farm Credit System regulators are aggressively working to make sure lenders recognize and mitigate risk
- Bank failures, FDIC losses and higher limits on insured deposits prompted FDIC to require bankers to prepay their premiums for the next 3 years

The Economy and the Ag Sector: What Lies Ahead

4. Financial regulators (continued)

- Congress/regulators are considering higher minimum capital requirements to mitigate risk
- Add these costs to higher risk premiums, increased funding of loan loss reserves, and interest rate spreads are going to increase

The Economy and the Ag Sector: What Lies Ahead

5. We've learned that Black Swan events are real. The tails of economic/financial distributions are larger than the normal distribution assumptions. Most risk models only capture "normal" periods, and that includes the rating services, e.g., Moody, Dun and Bradstreet, etc.
 - Econometric models are data dependent and backward looking
 - Total enterprise risk management is critical, but implementing it is both expensive and easier said than done. Even the most sophisticated financial institutions are still basically solo risk managers.

The Economy and the Ag Sector: What Lies Ahead

6. Return to "normal" margins in grains
 - Dairy and hogs were underwater for over a year, supplies have to come down – 2010 will see both foreclosures and voluntary exits
 - Remember, the function of a competitive market is to drive the economic return to the average producer to breakeven through supply and demand responses in both input and output markets. In equilibrium the top end are profitable and growing, the average are hanging in there, and the bottom end are losing money and exiting the industry. Business success and survival depend on continuous improvement at a pace necessary to stay out of the back of the pack.

The Economy and the Ag Sector: What Lies Ahead

6. Return to “normal” margins in grains (continued)
 - There hasn’t been much involuntary exit from agriculture in the last 4-5 years.
 - In competitive markets, extended boom periods tend to be followed by a cleansing period of about 3 years that can have a hangover for another 2 years.
 - The “half life” of lessons learned in a financial crisis appears to be about 10 years.

The Economy and the Ag Sector: What Lies Ahead

7. Lender impacts and reactions
 - Bank failures and the number of stressed FCS associations have increased – more mergers coming
 - Loan loss reserve requirements are now expected to be more forward looking and anticipatory, and less dependent on recent history
 - Greater emphasis is being placed on shock testing and portfolio concentration.

The Economy and the Ag Sector: What Lies Ahead

7. Lender impacts and reactions (cont.)

- Changes in lending practices
 - Less appetite for risk
 - More and better documentation of information provided by borrowers, and closer monitoring of performance after the loan is made
 - Increased emphasis on repayment capacity, including accrual adjusted net income
 - Working capital/liquidity – cash is king, but a borrower can be making payments and going broke
 - Shorter repricing terms (ability to sell or match fund)

The Economy and the Ag Sector: What Lies Ahead

7. Lender impacts and reactions (cont.)

- Changes in lending practices (cont.)
 - Higher interest rate spreads
 - Lower advance rates, i.e., higher equity or down payment requirements on new loans
 - Higher risk premiums – inadequate premiums had been priced into higher risk loans, often because of competition
 - More emphasis on borrower's risk management
 - Loans requiring overlines and participations are facing a pushback and fewer options
 - The use of FSA guarantees is increasing significantly, but there are looming issues

The Economy and the Ag Sector: What Lies Ahead

8. Interest rates and debt structure are as important as debt levels in terms of the impact of debt on producer's financial performance, and rates can change much more rapidly.
9. Farm operator's management ability is the primary determinant of success or failure, and it is hard to capture in risk rating models
 - Consulting study, Illinois, Kansas, SPA

The Economy and the Ag Sector: What Lies Ahead

10. Risk management will determine the winners and the losers, particularly as increased volatility gets priced into or pushed down the supply chain.
11. Counter party risk is becoming an increasing issue for producers, lenders, suppliers and buyers of agricultural products.

The Economy and the Ag Sector: What Lies Ahead

12. Eighty seven percent of total farm assets are in real estate.

- The ultimate financial impact on the financial health of the ag sector will be determined by and reflected in land values
- Census of Agriculture data
- While 70 percent of farm operations carry no debt, debt use is more concentrated among capital intensive and larger operations that depend primarily on farm business income

The Economy and the Ag Sector: What Lies Ahead

12. Eighty seven percent of total farm assets are in real estate (cont).

- Much of the shift away from debt has occurred among farms generating less than \$500,000 annual gross sales
- 42 percent of land in farms is owned by non-operator landlords, of the 58 percent owned by farmers, 61.3 percent is by farmers with less than \$250,000 annual gross sales

Caloric Density in Feedlot Diets

C. R. Krehbiel and L. O. Burciaga-Robles¹

Department of Animal Science, Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater; Feedlot Health Management Services, Okotoks, Alberta, Canada

The relationships between dietary energy density and animal performance were determined in an effort to evaluate a possible upper limit for energy density in finishing diets for cattle. Data were combined from 85 experiments (335 treatment observations) in which the dietary metabolizable energy [ME] concentration (Mcal/kg DM) was varied by level of concentrate, grain source, grain processing, level of dry or wet distillers grains plus soluble (DGS), and/or level of supplemental fat. Dietary concentrations of ME were determined using: 1) NRC (1996) values of ME from diet ingredients; or 2) values calculated from animal performance using NRC (1996) equations. Procedures for pooling data from multiple studies were used. Trial-adjusted dependent variables (dry matter intake [DMI], average daily gain [ADG], and gain efficiency [G:F]) were regressed on the independent variable (dietary ME concentration). Assuming NRC ME values for ingredients commonly used in finishing diets are correct, the upper caloric limit for maximizing ADG was determined to be 3.18 Mcal/kg DM. However, gain efficiency (G:F) increased linearly ($r^2 = 0.64$) as dietary ME increased. Assuming metabolic disorders can be prevented, it appears that caloric density of diets for feedlot cattle can be maximized to maximize feed efficiency.

Total Calories and Feedlot Cattle Performance

Modern diets for feedlot cattle contain from approximately 2.70 to 3.45 Mcal ME/kg DM (Krehbiel et al., 2006). Caloric density of finishing diets varies due to differences in grain level (66 to 88%; Vasconcelos and Galyean, 2007), source, and degree of processing (Owens et al., 1997); grain coproducts (5 to 50%; Vasconcelos and Galyean, 2007); roughage level (4.5 to 13.5%; Vasconcelos and Galyean, 2007); and fat supplementation (2.5 to 6.5%; Vasconcelos and Galyean, 2007; Zinn and Plascencia, 2002); among other factors (e.g., protein, liquid supplements). Grains, primarily corn, sorghum, barley and/or wheat, are the main constituents of diets for feedlot cattle, and are often processed to increase ruminal and total tract starch digestibility and ME concentration of the diet (Owens et al., 1997; Krehbiel et al., 2006). Feedlot performance is also influenced by roughage level and source, due to their affects on DM and NE intake (Galyean and Defoor, 2003). Fat is supplemented to finishing diets (2.5 to 6.5% of DM; Galyean and Gleghorn, 2002) to increase dietary energy density. Although increasing ME intake by supplementing fat has generally increased feed efficiency, supplementing fat above 6 to 7% of DM has resulted in decreased intake to a level where feed efficiency is maintained or decreased (Zinn, 1989; Krehbiel et al., 1995).

Ferrell and Jenkins (1995) showed that over a wide range of DMI, the relationship between ADG and feed intake appeared to be non-linear, suggesting that as feed intake increases, the incremental increase in ADG decreases. In a summary by Krehbiel et al. (2006), when dietary ME values were calculated using NRC (1996) values, a quadratic relationship was observed

between ADG and dietary ME concentration, with ADG increasing at a decreasing rate as dietary ME concentration increased. Results indicated that ADG reached an asymptote when dietary ME was 3.16 Mcal/kg DM. However, the equation relating ADG to dietary ME concentration accounted for only 23% of the variation in ADG. Gain:feed was maximized at 3.46 Mcal ME/kg DM. These data indicated that the relationship between G:F and dietary ME is non-linear in cattle fed high-energy diets, suggesting that as ME increases, G:F increases but at a decreasing rate. However, Krehbiel et al. (2006) cautioned that the calculated maximum for G:F derived from the equation using NRC (1996) values was above the upper range of the data for dietary ME, and that dietary ME of 3.46 Mcal/kg DM would be untenable using most practical formulation constraints for feedlot diets.

For the present paper, 90 additional treatment means were added to the data set presented by Krehbiel et al. (2006) from diets containing varying amounts of DGS. Procedures described by St-Pierre (2001) and applied by Krehbiel et al. (2006) for pooling data from multiple studies were used (MIXED procedure of SAS; SAS Institute Inc., Cary, NC). Figure 1 shows the relationship between total dietary ME concentration calculated from NRC (1996) values of dietary ingredients to trial adjusted DMI (% of BW), ADG, and G:F. When ME was calculated using NRC (1996) values, a linear relationship was observed between DMI and dietary ME concentration, with DMI (% of BW) decreasing 0.91% for every Mcal increase in dietary ME. Plegge et al. (1984) summarized data from feedlot trials (617 pens and 14,199 total cattle) conducted at the University of Minnesota. Similar to the present data, mean feeding period DMI of all dietary ingredients was calculated for each pen of cattle, and ME values were assigned to each ingredient according to NRC (1984) for calculating dietary ME density. Dietary ME concentration from the summary by Plegge et al. (1984) ranged from 2.0 to 3.4 Mcal/kg of DM, and the relationship between DMI and dietary ME concentration appeared quadratic. Dry matter intake decreased as dietary ME increased from 2.5 (constant BW) or 2.8 (relative BW) to 3.4 Mcal/kg DM, which is consistent with the decreasing DMI with increasing dietary ME in the present data summary. Dry matter intake decreased across dietary ME values ranging from 2.66 to 3.29 Mcal/kg DM (calculated from NRC [1996] values) in the present analysis.

In addition to determining diet ME values from NRC (1996), we used average cattle weights across the feeding period and DMI to compute ME values of the diets as described by Owens et al. (1997). Quadratic procedures from appropriate net energy equations for medium-framed cattle (NRC, 1984; 1996) were used. For DMI (% of BW), the cubic function was significant ($P < 0.001$; $R^2 = 0.923$; Figure 2) when DMI vs. ME concentration calculated from performance was evaluated for the combined data analysis. This likely resulted from the apparent greater rates of decrease in DMI (% of BW) at dietary ME below 2.60 and above 3.5 Mcal ME/kg DM. However, similar to ME values calculated from dietary ingredients, DMI (% of BW) generally decreased as dietary ME increased.

For the present data, when ME values were calculated using NRC (1996) values, a quadratic relationship was observed between ADG and dietary ME concentration, with ADG increasing at a decreasing rate as dietary ME concentration increased (Figure 1). Taking the first derivative of the quadratic equation and solving for zero indicated that ADG reached an asymptote when dietary ME was 3.18 Mcal/kg DM. This is similar to the 3.16 Mcal/kg DM reported by Krehbiel et al. (2006) when diets containing DGS were not included in the data analyses. The equation

relating ADG to dietary ME concentration accounted for 23% of the variation ($P < 0.05$). When ME values calculated from performance were considered, the relationship of ADG to dietary ME concentration was linear (Figure 2) with a positive slope, and 57.0% of the variation in ADG was accounted for by ME concentration with this equation. In contrast with the previous report (Krehbiel et al., 2006), the present data show that the relationship between G:F and dietary ME is linear in cattle fed high-energy diets, suggesting that as ME increases, G:F increases (Figure 1). The cubic response for G:F in Figure 2 may suggest a lesser rate of increase in G:F at ME less than 2.6 and at ME greater than 3.4 Mcal/kg of DM when ME was calculated from performance data.

Calories in Diets Containing Distillers Grains Plus Solubles

The ethanol industry has expanded during the past several years which has greatly increased the interest in and need for data evaluating the effects of feeding coproducts to finishing cattle on performance and carcass merit (Klopfenstein et al., 2008). Distillers grain plus solubles is the primary coproduct produced from grain fermentation for ethanol production. For the present analysis, we used 90 treatment observations from experiments where ME was altered by level of dry or wet distillers grains (Table 1). A summary of diet characteristics and performance and carcass merit response variables for data used in the distillers grains analysis is shown in Table 2. Studies screened were limited to peer-reviewed journal articles or data from research reports summarized by Klopfenstein et al. (2008). All manuscripts containing data used for the present analyses are included in the literature cited.

Figure 3 shows the relationships between performance response variables and ME concentration from diets which contained DGS. Similar to the combined data set, a linear relationship was observed between DMI (% of BW) and dietary ME concentration, with DMI decreasing 1.71% for every unit increase in dietary ME concentration when DGS were included in the diet. Decreased feed intake appears to be a consistent response of finishing cattle to increased dietary energy density, most likely reflecting chemostatic intake regulation due to energy metabolism or potentially increased metabolic acid load. In contrast to the combined data set, the relationship between ADG and dietary ME concentration was not significant ($P > 0.10$) when DGS were included in the analysis (Figure 3). It should be noted that the established interaction between grain processing and level of dietary DGS was not considered in the present analyses, and 8 treatments means are from cattle fed steam-flaked corn and greater than 20% DGS. Similar to the combined analysis, the relationship between G:F and dietary ME was linear ($r^2 = 0.69$) for cattle fed high-energy diets containing DGS.

Interestingly, when ME values calculated from performance were evaluated, the relationships between performance response variables and ME concentration from diets which contained DGS were similar to when data from the combined analyses were evaluated (Figure 4). The exception was data for ADG, which was best fit by a quadratic equation. Taking the first derivative of the quadratic equation and solving for zero indicated that ADG reached an asymptote when dietary ME was 2.97 Mcal/kg DM. Diets around the asymptote generally contained a combination of

high-moisture and dry-rolled corn or steam-flaked corn, and 15 to 20% wet or dry distillers grains plus solubles.

Calories Due to Grain Source, Level, or Degree of Processing

Krehbiel et al. (2006) also evaluated the relationship between DMI and performance response and ME concentration from grain calculated using NRC (1996) values. Similar to the combined data set, a linear relationship was observed between DMI and dietary ME concentration, with DMI decreasing 0.61% for every unit increase in dietary ME concentration from grain (Figure 5). A quadratic relationship was observed between ADG and dietary ME concentration, with ADG increasing at a decreasing rate as dietary ME concentration increased. As described by the quadratic equation, ADG reached an asymptote when ME from grain was 2.59 Mcal/kg DM. In addition, when ME concentration from grain was evaluated as the independent variable, G:F was maximized at 2.99 Mcal ME/kg DM from grain. Woody et al. (1983) studied the effects of increasing grain in the diet on ADG and G:F. Regression analysis indicated that ADG increased 0.009 kg for each percentage unit increase in grain level between 30 and 70%. Similarly, feed efficiency was improved by 0.058 kg of diet DM for each percentage unit increase in grain over the same range. Dry matter intakes remained relatively constant as the percentage of grain in the diet increased to approximately 80%, and then decreased. Average daily gain was improved until grain level reached 80%, and then decreased due to lower DMI. Similarly, Owens and Gardner (2000) showed that increasing concentrate levels in grain-based diets increased ADG and G:F to a plateau.

Calories from Supplemental Fat

Fat is supplemented to finishing cattle diets (2.5 to 6.5% of DM; Galyean and Gleghorn, 2002) to increase dietary energy density. Although increasing ME intake by supplementing fat has generally increased G:F, supplementing fat above 6 to 7% of DM has resulted in decreased intake to a level where G:F is maintained or decreased. Zinn and Plascencia (2002) studied the effects of increasing tallow fatty acids (0, 3, 6, and 9%) on growth performance of steer calves fed a high-energy diet. Increasing level of fat supplementation linearly decreased ADG, DMI, and dietary NE. Observed/expected dietary NE_m was 1.03 with 3% supplemental fat and declined to 0.90% with 9% supplemental fat. Zinn and Plascencia (2002) concluded that the feeding value of total fatty acids was proportional to total fatty acid intake. When total dietary fatty acid intake was less than 6%, the NE value of total fatty acid was consistent to the tabular values for tallow. Above 6%, the energy intake, ADG, and the NE value of total fatty acids decreased.

Figure 6 shows the relationship between DMI and performance response and ME concentration from supplemental fat calculated using the NRC (1996) value for tallow (Krehbiel et al., 2006). A linear relationship was observed between DMI and ME concentration from supplemental fat, with DMI decreasing 0.26% for each unit increase in dietary ME concentration from fat. A quadratic relationship was observed between ADG and supplemental fat ME content. As described by the quadratic equation, ADG reached an asymptote when ME from fat was 0.26 Mcal/kg DM. In addition, when ME concentration from supplemental fat was evaluated as the independent variable, G:F was maximized at 0.43 Mcal ME/kg DM from fat.

Maximum ADG and G:F were achieved at the equivalent of 3.99 and 6.75% supplemental fat, respectively, when the NRC (1996) ME value for tallow was used. These data are in agreement with the level of supplemental fat currently being used in feedlot diets by consulting nutritionists (Vasconcelos and Galyean, 2007), and support the plateau in G:F observed above 6 to 7% supplemental fat.

Conclusions

There are several limitations to the present analyses. For example, potential interactions between dietary ingredients (e.g., roughage level and degree of grain processing; DGS level and degree of grain processing) were not considered. In addition, differences in total dietary fat with varying levels of DGS likely contributed to variation in the results. Dietary ME calculated from performance did not account for implant strategy, although the majority of cattle used for the present analysis were fed an ionophore. Despite the limitations, the data clearly demonstrate that DMI is regulated by caloric density of finishing diets. Because ADG increases and/or plateaus with increasing energy density, G:F increases (i.e., feed efficiency is improved). Using NRC (1996) values for ME of dietary ingredients, the upper caloric limit for maximizing ADG was 3.18 Mcal/kg DM. The data also indicate that DGS can replace grain, roughage and/or protein sources in diets for finishing cattle without dramatically altering the relationships between performance variables and dietary ME. In addition to using data to model the biological responses due to calories derived from different grain sources, processing methods, and inclusion of coproducts (tallow, DGS, etc.), similar data (or a similar approach) may also be useful for modeling economics of the cattle feeding enterprise. Based on energy, feed commodity, and cattle prices, there may be times when it's more economical to maximize ADG, and other times when it's more economical to maximize gain efficiency. Understanding these relationships may allow one to optimize caloric density of feedlot diets in order to maximize profit. More work is needed to understand how caloric density impacts carcass characteristics and value.

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Table 1. Number of observations for distiller's grains from literature data used for mixed model regression analyses

Distiller's	Grain Source		
	Corn	Grain sorghum	Wheat
Wet	47	5	-
Dry	26	2	10

Table 2. Data ranges for diet characteristics and performance and carcass merit response variables for data used in the distillers grains analyses

Item	Minimum	Maximum	Mean	Median
Animals/treatment observation	10	90	39	40
Diet composition (DM basis) ^a				
Grain inclusion, %	48.0	90.0	59.8	68.0
Total roughage inclusion, %	0.00	12.50	8.25	8.00
Coproduct inclusion, %	0.00	87.5	24.0	17.5
Total dietary fat, %	1.90	8.80	5.78	5.65
Protein, %	11.4	32.9	15.5	15.0
ME content of diet (Mcal/kg), NRC (1996) ^b	2.90	3.19	3.09	3.11
ME content of diet (Mcal/kg), calculated ^c	2.38	3.61	3.16	3.16
Performance variables				
Initial weight, kg	277	409	346	343
Final weight, kg	458	620	561	570
Days on feed	97	188	133	126
Avg. BW for feeding period, kg	395	506	451	451
ADG, kg	0.84	1.96	1.55	1.58
DMI, kg	7.00	13.37	9.84	9.69
DMI, % of BW	1.62	2.74	2.11	2.09
G:F	0.113	0.218	0.160	0.160
Carcass merit variables				
Carcass weight, kg	293	391	349	355
Dress, %	58.9	65.4	62.9	63.2
LM area, cm ²	71.4	101.8	83.6	82.6
12th-rib fat thickness, cm	0.86	1.57	1.27	1.27
Marbling score ^d	4.12	5.79	5.00	5.19
KPH, %	1.93	3.37	2.31	2.14
Yield grade	2.21	3.87	2.89	2.77

^aDiet values represent 90 total treatment means.

^bTabular ME values from NRC (1996) for dietary ingredients were multiplied by the percentage of that ingredient (DM basis) in the diet to calculate ME.

^cMetabolizable energy values for diets were calculated from performance and the net energy equations (NRC, 1996).

^dSlight⁰⁰=3.00, Small⁰⁰=4.00, Modest⁰⁰=5.00.

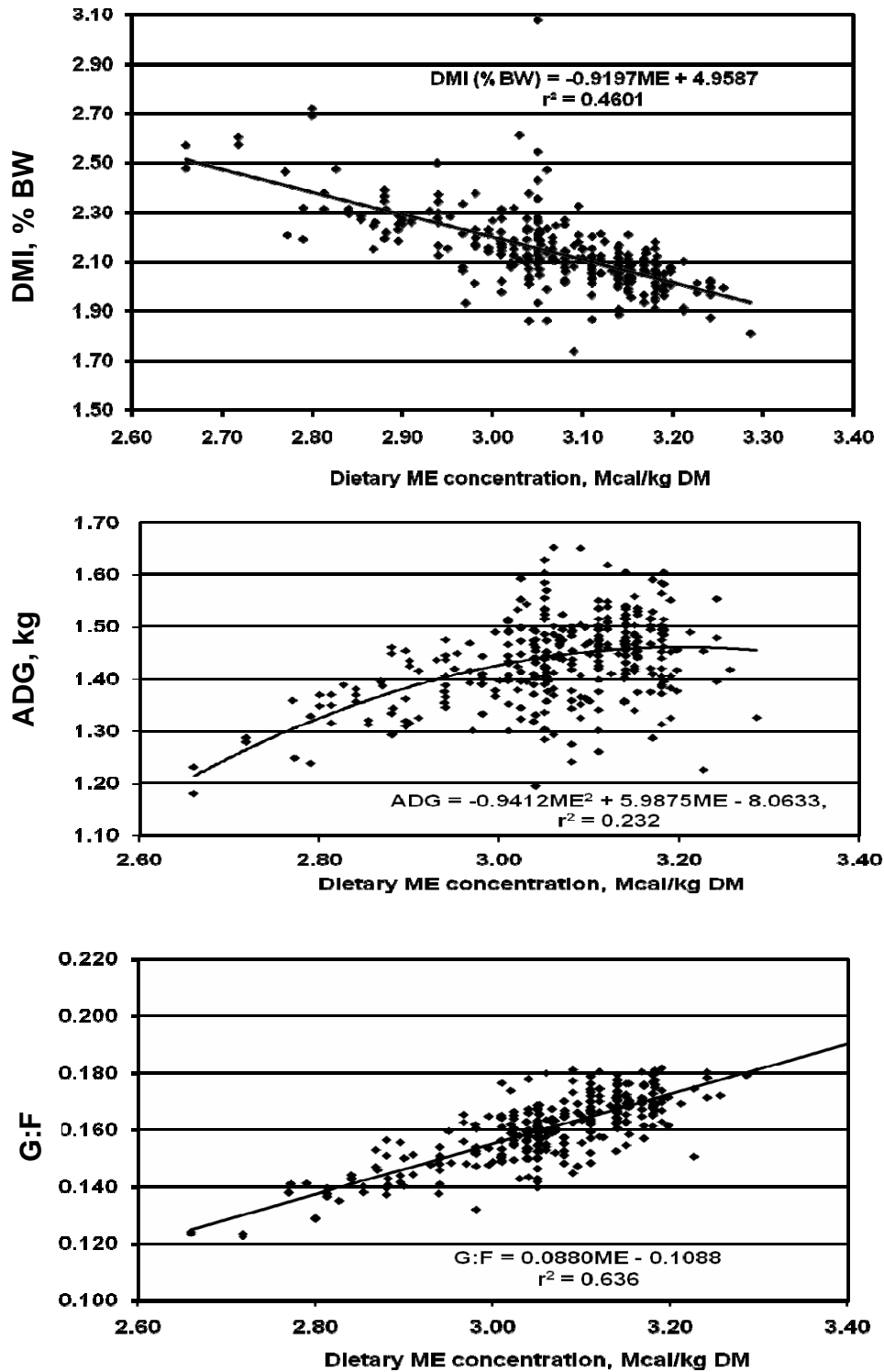


Figure 1. Relationship of dietary ME concentration calculated from NRC (1996) values of dietary ingredients to trial adjusted DMI (% of BW; top), ADG (middle) and G:F (bottom).

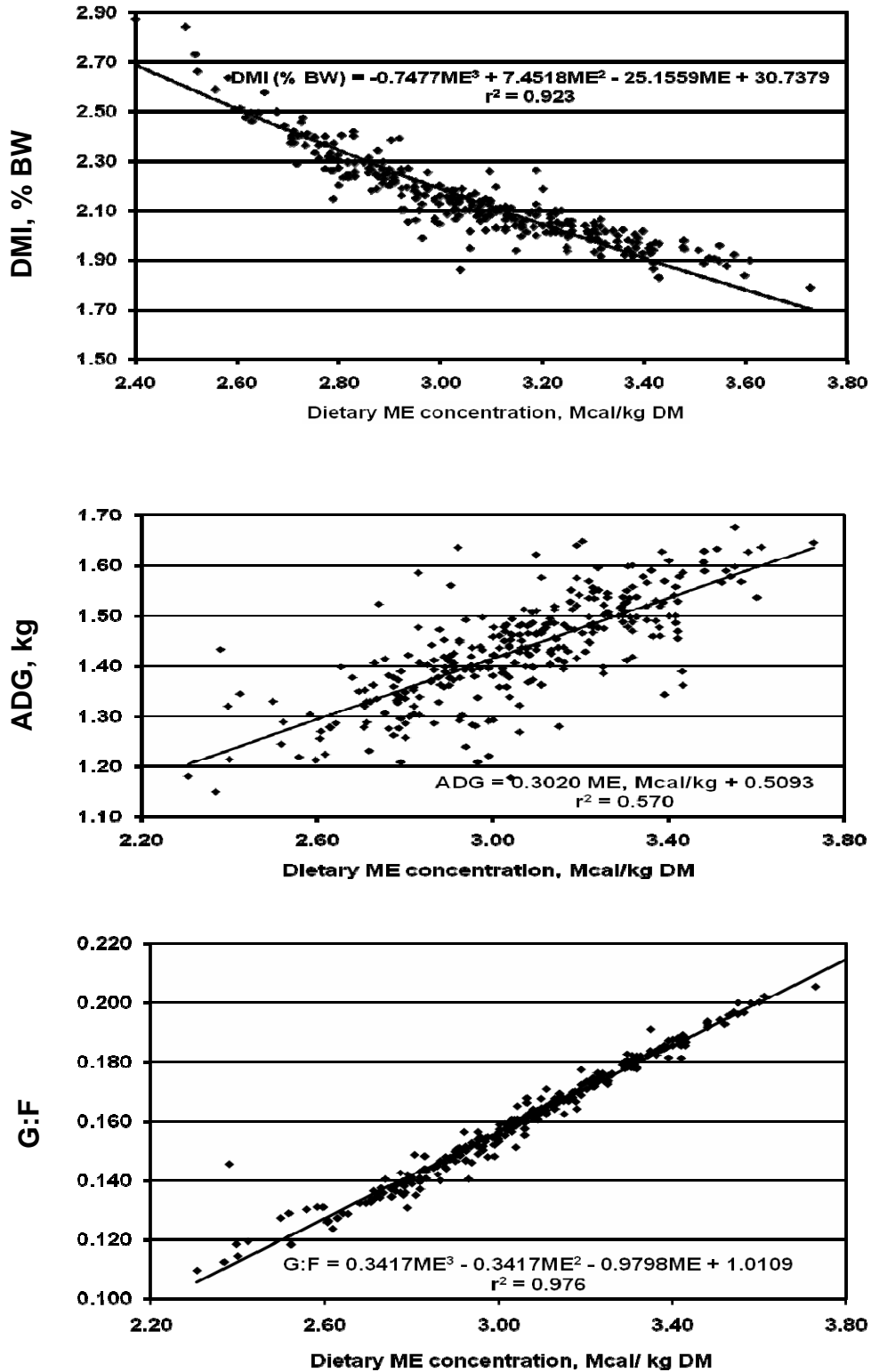


Figure 2. Relationship of dietary ME concentration calculated from performance and net energy equations (NRC, 1996) to trial adjusted DMI (% of BW; top), ADG (middle) and G:F (bottom).

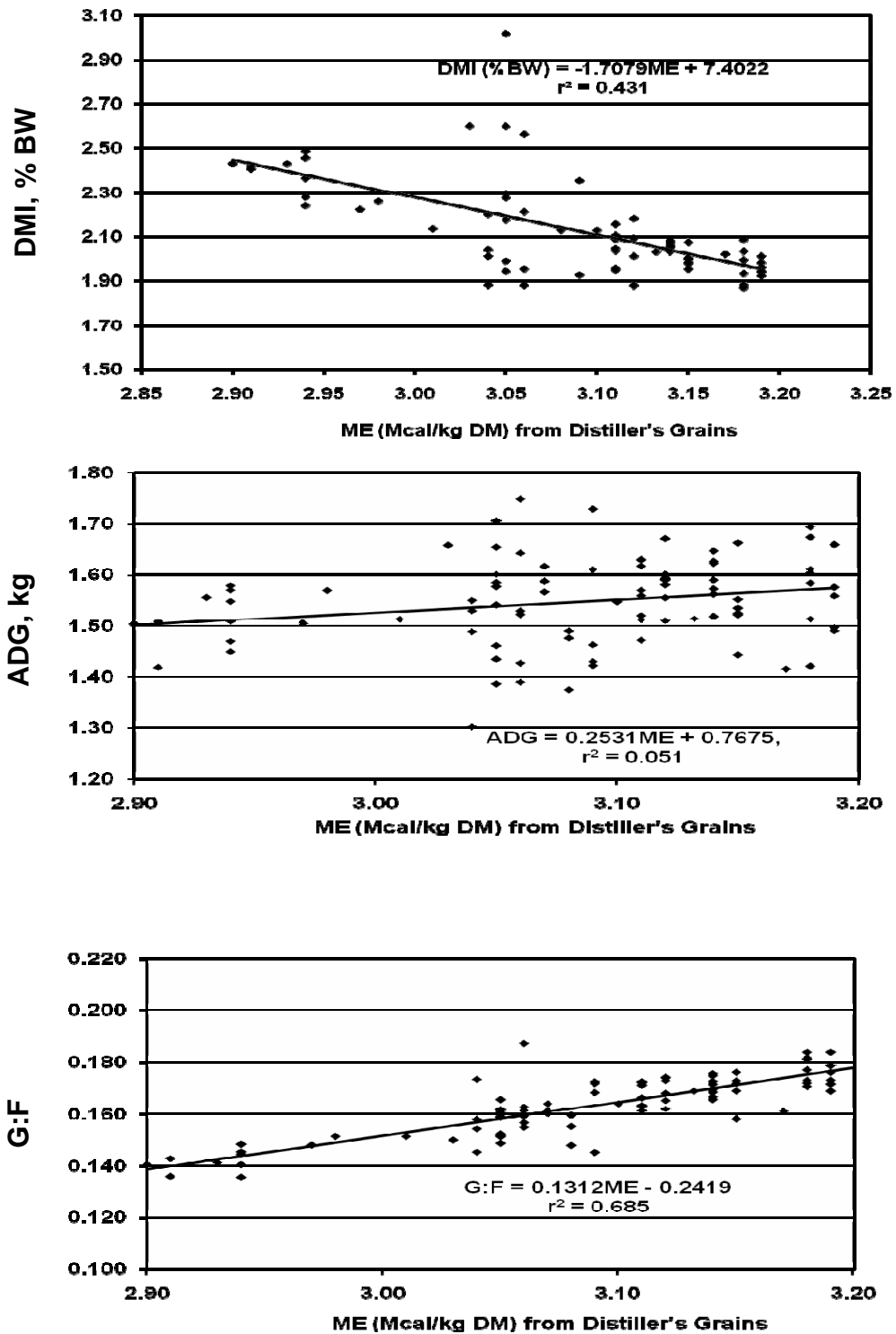


Figure 3. Relationship of ME concentration from diets containing distillers grains calculated from NRC (1996) values of dietary ingredients to trial adjusted DMI (% of BW; top), ADG (middle) and G:F (bottom).

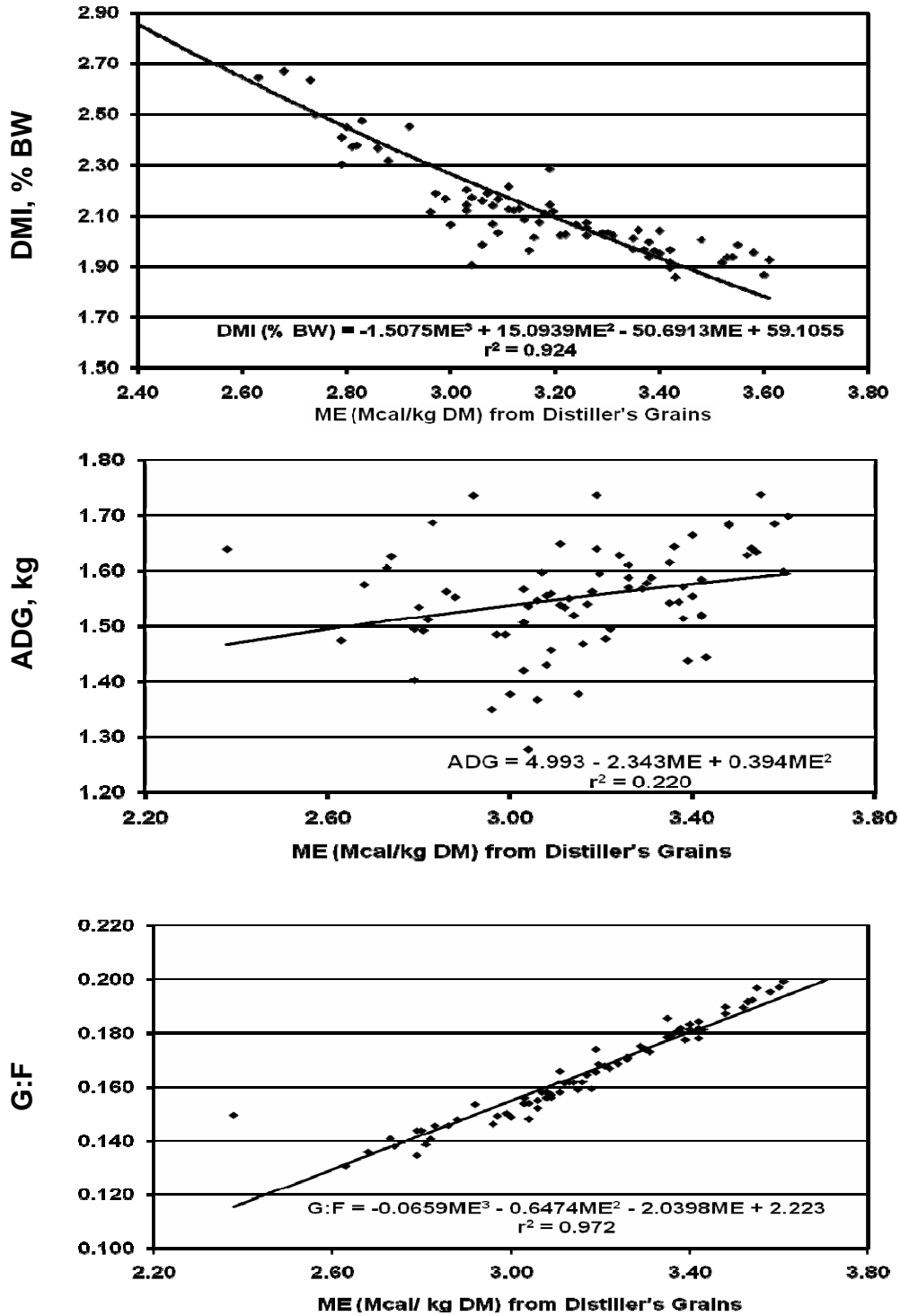


Figure 4. Relationship of ME concentration from diets containing distillers grains calculated from performance and net energy equations (NRC, 1996) to trial adjusted DMI (% of BW; top), ADG (middle) and G:F (bottom).

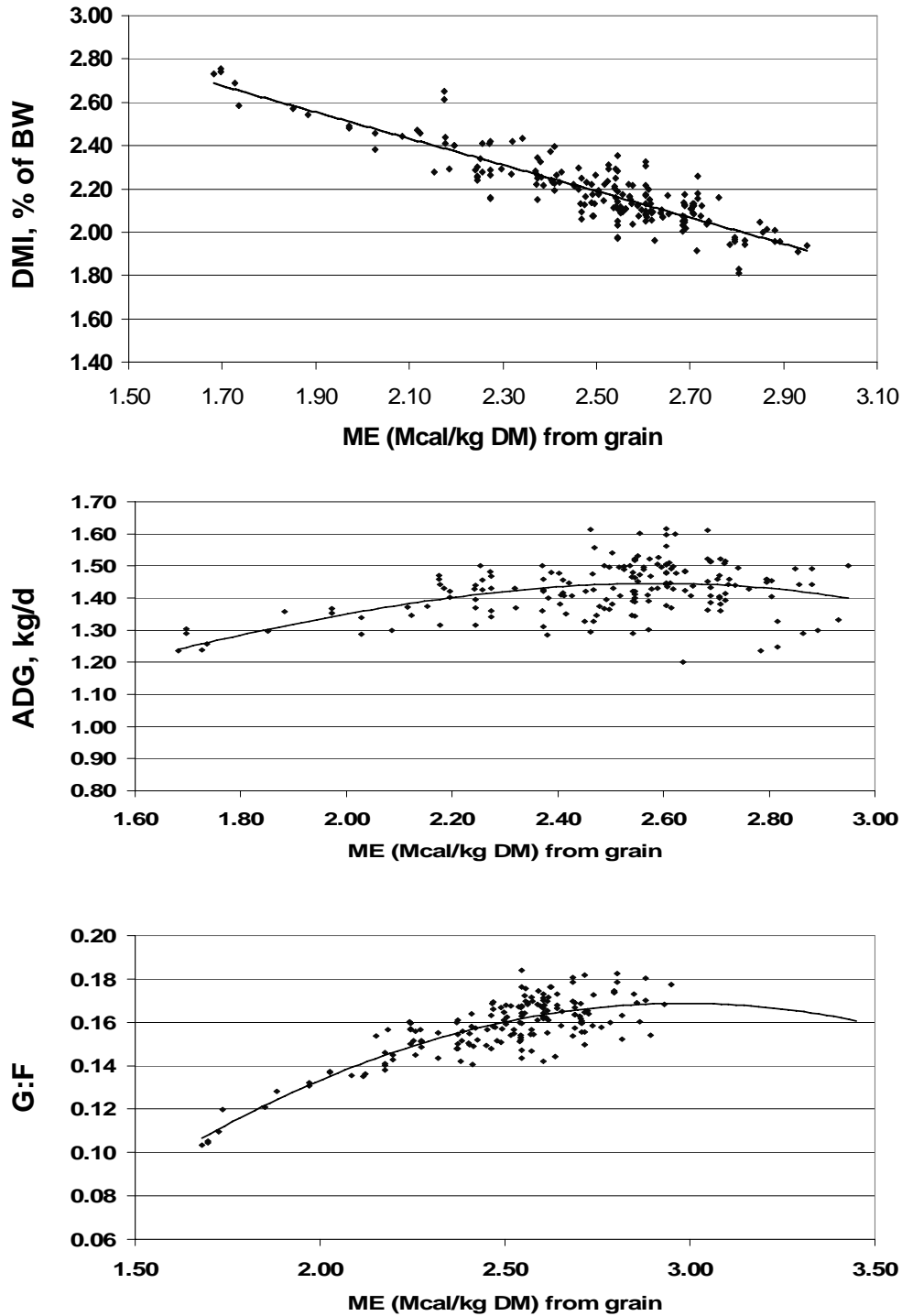


Figure 5. Relationship of ME concentration from grain calculated from NRC (1996) values to trial adjusted DMI (% of BW; top), ADG (middle), and G:F (bottom). $DMI (\% \text{ of BW}) = 3.71 - 0.608(\text{ME from grain, Mcal/kg}; r^2 = 0.78)$; $ADG, \text{ kg} = -0.083(\text{ME from grain, Mcal/kg}^2) + 0.322(\text{ME from grain, Mcal/kg}) + 0.72 (r^2 = 0.22)$; and $GF, \text{ kg/kg} = -0.037(\text{ME from grain, Mcal/kg}^2) + 0.219(\text{ME from grain, Mcal/kg}) - 0.16 (r^2 = 0.70)$.

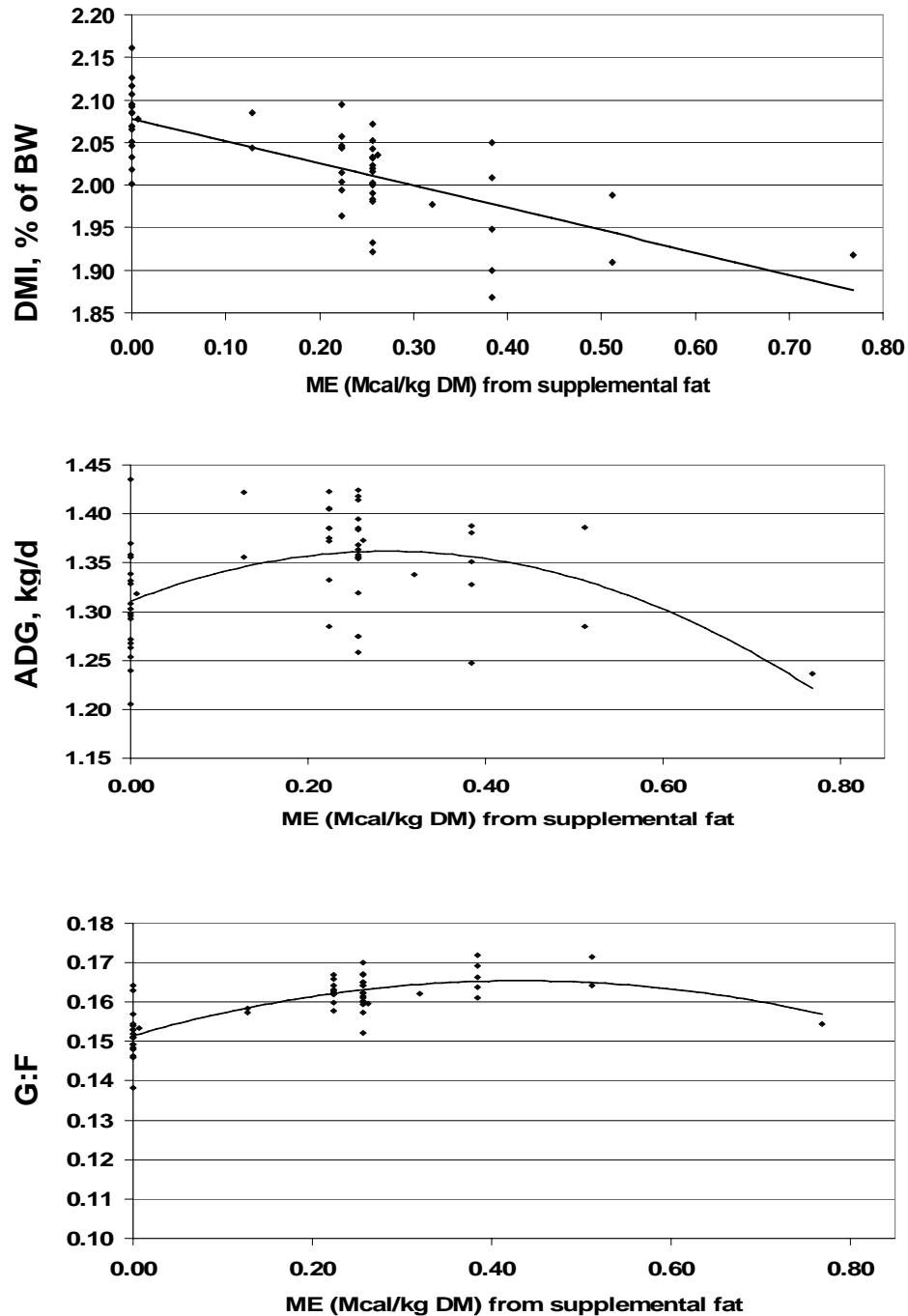


Figure 6. Relationship of ME concentration from supplemental fat calculated from the NRC (1996) value for tallow to trial adjusted DMI (top), ADG (middle) and G:F (bottom). DMI (% of BW) = $2.08 - 0.262(\text{ME from fat, Mcal/kg}; R^2 = 0.52)$; ADG, kg = $-0.609(\text{ME from fat, Mcal/kg}^2) + 0.352(\text{ME from fat, Mcal/kg}) + 1.31$ ($R^2 = 0.24$); GF, kg/kg = $-0.074(\text{ME from fat, Mcal/kg}^2) + 0.064(\text{ME from fat, Mcal/kg}) + 0.15$ ($R^2 = 0.61$).

The Application of Nutrition Models to Determine Feed Efficiency in Beef Cattle

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Introduction

During the last decade, the shift in the production paradigm from the traditional goal of maximizing output to optimizing the use of resources and maximizing efficiency has become a reality. It has been hypothesized that producers failing to comply with market specifications (carcass yield and quality traits) would be penalized (Ball et al., 1997).

The determination of *production efficiency* in beef cattle requires accurately accounting for variables that influence animal performance in each specific combination of animals, feeds, and environmental conditions. In practice, this task can be overwhelming and becomes almost infeasible mainly because the current organization of beef cattle production in the US is segregated into five major categories (cow/calf, backgrounding, feedyard, packing plant, and marketing) and the information feedback among these categories is often incomplete or inadequate. The whole system can only be efficient if there is coordination throughout the production and marketing chain (Guiroy, 2001). This coordination is typically incomplete or nonexistent even within the cattle production segments (seedstock or cow/calf, backgrounding, and feedyard) because there is no clear signaling and sometimes the players make independent decisions based on marketing feedback, which is often delayed, risky, and full of interference from exogenous sources. Therefore, *production efficiency* is restrained to each individual category and sometimes what is efficient in one category may not be efficient in another one. This discontinuous feedback among the segments of the beef cattle industry prevents coordinated production and it impacts the fluctuation in product availability and consistency, production efficiency, and ultimately the price of the product.

There are two ways to improve production efficiency within limitations of the current US beef production system. The first one is the status quo solution of trying to improve the *production efficiency* within a segment independent of other segments. The second option is to use decision support systems (**DSS**) or smart decision tools (**SDT**) to model selected segments of the beef industry to identify production alternatives that seek the enhancement of production efficiency given the simulation results. This option can also provide information feedback of the factors limiting production efficiency and economic feasibility (profitability).

The objective of this paper is to discuss the development and application of two DSS that can be used to improve the feed efficiency of the cow/calf and feedlot segments. More detailed information can be obtained from Fox et al. (2004a)¹.

¹ <http://nutritionmodels.tamu.edu/papers/FoxetalMineo2004.pdf>

Why Develop Decision Tools Based on Nutrition Models?

“One of the goals of energy metabolism research with ruminants always has been the development of an accurate means for evaluating feedstuffs and stating animal requirements” (Garrett and Johnson, 1983). These systems would allow for appraisal of feed biological/nutritive value and their substitution value, determination of quantity of feed to support different animal physiological needs, and estimation of animal performance when intake and feed quality value are known. Such requisites can be obtained with computer modeling.

Mathematical models can integrate the scientific knowledge of energy and other nutrients supply by the feedstuffs and requirements by the animals that have been accumulated over time and allow us to apply it in different production scenarios. Models have an important role in assisting the improvement of feeding systems and helping to understand the feedback structure that dictates the behavior of production systems. Thus, they can provide essential information to be used in the decision-making process of producers, and consultants to maximize production while minimizing the environmental impacts through reduced nutrient excretion in an economically feasible fashion. Several mathematical nutrition models have been developed to account for more of the variation in ruminant production (Tedeschi et al., 2005c).

Identifying Differences in Production Efficiency of Beef Cows

Increases in beef cow/calf production have occurred due to enhancements in reproduction indexes (e.g. calving frequency, age at first calving, calving interval), nutrition concepts (e.g. strategic supplementation, type of forage as well as quantity and quality), genetic selection (e.g. bull selection, crossbreeding), and (or) ranch management (e.g. matching breeding and calving seasons with availability of forage). Nonetheless, beef production still is a relatively inefficient process from the standpoint of energy expenditure. Research has indicated that beef cows are responsible for 60 to 70% of the total of energy expenditure (Johnson, 1984) in beef production (Ferrell and Jenkins, 1985). Ideally, efficient beef cows use less resource to obtain the same outcome in a sustainable environment. There are several indexes used to identify efficient beef cows. Most are based on retaining beef cows that routinely produce a weaned calf with fewer inputs, with a high ratio of pounds of calf weaned per number of females exposed to a bull. Additionally, beef cow maturation rate has also been shown to be correlated with production efficiency and may be used to select for efficient cows (Parker et al., 1972; Tedeschi et al., 2000a; Tedeschi et al., 2000b). Jenkins and Ferrell (2002) concluded that to evaluate biological efficiency, productivity must be expressed relative to some measure of input, and feed energy required per unit of output is logical.

A Brief Description of the CVDS Beef Cow Model

Several models have been developed to simulate cow/calf production systems (Boyd, 1977; Fox et al., 1988; Long, 1972; Miller et al., 1980; Naazie et al., 1997; Notter et al., 1979a; Notter et al., 1979b; c). Fox et al. (1988) developed a nutritional model to evaluate the match of the energy requirements of a cow/calf herd with forage available each month to enhance profitability of the herd. Their model computes a balance between energy requirements for maintenance, pregnancy, lactation, and tissue mobilization and energy available from the forage; thus, allowing one to match availability of forage with periods of higher energy demand by the cow and calf. Reynoso-

Campos et al. (2004) published an application of the Cornell Net Carbohydrate and Protein System [CNCPS; (Fox et al., 2004b)] for dual-purpose cows that computes daily energy balances between the herd requirements and forage available. Tedeschi et al. (2006b) have developed a nutrition model – Cattle Value Discovery System for Beef Cows, CVDS_{bc} – that computes the Mcal of metabolizable energy (ME) required by a cow per body weight (BW) of weaned calf. This index is termed the energy efficiency index (EEI, Mcal/kg); *the lower the EEI, the lower the Mcal required/kg of weaning weight. Thus, the cows with the lowest EEI are the most efficient.* Their model is based on those developed at Cornell as described by Fox et al. (1988) for beef cows and by Reynoso-Campos et al. (2004) developed for dual-purpose cows, with modifications as described therein.

Figure 1 summarizes the structure of the CVDS_{bc}. The objectives of the CVDS_{bc} model are (1) to compute the energy requirements of individual beef cows each day of the year and simulate the growth of the nursing calf given the information available, (2) to estimate energy balances for the herd each day of the year to evaluate the balance between herd numbers and requirements with the forage available, and (3) to identify differences in efficiency among individual beef cows in a herd.

Maintenance Requirement

Energy required for maintenance is based on body weight adjusted for conceptus weight, environment (climate effects), physical activities, and physiological stage (dry vs. lactation) as recommended by the NRC (2000). Smooth curve adjustments using the cubic spline technique are used during transition phases since this is a time-dependent model. DiConstanzo et al. (1990) found that among non-pregnant non-lactating Angus cows of similar fat masses, those with larger protein masses had higher energy requirements for maintenance because the ME required to maintain 1 kg of protein was 9.3 times higher than 1 kg of fat (192.9 ± 24.8 vs. 20.7 ± 21.5 kcal, respectively). Further modifications of the CVDS_{bc} should include adjustments for fat and protein masses.

Pregnancy and Lactation Requirement

Energy for pregnancy is based on the NRC (2000) recommendations that use days pregnant to derive energy concentration in the conceptus. The CVDS_{bc} assumes a fixed calving interval of 365 d. The model computes milk production by changing the peak milk until weaning weight (WW) predicted by the CVDS_{bc} matches observed WW. The energy requirement for lactation is computed based on NRC (2000) and Fox et al. (2004b). Milk composition is used to compute net energy of the milk, which drives the energy requirement for lactation. A fixed value of 5.29 Mcal of ME/kg of milk (DM basis) is assumed in computing intake of ME by the calf. The peak milk is used to plot the lactation curve (George, 1984), which predicts the daily amount of milk available for the calf.

Forage and Milk Intake of the Calf

The data of Abdelsamei (1989) were used to develop equations for estimating forage intake of the nursing calf. In his experiment, the daily ad libitum intake of chopped alfalfa of 40 Holstein calves fed according to 5 lactation curves (daily amounts based on peak milk at 59.5 DIM: 2.72, 5.44, 8.16, 10.88, and 13.6 kg) from birth to 200 d. The CVDS_{bc} as published by Tedeschi et al. (2006b) used five multiple regression equations to estimate forage intake for the pre-peak milk

phase and the intake of forage for the post-peak milk phase was computed using a surface response regression.

More recently, Tedeschi and Fox (2009) revised the submodel to compute forage dry matter intake (**DMI**) of nursing calves that accounts for forage quality, milk production (sucked milk by the calf), and calf BW. It has been shown that forage intake per unit of BW prior to weaning is consistently greater for calves receiving low quantities of milk (Broesder et al., 1990; Le Du et al., 1976a; b), and the consumption of milk reduces herbage DMI (Baker et al., 1976). Figure 2 represents these observations.

Body Reserves

It is well documented that body condition score (**BCS**) has an important role in beef production and reproduction efficiency (Houghton et al., 1990; Mortimer et al., 1991). In the model published by Tedeschi et al. (2006b) tissue mobilization and repletion is used to compute energy available/required for body reserves based on BCS changes, similar to that described by Reynoso-Campos (2004). Even though ultrasound has been successfully used to develop methods to determine body fat reserves (Schröder and Staufienbiel, 2006), its practical application is limited by cost and time. The mechanisms used for the BCS adjustments was delineated by Tedeschi et al. (2006c). A dynamic model to predict fat and protein fluxes associated with body reserve changes is being developed.

Figure 3 depicts the graphical representation of body fat and protein dynamics.

Evaluating the CVDS for Beef Cows

Simulations performed by Tedeschi et al. (2006b) indicated that as peak milk increases, WW increases almost linearly and the energy efficiency index decreases exponentially. Published data indicates that cow mature weight does not influence the efficiency of energy use (Ferrell and Jenkins, 1984a; b; Klosterman and Parker, 1976; Morris and Wilton, 1976). Their studies indicate that as mature size increases, maintenance requirement, milk production, weaning weight, and finished weight increase proportionally. Tedeschi et al. (2006b) also indicated that milk production is a determinant of calf WW and efficiency of the cow, which is supported by the studies of Abdelsamei (1989), Lewis et al. (1990), and Clutter and Nielsen (1987). As milk production increases, cow maintenance requirement becomes increasingly diluted by the additional weaning weight produced. However, it is well known that high-milk production cows have higher energy requirements for maintenance because the internal organs are larger and they have a faster metabolism compared to low milk production cows (Ferrell and Jenkins, 1984a; b; 1985). This means that higher-milking cows require more feed for maintenance and energy per kg of BW than lower-milking cows (Montano-Bermudez and Nielsen, 1990). If feed available is adequate, this higher maintenance requirement will be offset by an increased weaning weight of the calf. Cows selected for improved efficiency in a certain environment may not express their potential efficiency in another environment (Ferrell and Jenkins, 1985). When forage availability is not limiting, cattle with higher milk and growth potential can utilize the extra feed to wean heavier calves, therefore increasing weight sold for the forage available. However, when forage is limited, those with lower milk and growth potential can wean more calves for the same forage because there is a higher proportion of the energy intake above maintenance available for maintaining reproductive efficiency. Tedeschi et al. (2006b) concluded that the cow mature size

should be determined by the optimum weight for the calves at the target carcass composition, and that the milk production level should be based on the forage available.

A database was collected from the Bell Ranch, New Mexico (n = 182) to evaluate the model ranking ability of the most to the least efficient cows based on EEI. Cows were in grazing conditions and were supplemented during January and April with a protein mix. The CVDS_{bc} was able to identify accurately the cows that had been culled and to classify the ones that were judged to be efficient by the management team (Tedeschi et al., 2006b). Nonetheless, the authors recommended that further investigation is needed to evaluate the relationship of frame size and/or age with EEI, whether the model ranking of the same cow persists across years, and if calf sex, stocking rate or supplementation would impact the model ranking.

Recently, Bourg et al. (2009) used the CVDS_{bc} with Santa Gertrudis cows (n = 140) to assess the repeatability of EEI across years. Their preliminary analysis with 2 years of data indicated a strong negative relationship between predicted peak milk (computed by iteration) and EEI, which means that Mcal of ME required/kg of calf weaning weight decreased as peak milk increased. Peak milk and EEI were not correlated to either exit velocity or chute score. Relationships between EEI and peak milk with ultrasound fat measures indicated that more efficient cows (lower EEI) had greater peak milk and were leaner. Preliminary genetic assessment of EEI and ME required (**MER**) for the observed performance as predicted by the CVDS_{bc} indicated additive genetic heritability (h^2) of EEI and MER of 0.25 and 0.21, respectively.

Identifying differences in feed efficiency in beef cattle during post-weaning growth

Accurate prediction of the energy content of growth is critically important in formulating diets to meet requirements, predicting rate and cost of gain, predicting days required to reach a target weight and body composition, and allocating feed to individual animals fed in pens. This requires the use of growth models that can accurately predict rate of gain and accumulated body fat at a particular weight for cattle varying in mature body weight.

Several growth models have been developed to predict retained energy and growth rate (Fox and Black, 1984; Lofgreen and Garrett, 1968). Others have been developed that also use specific animal characteristics such as DNA accretion curves and protein to DNA ratio (Bywater et al., 1988; Di Marco and Baldwin, 1989; Di Marco et al., 1989; Oltjen et al., 1986; Oltjen et al., 2000), or are derived from growth rates and animal characteristics (Keele et al., 1992; Kilpatrick and Steen, 1999; Williams and Jenkins, 1998; Williams et al., 1992). Growth models that describe growth and body composition using biochemistry pathways and physiological mechanisms that relate the growth of three compartments (viscera, muscle, and adipose tissues) have been developed (Oddy et al., 1997) and evaluated with sheep data (Soboleva et al., 1999). More complex models based on metabolic processes have also been developed (France et al., 1987; Gill, 1984; 1996; Gill et al., 1989). These models are based on the assumption that the distribution of nutrients in body tissues is controlled mainly by substrate availability, which follows the principles of saturation enzyme kinetics (Baldwin, 1995). However, the complexity of such models and the availability of suitable input data under feedlot conditions restrict their use.

The Davis Growth Model [**DGM**; (Oltjen et al., 1986)] is based on general cell number and size mechanisms of growth to predict net protein synthesis. It assumes that (a.) organ size is determined by final DNA content of the organ, (b.) the DNA is genetically specific for each tissue and each species, and (c.) enzyme activity varies exponentially with organ size (Ferrell and Oltjen, 2008). A more complex DGM containing 2 pools of protein (body and viscera) was developed by Di Marco et al. (1989) and integrated with digestion and metabolism concepts (Di Marco and Baldwin, 1989). However, the main limitation of growth models in general is the integration with the supply of energy and nutrients from the diet.

Growth models can be used in individual cattle management systems (**ICMS**) to improve profitability, to minimize excess fat produced, to increase consistency of products, and to identify and reward individual owners for superior performance in the feedlot (Guiroy et al., 2001; Tedeschi et al., 2004). To accomplish this, cattle are marketed as individuals when at their optimum carcass composition, which typically requires having cattle with different owners in the same pen (co-mingled). This requires accurately allocating and billing feed fed to a pen to the individual animals in the pen. To make individual animal management work, the method used to allocate the feed consumed by animals from different owners that share the same pen must accurately determine cost of gain of each animal in a pen.

There are three critical control points in launching a successful ICMS:

- Predicting optimum finished weight, incremental cost of gain and days to finish to optimize profits and marketing decisions while marketing within the window of acceptable carcass weights and composition,
- Predicting carcass composition and backfat deposition rate during growth to avoid discounts for under- or over-weight carcasses and excess backfat, and
- Allocating feed fed to pens to individual animals for the purpose of sorting of individuals into pens by days to reach a target body composition and maximum individual profitability.

The Cornell/Cattle Value Discovery System for growing animals [**CVDS_g**; (Tedeschi et al., 2004)] was developed to account for these critical control points for growing animals. The CVDS_g is based on the nutritional concepts of the CNCPS (Fox et al., 2004b) to compute supply and requirement of energy and protein in support of maintenance and growth. The CVDS_g model and related publications can be downloaded at <http://nutritionmodels.tamu.edu/cvds.htm>.

A Brief Description of the CVDS Growing Model

Modeling systems that predict feed requirements and cost of gain must be able to account for differences in basal maintenance requirement, the effect of environment on maintenance requirement, the effect of body size, implant program and feeding system on finished weight and growth requirements, feed energy values, and DMI.

Accounting for Body Composition at the Marketing Target End Point

The first step for predicting feed required for the observed growth and incremental cost of gain and body composition as cattle grow is to identify the body composition at the marketing target end point. Carcass value in most markets and cost of gain can be related to proportion of protein

and fat in the carcass. Body fat in finished cattle when marketed typically varies from 16 to 21% empty body fat (**EBF**) in the French (INRA, 1989) and Brazilian (Leme et al., 2000) markets to over 30% EBF in segments of the Japanese and Korean Markets. Most other markets range between these two.

The single most recognizable quality grade in the world is USDA choice. Premium brand name products typically utilize the prime and upper 2/3 of the Choice grades and are increasing the value of U.S. beef products. Table 1 shows a summary of several experiments (Guiroy et al., 2001) that support the value of the Choice and prime grades level of fatness to minimize the percent of the beef that is unacceptable to consumers in the U.S. These data show that EBF was significantly higher with each incremental increase in grade up to the mid Choice USDA grade and USDA quality grades were correlated with changes in EBF as cattle grow. The most critical factor in this table for our model is the EBF at Standard (21.1%), Select (26.2%), and low Choice (28.6%) grades because these are the body composition endpoints for different marketing targets used to identify feed requirements during growth.

The USDA quality grade is related to U.S. consumer preferences for beef, which is related to fat content of the beef consumed, which is primarily intramuscular fat. The National Beef Quality Audit reported the percent of steaks with low eating quality for the USDA Prime, Choice, Select, and Standard grades were 5.6, 10.8, 26.4, and 59.1 %, respectively, in data collected from typical feedlot cattle (Smith et al., 1995). The % unacceptable values were lower for the data analyzed by Guiroy et al. (2001) likely because they were uniform calves fed a 90% concentrate diet beginning at approximately 7 mo of age. The National Beef Quality Audit conducted by Smith et al. (1995) also reported that up to 20% of all beef does not meet North America consumer satisfaction in eating quality and recommends that the % of cattle grading low Choice and above be increased.

The National Beef Quality Audit indicated the actual mix of USDA grades in cattle marketed in 1995 was 49% low Choice or better, 46.8% Select and 4.2% Standard grade and lower (Boleman et al., 1998); for 2000, this mix was 51.1, 42.3, and 6.5%, respectively (McKenna et al., 2002); and for 2005, this mix was 54.5, 40.2, and 5.34%, respectively (Garcia et al., 2008), suggesting a trend of increase in low Choice or better. The strong message from North America consumers is that the external fat must be removed from beef, but intramuscular fat (marbling) is required in the edible portion. This is likely due at least in part to the method of cookery commonly used compared to what is common in most other countries (Dikeman, 1987).

In the US, ultrasound is widely accepted to estimate backfat, rib-eye area, and intramuscular fat (marbling) (Greiner et al., 2003; Hassen et al., 2001). It is important to determine backfat and intramuscular fat because this is an important factor affecting not only consumer preferences but also the energy required for growth across different breeds; some breeds tend to deposit more intramuscular fat than others (e.g. Angus vs. Nellore). Cattle producers can accurately determine when to harvest cattle to achieve the target quality grade and the weight at which they are likely reach that grade based on experience and historical data from their feedlot or with the use of ultrasound, because price paid is based on quality grade and weight at that grade. After harvest, the EBF and final shrunk body weight (**SBW**) can be estimated from quality grade, rib eye area (**REA**), and carcass weight with equations developed by Guiroy et al. (2001) to allocate feed fed

to a pen of cattle to individuals in that pen. Before harvest, equations have been developed to predict intra-muscular fat (**IMF**) and REA from ultrasound.

Accounting for Requirements for Growth

The expected BW at the target quality grade, and thus the EBF content at harvest, is used by the CVDS_g to determine energy requirements for growth. It has been determined that cattle of different mature sizes have different fat and protein content of the weight gain at the same weight during growth (Fox and Black, 1984). Therefore, a size scaling procedure to account for differences in energy and protein requirements for growth among cattle of different frame sizes and genders has been developed (Fox and Black, 1984; Fox et al., 1988; Fox et al., 1992; Fox et al., 1999; Tylutki et al., 1994) and was adopted by the National Research Council Nutrient Requirements of Beef Cattle (NRC, 2000).

Three data sets with body composition data on individual animals varying in BW at 28% fat were used to test this system (NRC, 2000). With two of the data sets (82 pen observations of *Bos taurus* implanted steers and heifers varying in breed type, body size and diet type and 142 serially slaughtered non-implanted steers, heifers and bulls varying in body size aggregated into “pens” by slaughter groups), this system accounted for 94% of the variation in energy retained with only a 2% under-prediction bias. Similar results were observed for Angus and Holstein heifers (Fox et al., 1999). However, it cannot be assumed that this accuracy will apply to individual animals at a particular point in time during growth, since these results were obtained from pen averages and total energy retained. Many factors can alter estimates of finished weight of individuals, such as previous nutrition, implant programs, level of intake and energy derived from the diet, limits in daily protein and fat synthesis, and daily energy retained. The problem is to be able to predict those effects in individual animals based on information that will be available in feedlots and is practical to apply.

Accounting for Requirements for Maintenance

The basic concept used to account for maintenance requirements was described by Fox and Tylutki (1998). The effects of breed type are accounted for by adjusting the base NE_m requirement of 77 kcal/kg metabolic body weight (**MBW**) for *Bos indicus* and dairy types (-10 and +20% compared to *Bos taurus*). The effects of previous nutrition are accounted for by relating BCS to net energy for maintenance (**NE_m**) requirement (NE_m is changed by 5% for each BCS change).

The effects of acclimatization are accounted for by adjusting for previous month’s average temperature (ranges from 70 kcal/kg MBW at 30 °C to 105 kcal/kg MBW at -20 °C). This adjustment is continuous, with no effect at 20 °C (Fox and Tylutki, 1998). Current environmental effects are accounted for by computing heat lost vs heat produced, based on current temperature, internal and external insulation, wind, and hair coat depth and condition. This becomes important when the animal is below the computed lower critical temperature, and can range from no effect at 20 °C to twice as high (thin, dirty hide at -12 °C and 1.6 km/h wind). These adjustments were developed based on data reported by the NRC (1981). A more dynamic approach needs to be developed to adjust maintenance requirement for energy for different levels of production, animal types, and environments (climate) for use in dynamic models. The above adjustment can be used for static models, which are valuable to represent the mean of environmental effects for a

period of growth but cannot be used consecutively in a dynamic model because of repeated double accounting the previous climate effect (Kebreab et al., 2004; Tedeschi et al., 2004). The effects of environment (climate) have an important effect on animal production and have to be accurately accounted for. Berman (2003; 2005) provided some information regarding heat stress for producing animals and such information could be adapted to current models.

Determining Ration Energy Values

Accurate predictions of DMI and net energy for growth (**NE_g**) and **NE_m** are highly dependent on having feed net energy values that accurately represent the feeds being fed. Tedeschi et al. (2005a) evaluated the accuracy of three alternative methods for determining feed energy and protein values: (1) the level 1 of the NRC (2000), which uses tabular values for feed composition and energy; (2) the level 2 of the NRC (2000), which uses the CNCPS level 2 mechanistic rumen model (Fox et al., 2004b); and (3) a summative equation commonly used by feed analysis laboratories to predict feed energy values from chemical composition (Weiss, 1993; 1999; Weiss et al., 1992). The ME value was predicted by the CNCPS to be first limiting average daily gain (**ADG**) in 19 treatment groups (Tedeschi et al., 2005a). Across these groups, the observed ADG varied from 0.8 to 1.44 kg/d. When ME was first limiting, the ADG predicted by the CNCPS model accounted for more of the variation (80%) in actual ADG than did the summative equation or tabular (73 and 61%, respectively). Metabolizable energy allowable ADG predicted with the tabular system gave an overprediction bias of 11%, but the bias was less than 2% when predicted with the CNCPS or summative equation. The mean square errors (**MSE**) were similar in all predictions, but the CNCPS model level 2 had the highest accuracy (lowest root of mean square error of prediction, **RMSPE**). The diet metabolizable protein (**MP**) was predicted by the CNCPS to be first limiting in 28 treatment groups (Tedeschi et al., 2005a). Across these groups, the observed ADG ranged from 0.12 to 1.36 kg/d. The MP allowable ADG predicted by the CNCPS model accounted for more of the variation (92%) than did the summative equation or tabular (79 and 80%, respectively). Metabolizable protein-allowable ADG predicted with the tabular gave an overprediction bias of 4%, whereas the bias was less than 2% when predicted with the CNCPS or the summative equation. Similar to the ME first limiting analysis, the CNCPS model had the highest accuracy (lowest RMSPE: 0.11).

Predicting Days on Feed, Body Composition, and Quality and Yield Grade

Fox et al. (2002; 2001a) summarized the sequence of calculations of the growth model (Guiroy et al., 2001; Perry and Fox, 1997; Tedeschi et al., 2004; 2005b) developed to account for individual animal feed requirements when fed in groups. Evaluations of this model reported in those papers indicated the CVDS_g model predicted dry matter required (**DMR**) with an r^2 of 74% and mean bias of 2% (Tedeschi et al., 2004; 2005b) and feed conversion ratio (**F:G**) with an r^2 of 84% and a mean bias of 1.94% (Tedeschi et al., 2006a) using the data of 362 individually fed steers varying in breed type and 28% fat weight. Guiroy et al. (2001) reported that the CVDS_g accurately allocated the feed fed to 12,105 steers and heifers in a commercial feedlot, with a bias of less than 1%. Recent evaluations with pen-fed Santa Gertrudis steers and heifers indicated the model was able to accurately predict the feed that was allocated to the pens with a bias of 2.43% (Bourg et al., 2006a).

Using the CVDS_g to Evaluate the Relative Importance of ADG and DMI on Feed Efficiency and Cost of Gain

Fox et al. (2001b) utilized the Cornell Cattle Systems version 5 to simulate the effect of growth rate and feed efficiency on cost to gain 270 kg (initial BW of 260 kg and final BW of 530 kg). Based on their simulations, an increase of 10% in ADG alone was predicted to increase DMI 7% and improve profits by 18%, probably due to fewer days on feed (**DOF**) and thus less feed and non-feed costs. The reduction in feed cost was due to a reduction in feed required for maintenance due to fewer days required to gain 270 kg. On the other hand, when intake was kept the same but efficiency of ME use by the animal was improved by an amount that resulted in a 10% improvement in feed efficiency, profits increased by 43%. The simulations of Fox et al. (2001b) clearly suggested that improving feed efficiency or feed conversion ratio may result in a higher benefit to the producer. Similarly, Okine et al. (2004) compared the profitability of animals with different efficiency traits. Animals started at 250 kg and were slaughtered at 560 kg. Those with 5% increase in ADG saved US\$ 2 per head versus US\$ 18 per head for steers with a calculated increase of 5% in feed efficiency.

Similar to Fox et al. (2001b), Okine et al (2004) concluded that an increase in feed efficiency (or a decrease in F:G) leads to a higher profit. In part, this is because the same percentage change in DMI is [numerically] greater than that for ADG, which leads to a greater impact on the outcome; less DOF. Thus, comparison should be made on the same basis in which all variables are kept constant and only one variable is varied at a time. Animals with higher ADG will always be more efficient as long as the maintenance requirement is constant. This happens because of the dilution of the amount of feed required for maintenance compared to the total amount of feed consumed, leading to a more efficient animal per unit of gain. However, in practice this may not happen because organ size (digestive tract, liver, etc.) and thus maintenance requirement increases as ADG increases. Therefore, the most efficient animal will be that one that has a lower increase in maintenance per unit of ADG.

Table 2 shows a simulation slightly different than that performed by Fox et al. (2001b) and Okine et al (2004). In Table 2, the ADG (1.62 kg/d) was identical across the first three scenarios; therefore, we assumed that animals would change either DMI or maintenance requirements to obtain the same performance. In a fourth scenario, ADG was increased 10% for the same DMI. A 250-kg steer with AFBW of 560 kg was fed a diet containing 2.9 Mcal/kg of ME and costing US\$ 0.19/kg to set the conditions for the scenarios (Table 6). When ADG was held constant, 185 DOF were required to reach the low Choice USDA grade; a 10% increase in ADG reduced DOF to 168 days. A decrease in efficiency by 10% (increased DMI by 10%) reduced profits by 42% and an increase in efficiency by 10% (decreased DMI by 10%) increased profits by 37%. The increase in efficiency is smaller than that reported by Fox et al. (2001b), likely because they changed ADG rather than DMI. Increasing ADG by 10% and keeping DMI similar to the standard scenario would have increased the profit by 44%, identical to that achieved by Fox et al. (2001b). Selecting for animals with an increased ADG can improve feed efficiency so long as mature size does not change. If mature size is increased, the apparent increase in profit could be offset by more days required to reach the USDA low Choice grade.

Figure 4 depicts key variables involved in determining profitability in feedlot scenarios. The three feedback loops among DMI, BW, ADG, and BW at 28% fat are responsible for causing the dynamic complexity in the system. A sensitivity analysis is necessary to understand the behavior of these feedback loops. The result of a Monte Carlo simulation is shown in Figure 5 in which initial BW (300 ± 20 kg), diet ME (2.8 ± 0.2 Mcal/kg), and a fixed feed cost of (US\$ 0.15/kg) of a finishing steer fed for 120 days were assumed. The sensitivity analysis was conducted using 5,000 iterations and normal distribution was assumed for initial BW and diet ME. It indicated the expected ADG was skewed to the right with a range of 1.2 to 1.7 kg/d (90% confidence interval), the DMR was expected to be between 8.3 and 9.4 kg/d (90% confidence interval), and the FCR was predicted to average 5.04 to 7.94 kg/kg (90% confidence interval).

The analysis of the F:G indicated a higher correlation between F:G and ADG (-0.97) than F:G and DMR (0.62) (Figure 5). The variation in the standard deviation of ADG and DMR had the highest impact on the expected profit (0.82 and -0.28, respectively), indicating that for each change in the ADG by one standard deviation, profit would increase by 0.82 standard deviation units. Therefore, ADG would have a higher impact on the profit than the DMR (a proxy for DMI), and because these two variables had inverse effects on profit, changing feed efficiency might have a higher impact on profit than a change in ADG or DMR alone because a change in feed efficiency might be a combination of changes in both: ADG and DMR. This result is in agreement with that shown by Fox et al. (2001b), Okine et al (2004), and Table 2 in which ADG has a stronger impact on profit than intake, therefore, selecting for higher ADG than lower intake might be more profitable as long as target BW at 28% EBF is not changed.

Tedeschi et al. (2006a) reported a phenotypic correlation between DMR and DMI, ADG, and Kleiber ratio of 0.75, 0.65, and 0.55, respectively. The DMR is the expected intake required that is predicted by the model given the information on animal, diet and environment. This is similar to the expected intake predicted by the residual feed intake (**RFI**) using mean BW and ADG. Tedeschi et al. (2006a) reported the correlation of the residual (observed minus expected intake) between these two approaches was 0.84. Similarly, Bourg et al. (2006b) reported a correlation of 0.80.

Using Mathematical Nutrition Models to Select for Feed Efficiency in Replacement Herd Sires

Mathematical nutrition models have been evaluated for use with replacement herd sires to assess heritability and genetic correlations for feed efficiency. Williams et al. (2005) compared the Decision Evaluator for the Cattle Industry (**DECI**) and the CVDS_g models to predict DMR, using 504 steers from 52 sires. Heritability for DMR was approximately 0.33 for both models and genetic correlations between actual DMI and predicted DMR was greater than 0.95. Similarly, Kirschten et al. (2006) evaluated the genetic merits of the CVDS_g predictions and reported heritability of 0.35 and genetic correlations between DMI and DMR of 0.98, with low re-ranking of sires. These authors suggested that predicted DMR may be used in genetic evaluations for feed efficiency with minimal genetic differences between DECI and CVDS_g models. Further analysis confirmed that DMI and DMR had heritability of 0.42 and 0.33 respectively, and that genetic correlations were 0.83 for DMR and ADG, 0.45 for DMI and ADG, 0.58 for DMR and BW, and 0.50 for DMI and BW, suggesting that predicted DMR has

higher genetic correlations with ADG than observed DMI (Kirschten et al., 2007). Kirschten et al. (2007) concluded that DMR (as predicted by the CVDS_g) may substitute for actual DMI measurements for genetic purposes.

Conclusions

The CVDS_{bc} model can assist in the identification of efficient cows and simulation of different production scenarios to identify optimum management systems for beef cows to maximize profits on a given land base. In identifying the most efficient beef cow type, cow mature weight should be determined by the optimum weight for the calves at the target carcass composition, and milk production level should be based on the forage available. More work is needed to account for protein availability and quality in the current model. Once this is attained, this model can also be applied to select the best strategy for forage management and supplementation to minimize costs and environmental impacts of nitrogen.

The CVDS_g model provides a method for predicting energy requirements, performance and feed required by individual cattle fed in a group with good accuracy by accounting for factors known to affect cattle requirements (e.g. breed type, body size, stage and rate of growth). Feed can be accurately allocated to individual steers, heifers or bulls fed in group pens, based on prediction of final EBF from carcass measures. This allows cattle from different owners to be fed in the same pen, allowing for more efficient marketing of feedlot cattle and collection of data in progeny test programs. Our preliminary analysis suggests this model also has the potential to be used in identifying differences in feed efficiency between individual animals fed in group pens. The predicted feed required for the observed performance appears to be strongly related to actual feed intake, and is moderately heritable.

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Table 1. Relationship of carcass and empty body fat (EBF) to quality grade ^a

N	USDA Quality Grade ^b	Carcass fat, %	Mean EBF ^c , %	EBF SE	Score ^d	NA ^d , %
45	3.5	23.6	21.1 ^u	0.63	5.3	40
470	4.5	29.0	26.2 ^v	0.19	5.6	13
461	5.5	31.6	28.6 ^w	0.20	5.8	8
206	6.5	33.0	29.9 ^x	0.29	6.2	0
90	7.5	34.2	31.0 ^{xy}	0.44	-	-
51	8.5	35.2	31.9 ^y	0.59	-	-
32	9.5	35.8	32.5 ^z	0.74	-	-

^a Adapted from Guiroy et al. (2001).

^b Standard = 3 to 4; Select = 4 to 5; low Choice = 5 to 6; mid Choice = 6 to 7; high Choice = 7 to 8; low Prime = 8 to 9; mid Prime = 9 to 10.

^c Column means with different superscripts are significantly different at P < 0.05.

^d NA = not acceptable. Taste panel scores (1 to 8) and percent unacceptable values are from a subset of this data base.

Table 2. The impact of changing feed efficiency, DMI, or ADG by 10% on profits ^a

Variables	Standard	Increased DMI 10%	Decreased DMI 10%	Increased ADG 10%
DMI, kg/day	9.35	10.29	8.40	9.35
ADG, kg/d	1.62	1.61	1.61	1.77
Feed to gain ratio	5.78	6.40	5.22	5.27
Feed cost, US\$	326.98	361.86	295.43	298.37
Total cost, US\$	935.71	971.92	903.96	898.10
Profit, US\$	86.27	49.91	117.85	124.39
Total cost/gain, US\$/kg/d	1.57	1.69	1.46	1.44
Purchase breakeven, \$/kg BW	2.30	2.15	2.44	2.47
Annual margin for all costs, %	18.29	10.13	25.72	30.09

^a Purchase cost of US\$ 1.95/kg BW and sale price of US\$ 1.9/kg of BW were assumed.

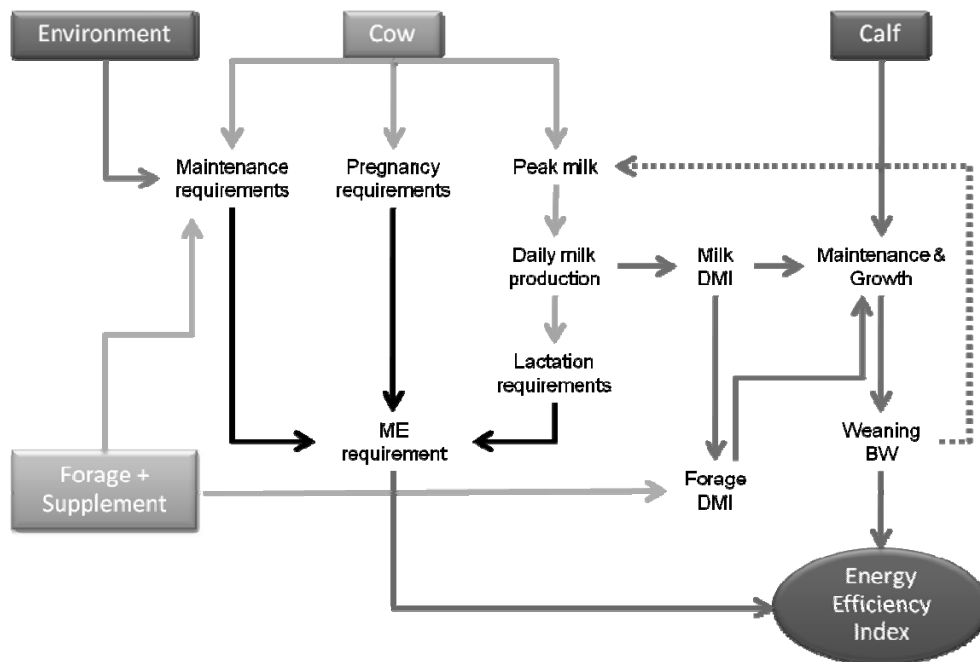


Figure 1. Flowchart of the Cattle Value Discovery System for beef cows (CVDS_{bc}).

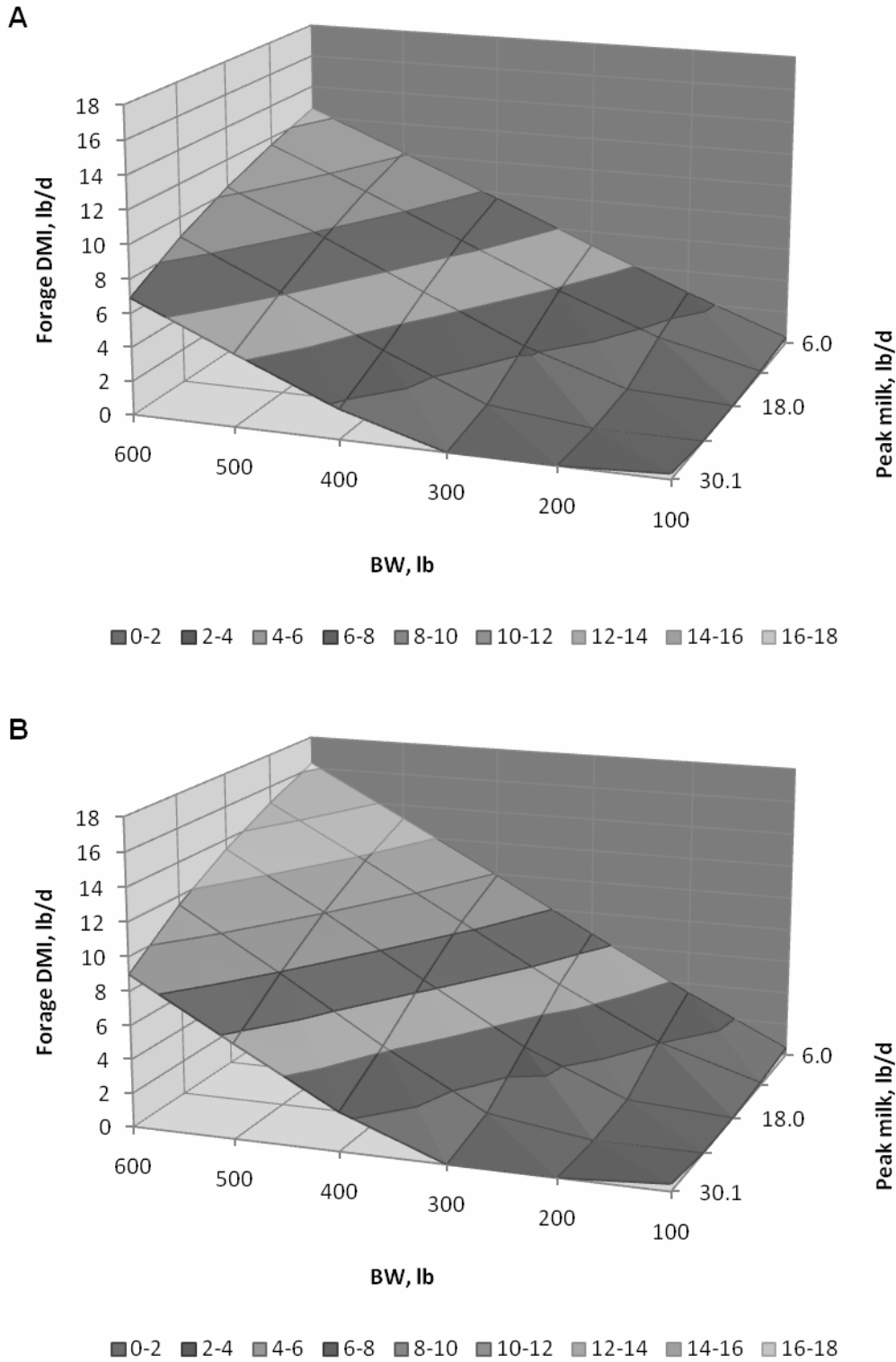


Figure 2. Simulated forage dry matter intake (DMI, lb/d) for different combinations of peak milk (lb/d) and body weight (BW, lb) assuming forage quality of (A) 55% and (B) 75% total digestible nutrients.

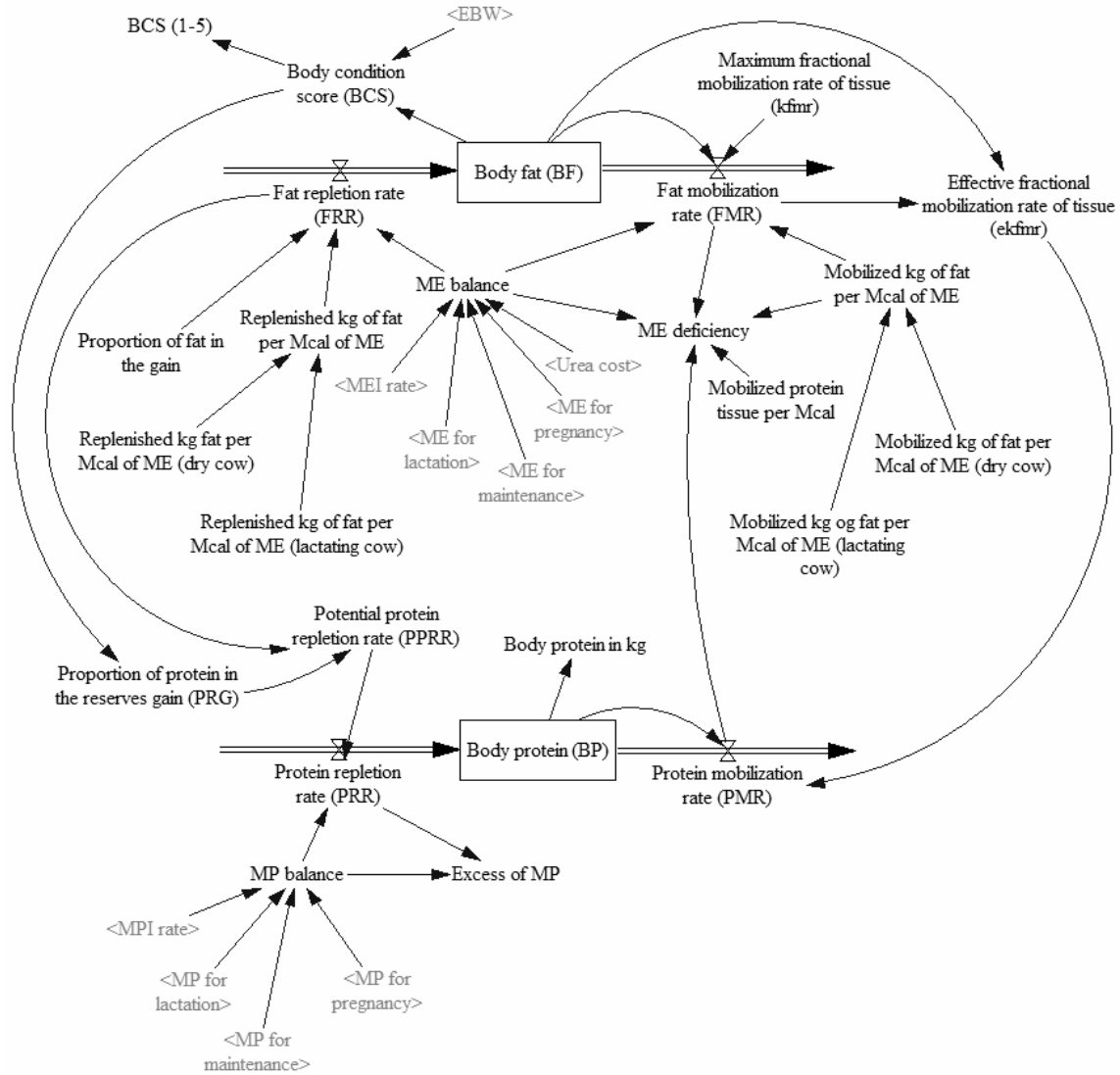


Figure 3. Graphical representation of stock or state variables (box) and flows or rates variables (double-line) of body fat and protein dynamics. Variables within angle brackets were defined in another view of the model.

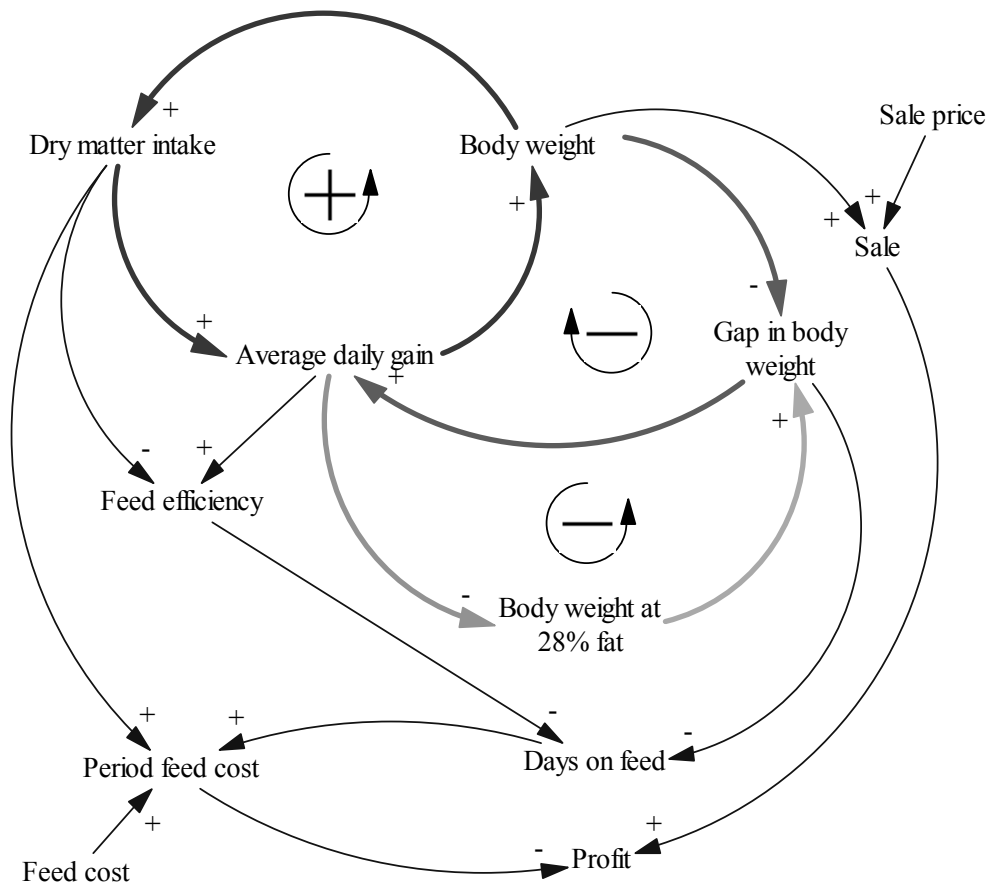


Figure 4. Feedback loops of key variables determining profitability in feedlot conditions.

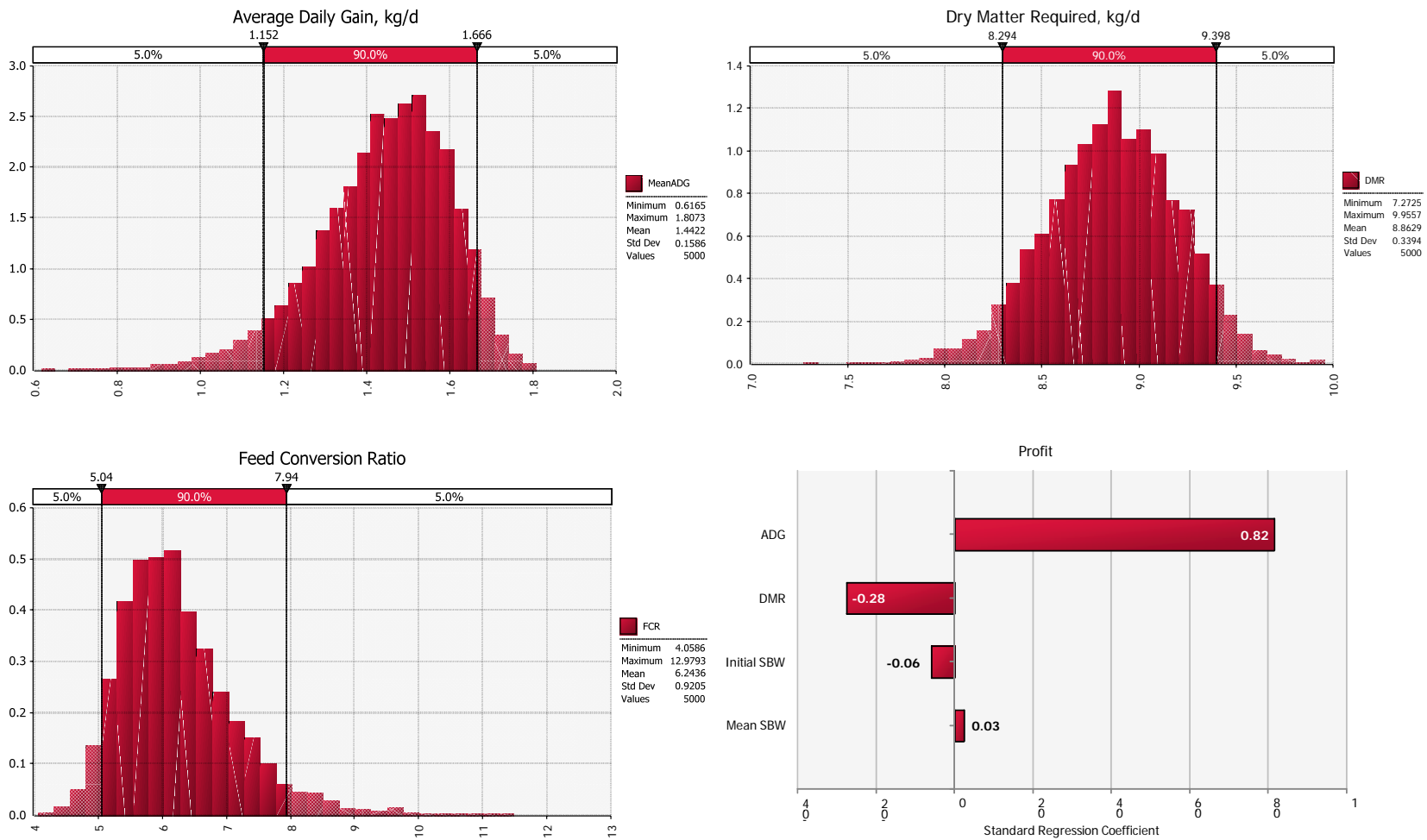


Figure 5. Simulation results of average daily gain, dry matter required, feed conversion ratio, and profit predicted by the CVDS model varying initial body weight and dietary metabolizable energy for a steer fed for 120 days.

Duration of Feeding: Decision Points

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Introduction

Some would say that the cattle industry is slow to change. However if you look at the change that as occurred during the past 60 years one may need to ask the question “Can we keep up with the change?” If we can keep up with this change, how can we control it? What factors should we consider when making the decision to select an endpoint for a set of cattle? What comes to each of our minds may bear a strikingly different aspect than the person next to us based on our most recent experience or those experiences which have influenced profitability. Thus, one will need to include purchase price, genetics, cost of gain, days on feed, implant strategy, use of beta agonists, and carcass composition in a model to achieve profitability. All of which may open a very new and different aspect to the topic.

This paper is our best effort in taking the limited data available to address a series of questions which are dynamic and often controlled by the psychological aspects of market anticipation which ultimately influence the outcome.

Background

As cattle-feeding has changed so have the methods used to market them. Now more than ever the ability to effectively look at a set of cattle and decide what their endpoint may be is critical to effective management. However, what may the endpoint be? Hot carcass weights continue to find their way above the previous year’s levels. Even though we can account for the seasonality (Figure 1) and price relationships (Figure 2) the driving force behind these increases is not as obvious as the initial perceptions.

Genetic Change

For many of us we have referred to the change that took place during the 60’s into the 70’s selecting away from smaller earlier maturing cattle and toward later maturing European breeds as the “Type Change”. This change was marked by phenotypic variables, which were obvious to the eye. However, the change that has been taking place in the present may not be as noticeable to the eye as what it was previously. This change continues with an increase in weight but is also marked by a moderation in height (Dib et al., 2010). While this may not be as noticeable as the changes in body type during the 60’s and 70’s it is important to remember that any initial change within a population is diluted out by the previous population until the generation interval is met.

Figure 3 outlines the changes described above for increasing genetic propensity for growth utilizing the across breed expected progeny differences (EPD) in a model developed by the Meat Animal Research Center, Clay Center, NE (Kuehn et al. 2009). All breeds continue to see increases in yearling weight (YW) EPD but Simmental, who have realized their breeds impact on

frame size and final body weight was too great to continue on the trend line of others and have flattened their rate of accent.

Angus has the greatest increase with a 33% increase in yearling weight EPD the last 10 years in addition to a 63% increase in carcass weight EPD (Figure 4). The influence of greater emphasis on growth traits has resulted in an increase in actual weaning and yearling weights of Angus cattle reported in the Angus Herd Improvement Records (AHIR) (Figure 5). Yearling bull weights have increased over 100 lbs in the past 20 years peaking out at 1144 lbs in 2004. Likewise, yearling heifer weights and weaning weights for both have increased over the 50 lb mark. The greater selection for added growth has resulted in larger cows in the which has directly impacted the final body size of the fed steer.

Ranch data collected from the same operation in western South Dakota over the past 24 years reveals this increase within a commercial herd, which utilizes artificial insemination and modest levels of crossbreeding. Since 1984, weaning weights increased from 465 lbs to 663lbs in the fall of 2008, which is 198 lbs heavier. This is an increase of 8.3 lbs per year for a 30% increase. Slaughter weights increased 24% or 319 lbs from 1014 lbs in 1984 to 1333 lbs in the spring of 2009, which is 13.2 lbs increase per year.

The most recent data to be published by the Meat Animal Research Center in Clay Center Nebraska summarizes Germ Plasm Evaluation (GPE) Cycle VII which are calves born in 1999 and 2000. Data summarized in table 1 compares changes in body type from the initial Cycle I (1970-1972) to Cycle VII which spans over 30 years (1970-2000). In 2000 steer weights averaged over 1337 lbs with average daily gains averaging 3.2 lbs per day at 455 days of age (Cundiff et al., 2007). This compares to steer weights in 1970 of 1090 lbs with steers averaging 2.4 lbs per day.

In the cattle evaluated 10 years ago British breeds grew as fast as their European breed counterparts and they had similar live weights at the same days of age. British breeds at that time (1999-2000) did fatten sooner reaching rib fat thickness and marbling scores targets earlier than the European breeds. European breeds did continue to maintain the advantage of possessing a greater proportion of retail product at a similar weight to British breeds.

The above may be a lengthy discussion on biological type but one must realize that the steer we feed today is vastly different than just five years ago by in its rate of growth and maturity pattern.

Use of anabolic growth promotants

Along with the improvement in genetic ability for cattle to obtain heavier weights anabolic growth promotants add to the genetic ability. Implants increase carcass weight (HCW) (10-15%) and ribeye area (REA). They improve dressing percent (DP) and feed efficiency (G:F). The response is similar to altering the animals frame size (Pritchard, 2001). Beta agonists have also proven their ability to increase ADG 12.5% (Vasconcelos et al., 2008) to 26% (Avendano-Reyes et al., 2006) for zilpaterol hydrochloride (ZH) and 14.4% for ractopamine hydrochloride (RH). Beta agonists allow cattle to be taken to heavier weights (9%) with less (14%) back fat than control steers (Vasconcelos et al., 2008). Recent research (Baxa et al., 2010) indicates that the

beta agonist ZH when administered with the growth implant Revalor-S results in an additive response to ADG, G:F, DP, HCW and REA.

The authors will not go into depth on the use of these promotants as they have been documented. However, within the paper we will quantify their use on affecting market endpoint decisions.

Feeder to fed relationship

The documentation of the management steps influences on carcass weight is easily quantifiable. However, the price spread between feeder and fed cattle is harder to quantify due to risk management strategies which may eliminate some of this interaction. Seasonally the largest spread between feeder and steer prices occurs in July and August. Hot carcass weights typically peak late September to October depending on the feeding conditions (figure 1).

Table 2 shows the example of taking a 700 lbs steer to heavier weights within reason. The ability to effectively distribute the cost of the feeder over more saleable weight lowers the breakeven. The bigger the spread between the feeder and fed prices the more incentive feeders have to take cattle to heavier weights. Taking cattle to heavier weights can result in price discounts which will be discussed within the decision points section.

Decision Points

Calves versus yearlings

A whole presentation can be devoted to differences in calves and yearlings and data will only be summarized here for establishing the differences that exist between each group as a marketing decision point. The University of Nebraska has conducted excellent comparisons between the two groups. Griffin et al. (2007) summarized calf-fed and yearling trials from 1996-2004. Cattle within the the calf system represented 804 head within 80 pens and the yearlings system represented 302 head from 18 pens. Table 3 outlines the differences reported between the calves and the yearlings fed similar finishing diets. Yearling cattle had higher values for nearly every measurable trait except BF. Yearlings had a higher DMI and ADG but were less efficient, however the yearlings averaged 78 fewer days on feed and consequently consumed less total feed. With higher feed costs and narrower feeding margins for the past two years cattle have entered the feeding phase heavier to alleviate feed costs. However does this method give a profit advantage to feeding yearling steers?

Research conducted at the University of Nebraska quantified the determinants of profit variability in calf fed or yearling production systems. (Small et al., 2010). Standardized beta coefficients were calculated to quantify the influence of sales price, purchase price, corn price, interest rate, average daily gain and feed conversion on profit (Figure 6).

The data reported by Small et al, (2010) would lend proof that market timing becomes the greatest component in insuring profitability feeding yearling steers. Corn prices account for 15.6 percent of the variation in profitability versus only 10.5 percent in the calf feds. Given the shorter feeding window for yearlings, the cost of corn at the time of feeding has a larger impact

than on the longer fed calves. One would think with the poor feed conversions of yearlings that feed efficiency would account for variation but because of the shorter days and less total feed consumed it accounted for a smaller variation in profit within the model.

Changes in Dressing Percent

Dressing percent is an influential factor in the decision points discussed above and is highly variable due to differences in fill. Implant and beta agonists improve dressing percents. Beta agonists can improve DP up to 2.5% points (Baxa et al., 2010). While not all studies have shown increased DP with increasing DOF (Van Koeveering et al, 1995) others have (May et al., 1992; Bruns et al, 2004; Vasconcelos et al., 2008) with R^2 values greater than .8 (figure 7). The serial slaughter data in Bruns et al, 2004 utilized calf feds ranging from 803 to 1277 lbs while May et al. (1992) used yearling cattle which were fed to heavier weights (736 lbs to 1372 lbs).

A regression equation for DP was developed from the May et al. (1992) data and overlaps the Bruns et al., (2004; table 4) regression equation. These two trials give a base regression of DP over the feeding period from YG ranging from 1 – 4.

Influence of days on feed on production and carcass variables

Utilizing a set of larger framed yearling steers, modeling was done to study the influence of days on feed on production and carcass variables. The yearling steers were fed for a 140 d in 24 pens (8 hd/pen). At slaughter these steers averaged .53 in. of ribfat. Covariate analysis was used to estimate HCW, marbling score, and Yield Grade at 0.4, 0.5, and 0.6 in. of ribfat. At each target fat depth the Coefficient of Variation for dependent variables was held constant. Actual cattle performance data was used to back calculate the NE values for the diet. During the time after 112 d on feed, DMI averaged 25.04 lb/d. Final live weight at each ribfat endpoint was calculated from HCW using a constant dress of 62.5%. This was done after establishing that within this population there were no meaningful relationships between HCW and YG ($r^2=.22$) or between YG and DP ($r^2=.03$). Assuming DMI at 25.04 lb/d and applying NE equations, we predicted ADG and consequently days on feed to reach the 0.5 in. ribfat target and then when targets changed from 0.5 to 0.4 in. and from 0.5 to 0.6 in. ribfat (table 5).

When looking at slaughter endpoints from the product end the optimal target would be nearer the 0.4 in rib fat target. The 0.5 target is closer to the feeders optimal endpoint and the 0.6 endpoint approaches over-feeding the cattle. The data within table 4 shows population shifts at 0.4, 0.5 and 0.6 in. of ribfat. Carcass weights increased along with YG and the percentage of carcass reaching choice and premium choice. Even though YG changed .4 and .3 of an YG between the target ribfat depths, the percentage of YG 4's changed dramatically from 1.73% to 7.44% to 26.4%. Likewise the percentage of heavy carcass over 1,000 lbs doubled from 0.5 in of rib fat to 0.6 in.

Changes in gross revenue show that the conventional endpoint (0.5 in ribfat) for this particular set of cattle was 1385 lbs. Increasing backfat an additional tenth of an inch, increased weight 24 lbs more which resulted in a price per cwt that was \$2.01 less than the cattle at 0.50 in. which

equated to a \$5.35 per head reduction in gross revenue loss. Likewise marketing the cattle too soon, in this case at a weight of 1361 lbs, would result in \$16.51 per head of lower revenue.

Similar conclusions were drawn by Feuz (2002) in a simulated economic analysis of altering days on feed with pens that differed in the carcass measurements. The author reported that additional weight that is acquired can offset the decline in price per cwt obtained due to the increase in YG; however, there comes a point where the percentage of discounted carcass lowers the price per cwt. This was between 0.5 and 0.6 rib fat for the SDSU cattle. Heavier yearling type cattle or cattle where a beta agonists was used may run a greater chance of being discounted at lower backfat depths

During modeling one can anticipate that increasing carcass weights will result in greater profitability until one starts to pick up discounts. Discounts for heavy weight carcasses (950-1,000 lbs) have been raised by many packers. Some packers will literally turn away cattle which weigh over 1,600 lbs because they may produce a carcass that is over 1,000 lbs. Likewise, cattle greater than 58" in height are not allowed for slaughter at one particular packer. Of the 192 steers in table 4, 8 hd weighed over 1600 lbs, cattle were not measured for height.

Carcass Gain to Live Weight Gain

As dressing percent increases, a common question raised, is whether there is a point of diminishing return for carcass gain to live weight gain. McDonald et al. (2007) compiled past data involving yearling type cattle and reported changes through regression for shrunk body weight and carcass gain through common days on feed. The author reported that as shrunk body weight gain decreased with increasing days on feed, carcass weight gain remained constant with a slope that was not different from zero. Applying a similar approach to the data of Bruns et al, (2004) regression lines were similar to that of McDonald et al., (2007; figure 8). Both authors reported that the slope of the line of carcass weight gain as a proportion of ADG was not different from zero. The difference in comparing the two trials may be attributed to McDonald et al. (2007) utilizing yearling cattle while Bruns et al. (2004) used calves. Calf-feds are probably demonstrating more true growth than are yearling at this stage of the finishing phase.

If DP or yield increases with increasing days on feed, then selling on a live basis would be better suited to shorter fed cattle. The practical upper limits on DP are probably dictated by the higher cost of gain and increased discounts that can occur as cattle are reaching/exceeding their physiological endpoint for true growth.

Interval cost of gain

With the advancements in the Cornell/Cattle Value Discovery System for growing animals (Tedeschi et al., 2006) one can effectively model changes in feed efficiency. As DOF progress and empty body fat increases, both actual and predicted ADG begin to decrease. Serial slaughter studies have been designed to study changes in carcass composition and due to the small sample size have not been able to quantify statistically changes in F/G. Bruns et al.,(2004) reported decreases in cumulative ADG from the reported high to the end of the trial from 21-25% where NRC(1996) predicted reductions in ADG from 40-55%. The cattle in this particular study

(Bruns et al, 2004) were medium framed, non implanted Angus steers who had the ability to extend their gain beyond what the NRC(1996) projected by 29-38%.

We looked at the incremental cost of gain for the modeled yearling steers referred to in table 4. The costs included additional feed, yardage, and the dilution of the fixed costs of purchase and placement costs. Although the grid based live price was highest when cattle were slaughtered at 0.4 in of ribfat, that would not have been the most profitable endpoint. Even with feed \$180/ton the cost of the added weight gain when feeding to the 0.6 in endpoint was lower than the discounted sale price for the over fat cattle (table 6).

Unrealized yardage can be an additional incentive to feed cattle to heavier endpoints. Consider a scenario where cattle were sold at 0.4 in rib fat and there were no cattle available to refill the pen. We assumed that the temporarily vacant pen has a yardage cost of \$0.28/d. That \$0.28/d cost becomes a cost to management and is not billed against a specific lot. The interval cost of gain was recalculated deducting this \$0.28/d from cost of gain. In this scenario, overfeeding cattle remained profitable even when diets costs were \$200/ton, with a market price of \$88.18/cwt and a cost of gain at \$83.27.

Psychology

It is human nature that if something is not working we can do one or more of the following -

1. Give up; decide that it is a lost cause and do something else.
2. Keep doing it; but with less enthusiasm which results in lower productivity
3. Work harder; intending to change the outcome by sheer effort.
4. Work smarter; change the work to yield successful results.

It is human nature to use one of the above responses when we are in a troubling situation. As carcass weights continue to climb one may attribute it to the historic philosophy which has plagued the market for so many years which is to feed our way out of a bad situation or to “*buy more time*” until the market improves. It is this aspect of “*buying time*” that needs to be addressed. Within other segments of the beef industry when one sets out to “*buy time*” we may do this by cutting costs. For example backgrounders base their profitability on lowering feed costs and reducing costs of gain until the market may improve.

Implications

As cattle supplies become tighter and open space in feed yards becomes greater, there are advantages to extending the length of time that cattle are on feed. The driver is compensate for reduced capacity. Increasing days on feed while managing the number of out carcasses would improve the yards bottom line. Mangers should be aware of the issues discussed above when choosing to marketing cattle at heavier carcass weights. Options do exist to address the issues above resulting in increased profitability for the yard with fewer cattle.

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zilpaterol hydrochloride feeding and days on the finishing diet on feedlot cattle performance and carcass traits. J. Anim., Sci. 86:2005-2015.

Table 1. Comparisons between Cycle I and Cycle VII cow weights and ending steer weights and marbling scores.

Breed	Five year old wts		Steer weights and marbling scores			
	Cycle I	Cycle VII	Cycle I		Cycle VII	
			End Wt	Marbling*	End Wt	Marbling*
Hereford	1023	1420	1017	Slight 60	1321	Small 20
Angus	1036	1411	1013	Small 50	1365	Small 84
Simmental	1083	1404	1122	Slight 60	1363	Small 27
Limousin	1052	1391	1058	Slight 50	1285	Small 04
Charolais	1154	1371	1129	Slight 60	1348	Small 17

Cycle I – years 1970-1972; Cycle VIII – 1999-2000

*Marbling scores converted to reflect current USDA Standards

Table 2. Feeder to fed ratio's effect on breakeven price

	Fed to 1300 lbs	Fed to 1400 lbs
Feeder steer weight	700	700
Price/cwt	\$1.10	\$1.10
Total	\$770	\$770
End weight	1300	1400
Cost of feeder/ sale weight	59.00	55.00
Carcass value gained 140/wt gain	0.23	0.20

Table 3. Comparison of calf-fed versus yearling system¹

	Calf-fed	Yearling	SEM
Initial wt.	642 ^a	526 ^b	5
Finishing initial wt.	642 ^a	957 ^b	7
Final wt.	1282 ^a	1365 ^b	8
Days on feed	168 ^a	90 ^b	1
Dry matter intake	21.36 ^a	30.56 ^b	0.15
Average daily gain	3.81 ^a	4.53 ^b	0.04
Feed to gain	5.63 ^a	6.76 ^b	0.02
Hot carcass wt.	808 ^a	860 ^b	5
Fat thickness, in.	.53 ^a	.47 ^b	0.01
Yield grade	2.71	2.60	0.14
Marbling score	510	525	9.9
Total feed ^c	3592 ^a	2754 ^b	32.1

¹Giffen et al., 2007^{ab}Means within a row with different superscripts differ (P<.01)^cTotal feed=amount of feed consumed during the finishing period.**Table 4.** Carcass data by slaughter group combined years^a

Variable	Slaughter Group					SEM	Linear
	1	2	3	4	5		
No.	16	16	18	7	8		
Hot carcass weight, lbs	459	542	649	775	838	6.9	.0001
Dressing percent ^b	57.1	58.6	62.3	64.1	65.6	.34	.0001
Rib fat, in.	.19	.26	.36	.55	.75	.02	.0001
Rib eye area, in ²	9.1	9.7	10.7	11.7	11.6	.16	.001
KPH, %	2.1	2.6	3.1	3.8	4.7	.09	.001
Yield Grade	2.2	2.6	3.1	3.8	4.7	.09	.0001
Intramuscular fat, %	2.57	3.65	5.00	6.50	8.19	.24	.0001
Marbling score ^c	412	453	541	633	709	9.8	.0001

^a Bruns et al., 2004^b Dressing percent calculated by (HCW / (Endwt*.96))^c Slight degree of marbling = 400; Small degree of marbling =500

Table 5. Yearling steer adjusted endpoint slaughter data.

Adjusted Rib Fat, in	Final Wt	Final HCW	Final YG	YG 4's	Choice	Premium Choice	Heavy Carcasses	Gross \$/hd
0.40	1361	851	2.82	1.73%	42%	9%	1.33%	1231.31
0.50	1385	866	3.20	7.44%	65%	20%	1.95%	1247.82
0.60	1409	881	3.59	26.4%	86%	26%	3.84%	1242.47

Table 6. Costs of Extending the Days on Feed

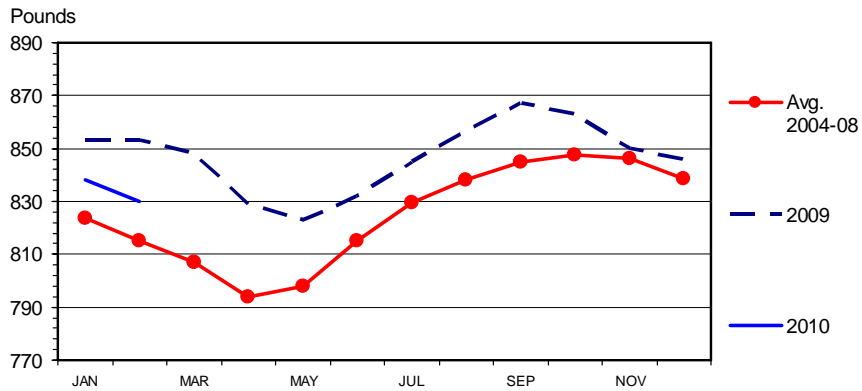
	Target Fat Endpoint, in.		
	0.4	0.5	0.6
Final BW Grid based	1361	1385	1409
Live Price, \$/cwt ¹	90.47	90.10	88.18
Feed Cost, \$/T	Interval Cost of Gain		
	0.4 - 0.5	0.5 - 0.6	
160	74.41	76.03	All costs ¹
	65.41	66.45	Opportunity costs ²
180	82.46	84.24	All costs ¹
	73.46	75.06	Opportunity costs ²
200	90.51	92.45	All costs ¹
	81.51	83.27	Opportunity costs ²

¹Based upon modeled grid pricing.

²Includes Feeder Cattle/Live Cattle Spread cost \$15/cwt; Placement cost \$56/head; Yardage All @ \$0.35/d; Yardage Opp @ \$0.07/d. All beyond reaching the 0.4" endpoint.

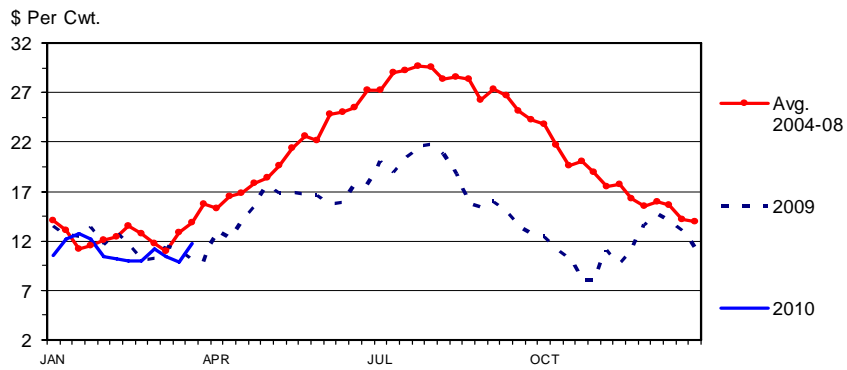
³Opportunity Yard = \$0.07/hd·d⁻¹. Cost difference between occupied and temporarily unoccupied (\$0.28).

Figure 1. Averaged Dressed Weight - STEERS Federally Inspected, Monthly



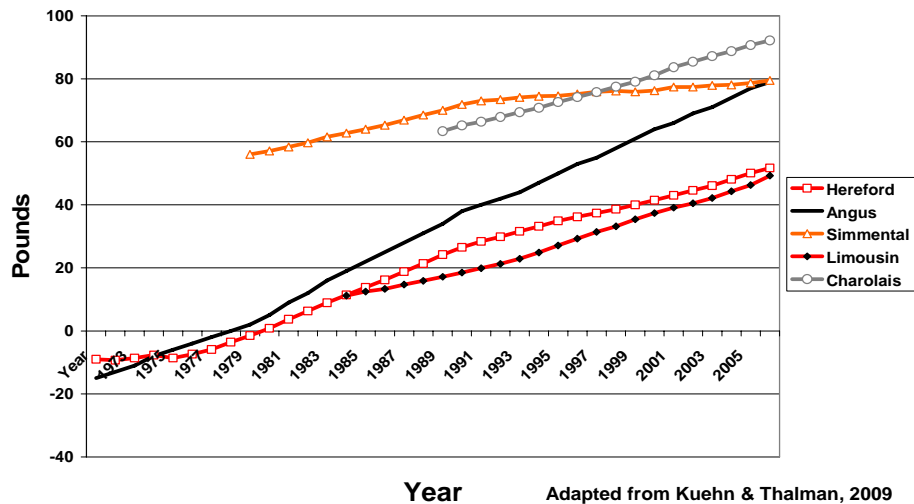
Livestock Marketing Information Center
Data Source: USDA/NASS

Figure 2. FEEDER STEER vs FED STEER PRICES 700-800 Lbs. Minus Slaughter Steer, S. Plains, Weekly



Livestock Marketing Information Center
Data Source: USDA-AMS, Compiled by LMIC

Figure 3. 2009 Across-Breed EPD's



Adapted from Kuehn & Thalman, 2009

Figure 4. Angus Genetic Trend by Birth Year

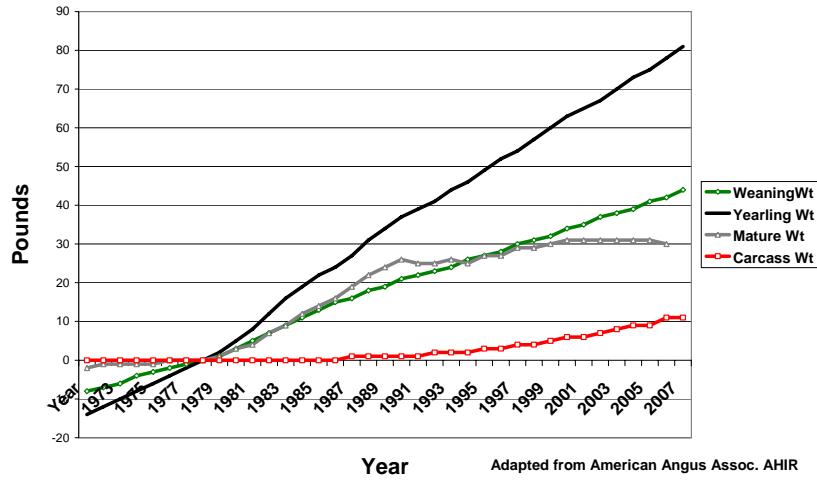


Figure 5. Changes in yearling and weaning weights of bulls and heifers.

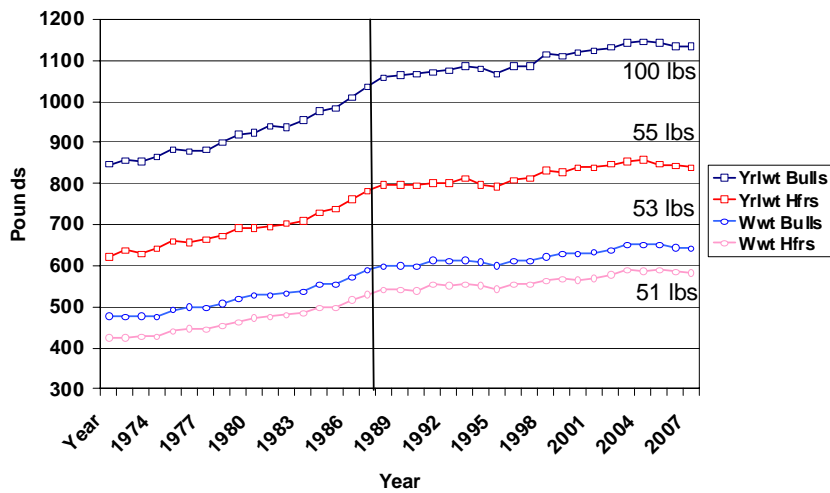


Figure 6. Variation in profit of calf-fed or yearlings.

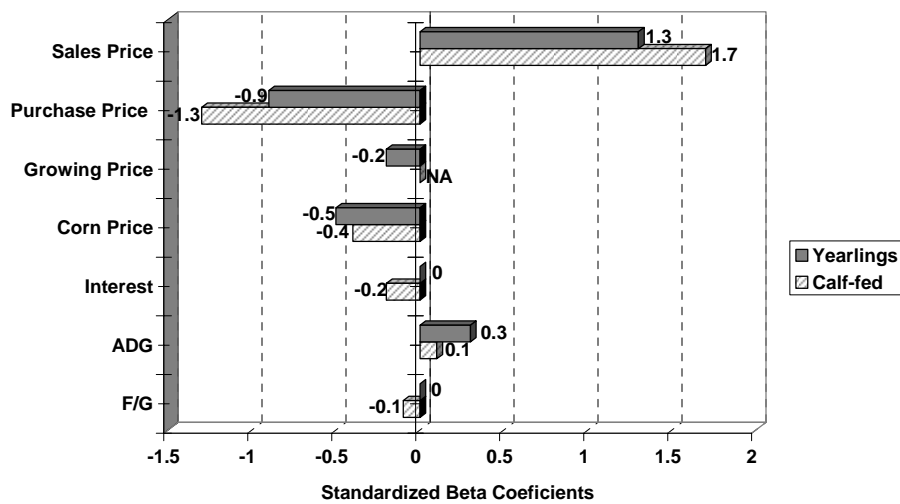


Figure 7. Dressing percent by hot carcass weight

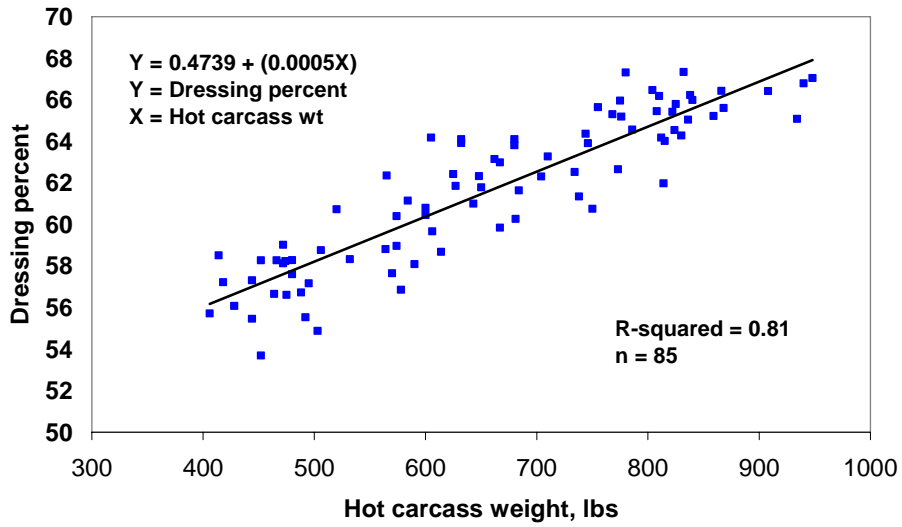
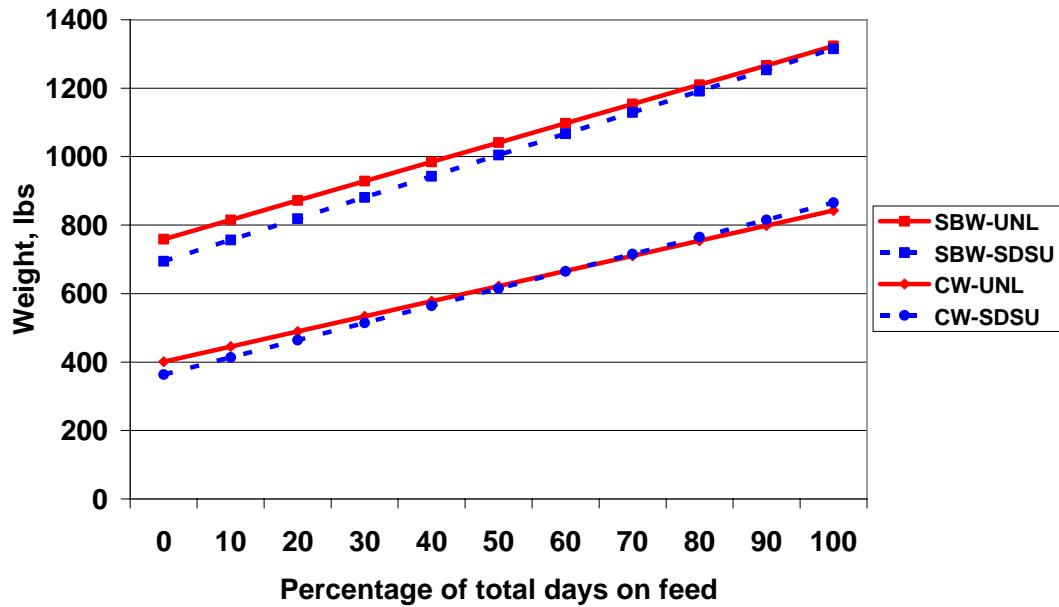


Figure 8. Shrunken body weight and carcass weight gain.



Practical Applications of Genetic Markers in the Cattle Feeding Sector

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This talk will discuss the recent history of genome research in cattle and technological advances that are positioning DNA markers for use in the cattle feeding industry. Unlike the seedstock and commercial cow/calf sectors where the technology is used to advance genetic improvement through more accurate selection of animals, for the feedlot sector it holds promise for allowing the operator to custom-manage individual animals according to their genetic potentials as determined by markers. Additionally, genetics will play a significant role in managing treatments and allowing for the more efficient use of resources. The development of these programs and applications using DNA technology is not a one-program-fits-all approach. Like many products in this segment of the industry, protocols will evolve over time.

Historically, selection based on statistical genetics has provided the framework to respond to the changing marketplace in the seedstock and commercial cow calf sectors. However, the rate of genetic change is slowed in beef cattle due to long generation interval and selection tools that have relatively low accuracy. The advancement of DNA technologies applied to cattle holds substantial promise to solve this problem, by increasing the accuracy of estimated breeding values, improving selection efficiency, and reducing the cost of altering the genetics of cattle to suit current production goals (Schaeffer, 2006). Improving production traits that are difficult and/or expensive to measure is a relatively slow and costly process. However, genomic technologies give us tools to make more headway for these hard to measure traits -- like feed efficiency and animal health. Already, application of DNA technology for the genetic improvement of traits such as milk yield is impacting livestock selection (VanRaden et al., 2009).

Advancements made at the top of the genetics pyramid, beginning at the seedstock sector, have impacted the industry throughout the food chain, from the farm gate to the consumer's plate. Sometimes the seedstock segment of the industry has been misguided, by taking selection for a single trait too far. However, the commercial portion of the industry has served as a system of checks and balances, and has helped the seedstock industry get back on track.

The promise of DNA based technologies for genetic improvement in the livestock industry has been made for the last fifteen to twenty years. Over the last decade, the scientific community has created many populations to discover quantitative trait loci (QTL). A large number of the beef cattle experiments used relatively few sires mated to a large number of dams, producing progeny that were phenotyped and genotyped to discover the QTL.

We now realize that deficiencies existed in the methodology for mapping QTL in cattle. These shortcomings resulted from underpowered studies, mainly because the expense of collecting phenotypic and genotypic information led to the use of populations too small to detect the numerous putative QTL that have a small to moderate effect on phenotype. Increased power and resolution can be achieved by increasing population size, although this is an expensive proposition. The majority of published QTL studies suffer from a lack of power that manifests as

an inability to detect QTL of small effect, a poor estimation of effect size, and low resolution in determining position. Despite their limitations, QTL experiments provided valuable knowledge about the presence and approximate locations of variation — which affect phenotype — that segregate in cattle populations. One of the success stories in the beef industry for QTL-enabled selection tools has been the DNA polymorphisms used to explain some of the variation for tenderness (Page et al., 2002; White et al., 2005).

There has been substantial effort in the research community to initiate marker assisted selection (MAS) in the beef industry with some limited success. Most economic traits for meat production are influenced by many genes. The tracking of a handful of genes using MAS has only accounted for a small portion of the genetic variation for a given trait(s). Even this small number of genes requires extremely large numbers of animals with data to accurately estimate their effects (Goddard & Hayes, 2007) as well as numerous QTL populations and genome scans to reveal their locations. In order to realize the potential for MAS in cattle, a much more comprehensive approach to discovering the sources of variation segregating in commercial populations was needed. Fortunately, recent technological advances provide a framework to achieve a more thorough, efficient approach to discovery of important genetic variation.

The Bovine Genome Sequencing Project (www.hgsc.bcm.tmc.edu), which produced the first draft assembly of the complete cattle genome in 2007, (based on the DNA of a Hereford cow) has assisted in the development of much needed technology to move the DNA marker assisted selection forward. This project produced a pool of over 300,000 single nucleotide polymorphisms (SNP) by sequencing animals from other breeds and comparing this sequence to the draft. The draft cattle genome, coupled with advancements in chemistry, has led to the development of higher density genotyping platforms – such as the Illumina BovineSNP50 BeadChip that contains >50,000 SNP spaced every 60,000-75,000 bp across the genome (Matukumalli et al., 2009). These advancements in technology have empowered us to explore the whole genome in greater detail. It has also set in motion the ability to develop genome-enabled and enhanced selection. Whole genome selection is moving at an accelerated pace when compared to previous marker products (VanRaden et al., 2009). Additionally, subsets (panels) of DNA markers are under development from the WGS research, for suites of traits custom-designed for different segments of the industry. These panels, using low cost genotyping technologies, are mostly in the research and development stages, but hold great promise to make marker assisted management (MAM) a reality for implementation in the beef cattle industry.

In the feedlot industry, management strategies have focused on improving production and managing groups of animals to targeted endpoints. Production systems have been set up to manage groups of animals rather than individual animals. Marker assisted management is an additional tool to enhance endpoint optimization, which allows for individual management of animals in traditional group managed settings. Marker assisted management consists of using genetic information to more efficiently manage inputs and output for maximum profit. Using MAM in the feeding/stocker industry differs relative to MAS in the seedstock industry, where decisions are being made to produce animals for the next generation. None-the-less, the two are similar from the standpoint of using genetic-based information on an individual animal to make a profit-based decision. With that in mind, the feedlot industry manages animals on a pen basis. It is these management decisions -- such as implant regimes, use of beta-agonist, diet, and days on

feed -- that will impact how efficiently cattle hit targeted endpoints. Genetics play a role in the outcome of the animal, but often little is known about the genetics of the individual animal or group of animals. DNA technology allows us to predict the genetic potential in an animal. The ability to take a look at this while an animal is young has numerous benefits.

Like all new technologies, implementation of genetic markers in feedlot management will take on many forms. One of the first considerations will be at what point in the management timeline will tissue samples be collected and tested. Ideally, this should take place prior to arrival at the feed yard. This would provide the ultimate system and allow the genetic information to be included in the first-sort and early management of animals.

For much of the industry, cattle will not likely be tested prior to arrival. Tissue sampling will occur upon arrival and will then be submitted to the laboratory. The resulting genetic test information will therefore be utilized a couple of weeks or more following arrival. The type and method of tissue collection will need to be considered. At present, tail hair (root follicles), blood (FTA card), ear punch and semen (one straw) are the primary tissues sampled by seedstock producers. Nasal swabs are being used in some programs and may be a viable alternative for efficient and economic source of DNA. Whatever the tissue of choice, the ease, speed and quality of collection, using the operation's present processing protocols, will be critical.

How predictions of performance from marker panels are used in the decision making process will vary greatly. One can envision many different sort strategies relative to final target markets. Some may use MAM with phenotypic sorting, and use known variation in growth curve parameters to determine economically ideal live and/or carcass endpoints. In this system, phenotypic indicator traits, coupled with genetic information for growth, will help determine things such as days on feed and carcass weight targets. For most markets, the primary goal is to maximize carcass weight while avoiding discounts for heavy carcasses and the related penalties for yield grade 4s and 5s.

In contrast, other programs may use genomic predictions to target cattle with a greater propensity to marble for branded programs driven by quality grade. These animals may be managed with different implant strategies. Cattle that do not possess the genetic potential to meet marbling thresholds, will be sorted to yield-oriented market targets, and fed for a set number of days, implanted more aggressively and potentially fed a beta agonist.

To date, the largest commercial use of marker assisted management has been implemented by Cargill Meat Solutions. Cattle are processed and tissue samples collected upon arrival. The cattle were sorted at re-implant time, using a combination of ultrasound scan body composition and genetic marker information. Cattle are sorted four ways;

- 1) Group 1 consists of early maturing cattle with the propensity to perform well in the early portion of the feeding period. These cattle are heavier and fatter. Management of group 1 includes the use of technologies promoting lean growth to keep the cattle from becoming too fat.
- 2) Group 2 cattle are considered as average for fat and growth, thus expected to produce carcasses with average weight, yield and grade.

- 3) Group 3 cattle are typically lighter and leaner and require more days on feed.
- 4) The final group 4 cattle had the highest propensity to produce carcasses with superior marbling and quality grade. These cattle are often not re-implanted to maximize the number of choice grading carcasses (Kolath, 2009).

Like many technologies, some of the greatest impacts may come unexpectedly from the hard to measure traits including health and feed efficiency. Being able to use DNA information to manage the propensity of animals for susceptibility to Bovine Respiratory Disease (BRD) would greatly impact overall profitability in the industry (Griffin, 2010). However, understanding the genetics of animal health for diseases like BRD will require significant investments to bring the use of genomics to application. In-depth clinical diagnoses and description of phenotypes is one of the primary challenges. An example of this is the number of slaughtered animals with lung lesions, but never exhibited symptoms that resulted in treatment (Schneider et al., 2009).

Historically, feed efficiency is one of the primary traits effecting profitability in fed cattle. Yet, our ability to select and manage for its expression has been limited (Johnson et al., 2003). Across the feeding industry, feed efficiency has typically been measured as feed conversion ratio (feed intake:live weight gain). Indirect selection for feed conversion has occurred through selection for growth, and is significantly influenced by the composition of gain.

Residual feed intake (RFI), or net feed intake (NFI), is presently the trait of choice among most researchers working in the area of beef cattle energy utilization. By definition, RFI is the animal's average daily dry matter intake subtracted from the predicted average daily intake based on the animal's body weight and gain during the course of the feeding period. The idea of RFI was first describe in cattle by Koch et al. (1963). The approach uses an analysis where feed intake phenotype is forced to be independent of other traits under selection. This means that the measure of feed intake for an individual is not directly correlated with growth rate, fat deposition, milk production, size, etc.

In the cattle feeding industry, the ratio of feed to gain will likely continue to be the primary driver defining feed efficiency. The use of genetic markers may finally allow us to truly understand the relationships between the different measures of efficiency and apply them more profitably. Understanding the differences and similarities between measures of feed efficiency in the feedlot and cow-calf sectors, will help prevent us from making some of the mistakes of the past.

One can envision matching specific genetic/biological types more efficiently to growing and finishing diets. Jenkins and Ferrell (1991) previously showed differences between breeds in energy efficiency relative to intake levels by measuring heat production with indirect calorimetry. Hereford females were more efficient than Simmentals when fed low levels of energy, but as energy levels increased the two breeds became similar in efficiency. At the highest energy level, Hereford females were less efficient than Simmental. This study shows us how changes in the rumen environment and digestibility, in response to finishing versus higher roughage diets, provides the opportunity to manage feed resources differently when the genetic potential of an animal is known.

The beef industry is constantly faced with challenges – many of which can be turned into opportunities if armed with the latest technologies and expertise. The addition of DNA marker technology to the current tools used for genetic selection and management holds exciting possibilities for enhancing production efficiency, product quality and profitability across the industry. Past efforts to develop DNA markers have been limited by costs and available technologies. But today, advancements in genotyping and sequencing have created a big impact in the dairy industry and are beginning to positively impact the seedstock industry. These results show the power of new genomic tools. In time, these tools will result in advancements for quantitative traits impacting management of animals in the stocker and feeding sectors of the industry.

Although the implementation of such technology will not be easy, the potential rewards are substantial. Integration will vary from operation to operation, and as with most new technologies, there will be a learning curve and growing pains. What we learn will give way to more profitable decision making tools that will ultimately enhance the stockers' and feeders' ability to provide some of the finest beef in the world.

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Nutritional Management Approaches for Receiving and Starting Cattle

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Introduction

Morbidity and mortality from bovine respiratory disease (BRD) in newly received cattle continues to be the most significant health problem facing the US beef cattle industry (Duff and Galyean, 2007). Mortality from BRD and the expense of medicine and labor to treat BRD represent only a portion of the differences in net returns for treated vs. untreated cattle, with the majority of the differences in profitability resulting from poorer gains and efficiency and lower sale value (McNeill et al., 1996). Numerous studies have shown that morbidity in feedlots suppresses performance and carcass quality and value (McNeill et al., 1996; Gardner et al., 1999; Roeber et al., 2001; Waggoner et al., 2007; Montgomery et al., 2009). These data clearly illustrate that the response and performance of feedlot cattle during the overall feeding period is affected by their health and performance response during the receiving/starting period. Thus, the receiving period plays a crucial role in the economic outcome of cattle feeding.

Several excellent reviews have been published focusing on the management of newly received feedlot cattle and the interaction of nutrition with beef cattle health and immunity (Galyean et al., 1999; Duff and Galyean, 2007; Preston, 2007). Many factors affect the responsiveness of the immune system. It has been well established that energy deficiency in cattle can severely depress the immune system (Hutcheson, 1989; Nockels, 1991; Carroll and Forsberg, 2007). It is recognized that newly received cattle in the feedlot, especially younger, light-weight cattle do not eat well. Hutcheson and Cole (1986) measured individual feed intakes of newly received cattle in 18 experiments. They reported that during the first week that healthy calves and morbid calves were only eating 1.55 and 0.9% of their body weight (BW), respectively. In this study after 2 weeks, the healthy calves were eating only 1.9% of BW and the morbid calves were eating only 1.84% of BW after 4 weeks. In general, until cattle are eating 2% of their BW, the best one can hope for is to maintain body weight. These data clearly illustrate that it is critical to get newly received calves eating as soon as possible and to feed a nutrient dense diet.

Since the receiving/adaptation period plays a crucial role in the economic outcome of cattle feeding, the objective of this paper is to review the research on nutritional management approaches for receiving and starting cattle on feed particularly as it relates to dietary energy concentration and sources. The following topics will be addressed: dietary energy concentration in the diet, dietary concentrate type (starch level), and adaptation programs for starting cattle on feed.

Dietary Energy Concentration

Since the energy concentration of diets is typically altered by changing dietary roughage concentration, the effects of energy intake are generally confounded with changes in dietary

ingredients, particularly roughage (Duff and Galyean, 2007). Lofgreen (1983) reported that stressed beef calves seem to have altered eating patterns compared with their unstressed counterparts. In this research on dietary preference of lightweight, stressed cattle, it was noted that stressed calves exhibited behavior the reverse of that seen in unstressed calves, in that they preferred and consumed more of high-concentrate (high-energy) diets than high-roughage (low-energy) diets. When given a choice among feed mixtures varying in concentrate level, stressed calves selected diets with 72% concentrate during the first week after arrival, whereas, unstressed calves selected diets containing 62% concentrate (Lofgreen, 1983). Thus, the intakes and performance of lightweight, newly-received calves are typically optimized with higher concentrate diets (Lofgreen et al., 1975, 1980, 1981, 1988). However, morbidity and treatment days per calf are generally lower with high-roughage diets (Lofgreen et al., 1975, 1981).

Lofgreen et al. (1980) reported that feeding steam-flaked milo diets (SFM) containing 50 and 75% concentrate promoted more rapid recovery of purchase weight and more efficient gains than a diet containing 25% concentrate in stressed, 353 lb calves. In this same study it was noted that feeding free-choice alfalfa hay (averaged 3.9 lb/hd/d) with the SFM diets for 28 days reduced mortality, morbidity, and the number of treatments per medicated calf. In contrast, in two other trials, Lofgreen et al. (1975, 1981) found no benefit from feeding either alfalfa hay or millet hay with the concentrate ration during the 28-d receiving period. Lofgreen (1988) reported that feeding a 75% concentrate ration for the entire 28-d receiving period plus free-choice native grass hay for the first week improved performance without altering morbidity compared to feeding a high-roughage diet.

Fluharty and Loerch (1996) used 60 individually fed steers (467 lb initial BW) in a 28-d trial to compare diets with either 30, 40, 50, or 60% corn silage on a DM basis (85, 80, 75, or 70% concentrate, respectively). They reported that DMI increased linearly ($P < 0.02$) with increasing concentrate level during wk 3 and 4 after arrival and over the total trial. No differences in daily gain and feed efficiency due to concentrate level were observed over the 28-d trial. In a second trial with 77 individually fed steers (499 lb initial BW), feeding 85 vs. 70% concentrate diets (30 vs. 60% corn silage) over a 28-d period increased DMI ($P < 0.01$) for the first 2 wk, but not over the total trial. Similarly, daily gain and efficiency were improved ($P < 0.01$) with the 85% concentrate diet during wk 1 but not over the total trial. Morbidity and the number of treatments per medicated calf were similar across dietary treatments in both trials.

To evaluate the statistical relationships between BRD and dietary roughage concentrations, Rivera et al. (2005) reviewed and summarized six receiving trials conducted at the Clayton Livestock Research Center during the 1970's and 1980's by Glen Lofgreen. These trials examined the use of different dietary concentrate/roughage concentrations on the performance and health of newly received cattle. In general, the cattle used in these trials were lightweight crossbred calves purchased at auction barns and shipped long distances (calves from Arkansas, Florida, and Missouri), but some cattle were locally purchased and a few were yearlings. The purchase weight on these cattle ranged from 354 to 554 lb with the majority of the cattle weighing less than 400 lb. Diets were typically based on SFM or whole-shelled corn (WSC) as the grain source, with alfalfa hay, cottonseed hulls, or native grass as the primary roughage source.

In this analysis, Rivera et al. (2005) reported that morbidity from BRD only decreased slightly as dietary roughage concentration increased [morbidity, % = $49.59 - (0.0675 \times \text{roughage, \%})$; $P = 0.003$]. A 20% increase in roughage concentration only decreased morbidity by 1.35%. Whereas, ADG [ADG, lb = $2.58 - (0.0196 \times \text{roughage, \%})$] and DMI [DMI, lb = $11.77 - (0.0298 \times \text{roughage, \%})$] were negatively affected by increasing roughage concentrations. A 20% increase in roughage decreased ADG by 0.39 lb and DMI by 0.59 lb. In their economic analysis of this data, cattle started on a 40 vs. 100% roughage diet made approximately five times more profit during the 28-d receiving period. Rivera et al. (2005) concluded that the optimum dietary strategy for starting light-weight, highly stressed, newly received cattle on feed would be to feed a 50 to 75% concentrate milled diet. This allows cattle to perform well without economically important negative effects on receiving period health.

In summary, these studies evaluating dietary roughage and concentrate levels suggest that feeding higher energy diets (achieved by decreasing roughage concentration) may slightly increase the rate of BRD morbidity in newly received light-weight cattle. However, these higher energy diets also increase gain, feed intake and gain efficiency compared with lower energy, greater roughage diets. The Rivera et al. (2005) review suggested that the optimal receiving diet would contain 50 to 75% concentrate. The slight increase in morbidity that might occur with this diet can be minimized by feeding free-choice hay for the first week of the receiving period (Lofgreen, 1988).

Dietary Concentrate Type (Starch Level)

High concentrate diets are often made up of readily fermentable carbohydrate (starch) which is the component primarily responsible for causing acidosis in cattle (Owens et al., 1998). Thus, feeding high-concentrate diets to newly received, stressed feedlot cattle may further stress the calves, making them more susceptible to health problems. Low-starch by-products may offer alternatives to grains for formulating high-energy receiving diets.

Gill et al. (1994) fed newly received calves either an 85% concentrate diet with 43% corn distillers grain or free-choice prairie hay plus protein supplement over a 28-d period. They noted that the 85% concentrate diet contained a dietary starch level similar to that found in feedlot starting rations containing 50 to 60% grain. As would be expected, ADG and efficiency were markedly improved ($P < 0.05$) with the 85% concentrate diet as compared to the hay diet. However, morbidity did not differ between treatments. Gill et al. (1994) speculated that the high starch content of receiving diets may be responsible for the increase in morbidity often observed with high-concentrate diets.

McCoy et al. (1998) evaluated feeding 55% concentrate diets (45% alfalfa hay) based on either dry rolled corn (DRC) or wet corn gluten feed (WCGF) in two receiving trials. In Trials 1 and 2, 398 calves (567 lb initial BW) and 315 calves (556 lb initial BW), respectively, were fed these diets for 20 to 33 days. In Trial 1, calves fed WCGF consumed less DM ($P < 0.01$) and gained slower ($P < 0.05$) than calves fed DRC. Morbidity was lower in the calves fed DRC ($P < 0.10$) than the calves fed WCGF, but the difference was small (18.8 vs. 23.3%). In Trial 2, calves fed WCGF consumed less DM ($P < 0.01$), gained similarly ($P > 0.15$), and were more efficient ($P < 0.10$) than calves fed DRC. Morbidity did not differ between treatments. Dietary NEg

calculated from animal performance showed that the WCGF diets were higher in energy than the DRC diets in this trial (NEg was 139% that of DRC). McCoy et al. (1998) concluded that these results suggest that WCGF has a NEg greater than DRC in receiving diets.

Drouillard et al. (1999) used 620 weaned steer calves in two 28-d receiving experiments to evaluate growth performance and health with the feeding of 60% concentrate diets (40% alfalfa hay) based on either DRC, dried distillers grains with solubles (DDGS), or wheat middlings. In Trial 1, calves fed DRC-based diets tended to gain faster ($P = 0.20$) and more efficiently ($P = 0.09$) than calves fed wheat middling-based diets. No differences in morbidity were observed. In Trial 2, calves fed DDGS-based diets consumed more DM ($P = 0.05$) and tended to gain faster ($P = 0.09$) than calves fed DRC-based diets. Morbidity tended to be greater ($P = 0.09$) for calves fed DDGS than DRC (26.7 vs. 14.8%). Drouillard et al. (1999) concluded that grain by-products are reasonable substitutes for grain in receiving diets. However, the incidence of BRD was not reduced with the feeding of these by-products.

Berry et al. (2004) studied the effects of dietary energy and starch concentrations on the performance and health of newly received calves during a 42-d receiving period. In this study, 572 crossbred calves (410 lb initial BW) were fed one of two dietary energy levels (0.39 or 0.49 Mcal NEg/lb DM, 45 vs. 35% roughage) and one of two dietary starch levels (34 or 48% of ME from starch) in a 2 X 2 factorial arrangement of treatments. Daily gain and efficiency were not affected by dietary energy or starch concentrations. Dietary starch level had no effect on DMI, however, calves fed low-energy diets consumed more DM than calves fed high-energy diets over the 42-d trial ($P < 0.05$; 12.35 vs. 11.80 lb/d). Dietary energy concentration did not influence morbidity in this study. However, calves fed the high-starch diets had numerically greater morbidity ($P = 0.11$) than calves fed the low-starch diets (68.8 vs. 59.4%). Berry et al. (2004) noted that although animal performance was not influenced by dietary energy concentration that feeding the high-energy diet decreased the shedding of *Pasteurella multocida* and *Haemophilus somnus* pathogens in morbid calves. Since the dietary roughage concentration varied over a narrow range in this study (35 to 45%), it is not possible to compare these results with the results of previous studies (Lofgreen et al., 1975, 1980; Lofgreen, 1988) where the variation in roughage concentrations were much greater (10 to 100%).

Neville et al. (2008) evaluated feeding either corn DDGS or wet corn distillers grain with solubles (WDGS) at three levels (0, 20, or 40%, DM basis) in 57% concentrate diets to newly received calves. In this study, DDGS and WDGS replaced corn and soybean meal in the diet. They concluded that feeding increasing levels of corn distillers grains reduced DMI and improved gain efficiency both linearly ($P = 0.01$ for DMI and $P = 0.07$ for G:F) and quadratically ($P = 0.06$ for DMI and $P = 0.01$ for G:F). Feeding distillers grains did not affect ADG.

May et al. (2009b) fed 220 steers (616 lb initial BW) 65% concentrate diets based on steam-flaked corn (SFC) containing either 0 or 15% WDGS over a 42-d receiving period. Dietary treatment did not affect ADG, DMI, or efficiency during the receiving period. Morbidity data was not reported since only 3 animals were treated during this trial.

In summary, these studies evaluating dietary energy sources generally suggest that reducing the grain portion of the diet by adding low-starch grain by-products during the receiving period has

minimal effect on performance and health. In theory, feeding low-starch by-products should reduce stress on the animals by minimizing the risk of acidosis. However, recently published studies with ruminally cannulated steers have suggested that feeding distillers grains may actually reduce rumen pH (Corrigan et al., 2009) or increase ruminal lactic acid concentrations (May et al., 2009a; Uwituze et al., 2010).

Adaptation Programs for Starting Cattle on Feed

Traditionally, feedlot cattle have been adapted to high-grain diets by ad libitum feeding of sequential diets with increasing grain concentration (decreasing roughage concentration) over 2 to 4 wk. This allows ruminal microorganisms to gradually adapt to a ruminal environment with a lower pH in an attempt to minimize subacute acidosis and intake variation that can occur with overeating of grain. Other methods of starting cattle on feed that have been studied include using the traditional approach of stepping roughage levels down but with limited maximum intakes, starting cattle on the final diet with restricted intakes, and starting cattle with diets containing high levels of WCGF or WDGS and then sequentially reducing these ingredients over 2 to 4 wk.

Limited Maximum Intake

Xiong et al. (1991) adapted steers (807 lb initial BW) to 91% concentrate diets based on SFM by feeding diets containing 65, 75, and 82% concentrate for 7-d each. Steers were either allowed ad libitum access to these diets or DMI was limited to 2.3, 2.5, and 2.7 times their NEm requirements (based on initial weights) for wk 1 through 3, respectively. From the 4th wk and thereafter, DMI was limited to 2.9 X NEm (based on 28-d weights). The limited intake program reduced DMI ($P < 0.005$) and ADG ($P = 0.03$) without affecting gain efficiency over the first 28 d on feed (Preston, 1995). However, performance over the entire 116-d feeding period and carcass characteristics were not altered by limiting intake. Bartle and Preston (1992) further evaluated this limited maximum intake program by adapting steers (818 lb initial BW) to 90% concentrate diets based on SFM by feeding diets containing 65, 75, and 85% concentrate for 7 d each. Steers were either allowed ad libitum access to these diets or DMI was limited to a multiple of the NEm requirement (2.1, 2.3, 2.5 and 2.7 and 2.3, 2.5, 2.7, and 2.9 times NEm requirements for wk 1 through 4, and thereafter, respectively). These authors noted that cattle initially fed 2.1 X NEm tended to have improved gain efficiency during the first 28 d and greater ADG (6.7%, $P = 0.08$) and gain efficiency (4.3%, $P = 0.15$) over the entire 116-d feeding period. Carcass characteristics were not altered by limiting intake. Preston (1995) concluded that these two studies show that limited maximum intake programs can control fluctuating feed intake and improve performance.

Restricted Intake

Bierman and Pritchard (1996) adapted steers (875 lb initial BW) to a 92% concentrate diet based on WSC by either allowing ad libitum access to 45, 65, 75, and 82% concentrate diets over 11 days or by initially restricting DMI of the final diet (1.74% of initial BW) followed by gradual increases until ad libitum intake was achieved. The restricted steers consumed 20.5% less DM ($P = 0.0001$) and were 19.1% more efficient ($P < 0.07$) over the first 29 d than ad libitum fed

steers. Over the entire 121-d feeding period, restricted steers consumed 10.7% less DM ($P < 0.009$) and were 10.9% more efficient (F:G, $P < 0.10$) than ad libitum fed steers.

Weichenthal et al. (1999) adapted yearling steers (845 lb initial BW) to a 95% concentrate diet based on DRC by either allowing ad libitum access to 66, 74, 81, and 88% concentrate diets over 23 d or by restricting intake of the final diet to 1.76% of initial BW on d 1 and increasing DMI by 0.4 to 1 lb/d until they reached ad libitum intake in about 3 wk. Over the entire 123-d feeding period, restricted steers consume 5.8% less DM ($P = 0.06$) and were 7.7% more efficient (G:F, $P = 0.004$).

Choat et al. (2002) adapted yearling steers (922 lb initial BW) to a 90% concentrate diet based on SFC by either allowing ad libitum access to 70, 75, 80, and 85% concentrate diets over 20 d or by restricting intake of the final diet to 1.25% of initial BW on d 1 and increasing DMI by 0.5 lb/d when a pen's bunk was slick at the morning feed call. Restricted steers consumed 22.3% less DM ($P < 0.01$) and ADG was reduced by 27.1% ($P < 0.01$) over the first 28 d compared to ad libitum fed steers. Over the entire 70-d feeding period, restricted steers consumed 8.8% less DM ($P < 0.01$) while ADG and gain efficiency were not different between treatments. Carcass characteristics were not influenced by adaptation method. It was noted that intake variation on a daily basis was greater ($P < 0.01$) for ad libitum fed steers on d 11 through 15, 16 through 20, and 21 through 25 compared with restricted steers. In a second trial, steer calves (637 lb initial BW) were adapted to a 92.5% concentrate diet based on DRC by either allowing ad libitum access to 65, 75, and 85% concentrate diets over 22 d or by restricting intake of the final diet. These restricted steers were adapted in the same manner as the steers in the first trial. Restricted steers consumed 30.3% less DM ($P < 0.01$) and ADG was reduced by 27.0% ($P < 0.01$) over the first 28 d compared to ad libitum fed steers. Over the entire 141-d feeding period, restricted steers consumed 5.1% less DM ($P < 0.01$) and ADG was reduced by 8.5% ($P < 0.01$), whereas, gain efficiency did not differ between treatments. However, DMI of the restricted calves did not approach that of ad libitum fed steers until approximately 40 d on feed compared to approximately 27 d in the first trial. Carcass characteristics were not influenced by adaptation method. However, hot carcass weight (HCW) was reduced by 51 lb ($P < 0.01$) with the restricted intake program. In contrast to the previous trial, daily DMI variation was greater ($P < 0.01$) for restricted steers from d 9 through 17 compared with steers fed ad libitum.

Holland et al. (2007) evaluated four methods of adapting highly stressed steer calves (626 lb initial BW) to an 88% concentrate diet based on DRC which was program-fed during a 60-d growing trial. The four adaptation treatments were as follows:

- 1) Traditional (TRAD) - Steers were sequentially fed 64, 72, and 80% concentrate diets for 7 d each. Feed delivery was increased by 2 lb/d when a pen's bunk was slick at the morning feed call. On d 22, the final diet was fed at an intake programmed (NRC, 2000) so the steers would gain 2.5 lb/d.
- 2) Receiving (REC) – Steers were fed the 64% concentrate diet and bunks were managed as above through d 28 before feeding the 72 and 80% concentrate diets for 7 d each. Program feeding began on d 43.
- 3) Limited maximum intake (LMI) – The step-up diets were fed for 7 d each, but intake was limited to 2.1, 2.3, and 2.5 X NEm requirements. Program feeding began on d 22.

- 4) Program-fed (PF) – On d 0, the 88% concentrate diet was fed to provide equivalent metabolizable energy as the 64% diet in the previous treatments. Feed delivery was increased by 0.5 lb/d and the maximum allowable intake was the amount programmed for steers to gain 2.5 lb/d.

These authors reported that over the entire growing period, ADG was greatest ($P = 0.02$) for REC, intermediate for TRAD and LMI, and least for PF. However, the REC calves gained slower and were less efficient (average ME intake/ADG) than the other treatment groups once program feeding began on d 43. Over the entire 60-d period, the REC calves consumed the greatest amount of ME/d ($P < 0.001$), but tended to be the least efficient in converting ME to gain ($P = 0.06$). Total BRD morbidity on this trial was high with 38.7% of the calves treated. Morbidity was greater ($P = 0.02$) for TRAD (45.9%) and PF (43.6%) calves as compared with REC (34.0%) and LMI (29.6%) calves. Holland et al. (2007) concluded that extending the period during which a higher roughage diet is fed or limiting the maximum intake during the adaptation period can reduce morbidity in newly-received feedlot calves.

These studies evaluating starting cattle on feed by restricting intake of the final diet suggest that using this approach with yearlings may reduce DMI (Bierman and Pritchard, 1996; Weichenthal et al., 1999; Choat et al., 2002) and improve efficiency (Bierman and Pritchard, 1996; Weichenthal et al., 1999) over the entire feeding period. Thus, this method of adaptation should reduce feed cost of gain with yearlings. However, using this approach to start calves on feed may not be advisable. Choate et al. (2002) observed reduced gains and carcass weights with this method of adaptation in calves. Holland et al. (2007) observed that adapting calves using either the traditional approach (feeding sequential diets with increasing grain concentration) or restricted feeding of a high concentrate diet will increase morbidity in calves as compared to feeding a medium concentrate diet (64% as suggested by Rivera et al., 2005 review) or using the limited maximum intake approach as recommended by Preston (1995).

Use of WCGF or WDGS in Sequential Diets

Birkelo and Lounsbery (1993) compared starting yearling steers (730 lb initial weight) on feed with ad libitum feeding of either a traditional sequential step-up program (hay content decreased from 50% to 40, 30, 20, and 10% on a DM basis) or high energy diets initially containing 43% wet distillers grain (WDG) sequentially reduced to 30, 20, 10, and 0% in which the hay content was held constant at 10% (DM basis). In each program, diets 1 through 4 were fed 7, 5, 6, and 4 d, respectively. The final diet was the same for both programs and was fed for 5 d. During this 28-d trial, ADG was not affected by diet. However, DMI was 21.9% less ($P < 0.10$) for calves started on WDG, resulting in a 22.7% improvement in efficiency (F:G, $P < 0.001$).

Huls et al. (2009a) adapted steer calves (602 lb initial weight) to a 92.5% concentrate diet (contained 35% WCGF, 15% corn silage and 45% corn in a 1:1 ratio of DRC and high moisture corn, DM basis) using two different adaptation schemes (either alfalfa hay or WCGF). Within each scheme, four grain adaptation diets were fed for 5, 7, 7 and 7 d, respectively. In the traditional hay adaptation scheme, the level of alfalfa was reduced from 37.5 to 0% while corn increased from 7.5 to 45%. In the WCGF adaptation scheme, WCGF decreased from 85 to 35% while corn increased from 0 to 45%. Over the entire 147-d feeding period, DMI did not differ

between treatments. However, steers adapted with WCGF had 4.8% greater ADG ($P < 0.01$) and were 4.4% more efficient (F:G, $P < 0.01$) than steers adapted with hay. Carcass characteristics were not influenced by adaptation method. However, HCW was 16 lb greater ($P < 0.01$) with WCGF adaptation.

Hul et al. (2009b) conducted a 33-d grain adaptation metabolism trial using ruminally fistulated steers fed either decreasing levels of WCGF or alfalfa hay. The adaptation schemes were the same as those used in the Huls et al. (2009a) finishing trial with the exception that only DRC was fed. Steers adapted using WCGF had greater DMI ($P < 0.01$) than those adapted with hay. However, average ruminal pH, minimum pH, and maximum pH were lower ($P \leq 0.01$) for WCGF steers than hay steers. These authors speculated that ruminal pH was lower in the WCGF steers because of their greater DMI. Huls et al. (2009a, b) concluded that decreasing WCGF inclusion instead of forage is a viable method for adapting feedlot cattle to high-concentrate diets.

Rolfe et al. (2010) conducted a 35-d grain adaptation trial using ruminally fistulated steers fed either decreasing levels of alfalfa hay or WDGS. In each treatment group, the final diet contained 52.5% DRC, 35% WDGS, 7.5% alfalfa hay, and 5% supplement (DM basis). Within each scheme, four grain adaptation diets were fed for 7 d each followed by the final diet for 7 d. In the traditional hay adaptation scheme, the level of alfalfa was reduced from 45 to 7.5% while corn was increased from 15 to 52.5%. In the WDGS adaptation scheme, WDGS decreased from 87.5 to 35% while corn increased from 15 to 52.5%. Traditionally adapted steers had higher DMI ($P = 0.01$) on adaptation diets 1 through 3 than WDGS adapted steers. However, DMI did not differ between treatments on adaptation diet 4 or the final diet. Ruminal pH was lower in WDGS adapted steers than hay steers on adaptation diets 2 and 3. However, ruminal pH did not differ between treatments on adaptation diet 4 or the final diet.

In summary, the two finishing studies evaluating the sequential reduction of either WDG (Birkelo and Lounsbery, 1993) or WCGF (Huls et al., 2009a) to adapt steers to the final diet suggest that efficiency is improved over the entire feeding as compared to using a traditional adaptation scheme with decreasing forage content. However, the two studies using ruminally fistulated steers suggest that ruminal pH might be reduced in adaptation schemes utilizing WCGF (Huls et al., 2009b) or WDGS (Rolfe et al., 2010) as compared to hay. These data suggest that additional research evaluating the use of these low-starch grain by-products in adaptation programs is needed.

Summary

The receiving/adaptation period is a critical period of time in which nutritional management practices can promote or impair subsequent performance and health. Different methods of starting cattle on feed have been evaluated over the last 40 years. Studies evaluating dietary roughage and concentrate levels with newly received calves suggest that diets with increased energy concentrations achieved by decreasing dietary roughage concentrations may slightly increase the rate of BRD morbidity. However, these higher energy diets also increase gain, feed intake and gain efficiency compared with lower energy, greater roughage diets. Research suggests that the optimal receiving diet would contain 50 to 75% concentrate. The slight

increase in morbidity that might occur with this diet can be minimized by feeding free-choice hay for the first wk of the receiving period. Studies evaluating the use of varying dietary energy sources generally suggest that reducing the grain portion of the diet by adding low-starch grain by-products during the receiving period has minimal effect on performance and health.

Traditionally, feedlot cattle have been adapted to high-grain diets by ad libitum feeding of sequential diets with increasing grain concentration (decreasing roughage concentration) over 2 to 4 wk. This allows ruminal microorganisms to gradually adapt to a ruminal environment with a lower pH in an attempt to minimize subacute acidosis and intake variation that can occur with overeating of grain. Other methods of adapting cattle to high-grain diets on feed that have been studied include using the traditional approach of stepping roughage levels down but with limited maximum intakes, starting cattle on the final diet with restricted intakes, and starting cattle with diets containing high levels of WCGF or WDGS and then sequentially reducing these ingredients over 2 to 4 wk.

Research evaluating limited maximum intake adaptation programs suggest that this method of starting cattle on feed can control fluctuating feed intake, thus, improving performance. This program might also reduce morbidity in highly stressed calves.

Studies evaluating starting cattle on feed by restricting intake of the final diet suggest that using this approach with yearlings may reduce DMI and improve efficiency over the entire feeding period. Thus, this method of adaptation should reduce feed cost of gain with yearlings. However, using this approach to start calves on feed may not be advisable in that some research has suggested that it may reduce gains over the entire feeding period and increase morbidity in calves during the start-up period.

Limited research evaluating the sequential reduction of either WDGS or WCGF to adapt steers to the final diet suggest that efficiency is improved over the entire feeding period as compared to using a traditional adaptation scheme with decreasing forage content. However, studies using ruminally fistulated steers suggest that ruminal pH might be reduced in such adaptation schemes. Since the use of distiller's grains by feedlots has rapidly increased over the last few years due to the rapid expansion of the ethanol industry, additional research evaluating the use of these low-starch grain by-products in starting/adaptation program is needed.

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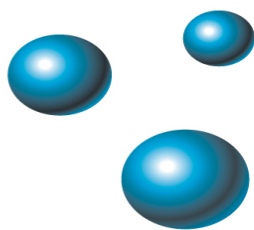
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Research Updates

University of Nebraska – Panhandle Research and Extension, Scottsbluff, NE

K. H. Jenkins^{1,2}, G.E. Erickson¹, J.T. Vasconcelos³

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Recent research at the University of Nebraska – Panhandle feedlot in Scottsbluff has focused on the use of antioxidants, by-products, and alternative feeds to increase the efficiency of finishing cattle fed dry-rolled corn (DRC) or steam-flaked corn (SFC) based finishing diets.

Effects of Urea Level on Performance and Carcass Characteristics of Finishing Cattle fed Dry-rolled Corn-based Diets containing Wet Distiller's Grains with Solubles

K.H. Jenkins, G.E. Erickson, J.T. Vasconcelos, and S.A. Furman

The high level of energy contained in finishing diets has been associated with a deficiency in degradable intake protein (DIP) and therefore may reduce microbial protein synthesis. Wet Distillers Grains plus Solubles (WDGS) have been determined to be high in undegradable intake protein (UIP). The addition of WDGS to finishing diets may result in a DIP deficiency causing daily gain and efficiency to be less than potential. Therefore, the objective of this study was to evaluate the effects of DIP level, supplied as urea, on performance and carcass characteristics of finishing cattle fed dry-rolled corn-based diets containing 25% WDGS. Crossbred steers (n=336; initial BW = 802 ± 68 lb) were blocked by BW and assigned randomly to 24 pens (14 steers/pen) and three dietary treatments were assigned randomly to pens (8 pens/treatment). Treatments included 1) 0% urea, 2) 0.5% urea, and 3) 1.0% urea added to the finishing diet (DM basis). DIP balances were -273, -115, and 43 g/d respectively for each treatment. Cattle were adapted to the finishing diets over a 21 d period by decreasing roughage and increasing corn. Cattle were fed an average of 142 d. Data were analyzed as a completely randomized block design using the MIXED procedure of SAS. Results are presented in Table 1. From d 0 to d 61 no differences ($P \geq 0.84$) were observed for dry matter intake (DMI). However, a linear response ($P = .03$) was observed for average daily gain (ADG) as level of urea increased. This resulted in decreased F:G ($P < 0.01$). However, for the entire trial (142 d) no differences ($P > 0.30$) were observed for DMI, ADG, F:G, or final carcass adjusted BW. No differences ($P \geq 0.14$) were observed for carcass characteristics. Overall, providing supplemental urea in finishing diets containing 25% WDGS had little effect on performance or carcass characteristics of finishing steers, which suggests that sufficient amounts of urea were recycled to the rumen to meet the DIP requirement.

Table 1. Effects of inclusion of 0, 0.5, or 1.0% urea in diets containing 25% wet distillers grains with solubles on performance and carcass characteristics of finishing cattle.¹

Item	Urea level			SE ²	P-value	
	0	0.5%	1.0%		L	Q
<i>Live Performance</i>						
Initial BW, lb	802	803	803	0.8	0.30	0.66
d 61 BW, lb	1123	1126	1138	5.9	0.02	0.41
d 0 - 61 ADG, lb	5.27	5.31	5.49	0.07	0.03	0.38
d 0 - 61 DMI, lb	21.28	21.41	21.29	0.50	0.99	0.84
d 0 - 61 F:G	4.04	4.04	3.87	0.03	<0.01	0.04
<i>Carcass-adjusted Performance</i>						
Initial BW, lb	802	803	803	0.8	0.30	0.66
Final BW, lb ³	1398	1392	1405	8.3	0.55	0.37
ADG, lb	4.21	4.17	4.25	0.06	0.60	0.36
F:G	5.57	5.67	5.52	0.06	0.54	0.11
<i>Carcass</i>						
HCW, lb	905	901	909	5.4	0.55	0.37
Fat thickness, in.	0.62	0.62	0.63	0.02	0.82	0.84
LM area, sq. in.	14.38	14.58	14.40	0.12	0.92	0.24
KPH, %	2.15	2.10	2.08	0.032	0.14	0.77
YG	3.34	3.23	3.34	0.34	0.95	0.14
Marbling	448	434	430	7.2	0.09	0.61
% Upper Choice	19.64	18.13	15.77		0.51	0.84
% Choice and above		72.78	65.73		68.45	0.57
	0.44					
% Select		27.22	34.27		31.55	0.57
	0.44					

¹Cattle in the heavy blocks (12 pens) were on feed for 138 d, whereas cattle in the light blocks (12 pens) were on feed for 145 d, resulting in an average of 141.5 d on feed.

²Pooled standard error of main-effect means, n = 8 pens/main-effect mean.

³Adjusted final BW equaled HCW divided by 64.7%.

Effects of a Dietary Antioxidant on Performance and Carcass Characteristics of Feedlot Cattle fed WDGS or High Grain Diets. J.P. Moore, J.T. Vasconcelos, G.E. Erickson, C.N. Macken, and S.A. Furman

Wet distillers grains with solubles (WDGS) contain high levels of unsaturated fatty acids that are prone to oxidation, and contribute to the load of free radicals in the animal. Dietary antioxidants may control excessive lipid oxidation and decrease these negative effects by reducing the

peroxidation of fatty acids. A finishing study was conducted to evaluate the effects of feeding a dietary antioxidant (ethoxyquin and tertiary-butyl-hydroquinone; AOX) in beef cattle fed dry-rolled corn-based finishing diets containing 0 or 30% WDGS. British x Continental steers (n = 467; initial BW = 778 ± 64 kg) were blocked by BW (8 blocks), stratified within block, assigned randomly to 32 pens (14-15 steers/pen) and 4 dietary treatments were assigned randomly to pens (8 pens/treatment). The mean of 2-d weights was used for initial BW. Treatments were arranged in a 2 x 2 factorial, which included 0% or 30% WDGS, and 0 or 150 ppm AOX. There was a 21-d adaptation period, with decreasing roughage levels and an equal increase in corn, consisting of 3 periods of 7 d. Data were analyzed as a completely randomized block design using the MIXED procedure of SAS. No WDGS level x AOX level interaction was observed ($P \geq 0.05$); therefore, only main effects were evaluated. Final BW, DMI, ADG, HCW, 12th rib fat, KPH and YG increased ($P < 0.01$) with 30% WDGS inclusion while F:G decreased ($P < 0.01$). Smaller ($P = 0.05$) LM area (14.4 in² to 14.0 in², for 0 and 30% WDGS, respectively) was observed with the inclusion of 30% WDGS. No differences were observed between treatments for marbling scores ($P = 0.29$) or the distribution of USDA QG categories ($P \geq 0.13$). No difference was observed in live performance ($P > 0.19$) or carcass characteristics ($P > 0.13$) with the inclusion of AOX. The inclusion of WDGS increased final BW by 7%, ADG by 16% and decreased F:G by 11%. The inclusion of a dietary antioxidant had no effect on performance or carcass characteristics.

Effects of different levels of glycerin in feedlot diets containing steam-flaked corn *J. P. Moore, J. T. Vasconcelos, G. E. Erickson, S. A. Furman, W. A. Griffin, and C. T. Milton*

A finishing study was conducted to evaluate the effects of different levels of glycerin on performance and carcass characteristics of crossbred steers (n = 515; initial BW = 939 lb ± 81 lb). Steers were adapted to a finishing diet for a 21-d period, which consisted of 3 periods of 7 d in which roughage levels were decreased and corn concentration was increased. Steers were fed at 2% of the BW (DM basis) during the last 7 d of the adaptation period. After adaptation, cattle were weighed (d 0) and blocked by BW (10 blocks). Cattle were then assigned randomly to 40 pens (12 - 13 steers/pen), and 4 dietary treatments were assigned randomly to pens (10 pens/treatment). Treatments included increasing levels (0, 3, 6 and 9%) of glycerin replacing steam-flaked corn. Results are presented in table 2. Final BW increased ($P = 0.05$) linearly with increasing levels of glycerin. There was a quadratic ($P = 0.03$) response in DMI with the greatest DMI at 6% inclusion (24.0 lb/d). Average daily gain increased ($P = 0.02$) linearly from 3.10 lb/d (0% inclusion) to 3.26 lb/d (9% inclusion). F:G decreased linearly ($P < 0.01$) with increasing glycerin inclusion. HCW increased ($P = 0.05$) linearly with increasing glycerin inclusion with the heaviest carcass for 6% inclusion (849 lb). There tended to be a linear ($P = 0.08$) increase in LM area with increased glycerin inclusion. No differences in glycerin inclusion levels were observed for 12th rib fat ($P \geq 0.76$), yield grade ($P \geq 0.56$), marbling score ($P \geq 0.20$), or occurrence of liver abscesses ($P = 0.28$). Improved performance was observed by feeding up to a 9% glycerin inclusion, by decreasing DMI 3%, decreasing F:G by 8%, and increasing ADG 5%. There were no effects on carcass characteristics when glycerin was included in the diet. These data suggest that glycerin could be added to steam-flaked corn-based feedlot diets.

Table 2. Effects of Increasing Glycerin Level on Finishing Performance

Item	Treatments				P-value	
	0	3	6	9	Linear	Quadratic
Initial BW, lb	977	979	986	986	0.84	0.06
Final BW, lb ¹	1333	1342	1353	1344	0.03	0.60
DMI, lb	23.8	24.0	24.0	23.1	0.04	0.06
ADG, lb	3.10	3.10	3.23	3.26	0.02	0.77
F:G	7.68	7.74	7.43	7.09	<0.01	0.33

¹HCW/63% average dressing

Evaluation of Performance, Carcass Characteristics, and Sensory Attributes of Beef from Finishing Steers Fed Field Peas *J.T. Vasconcelos, J.B. Hinkle, K.H. Jenkins, S.A. Furman, A.S. de Mello, Jr., L.S. Senartne, S. Pokharel, and C.R. Calkins*

Field pea (*Pisum sativum*) production is increasing rapidly in the northern High Plains as an alternative to fallow due to the nitrogen fixing capacity of peas. Broken and discolored peas are not acceptable in the human food consumption market and may be discounted enough to be competitive as a cattle feed. As a result, there is an increased interest in the inclusion of this feedstuff into feeder cattle diets. The expanding supply of this high quality source of energy creates an opportunity for livestock production. Whole field peas were fed at 0, 10, 20 and 30 % of DM to 139 yearling steers (British cross; 900 ± 68 lb of initial BW) for a 119 d finishing period. Carcass data and Choice grade strip loins (n = 98) were collected from a commercial abattoir in Lexington, NE. Consumer sensory and Warner-Bratzler shear force analyses were performed on 1-in. strip steaks. No differences ($P \geq 0.17$) were observed in final BW, ADG, DMI, and F:G of steers. Likewise, no differences ($P \geq 0.23$) were observed for HCW, LM area, fat thickness at the 12th rib, yield grade, and marbling scores. However, KPH responded quadratically to increasing dietary amount of field peas ($P = 0.02$). Regarding the sensorial analysis, feeding peas linearly increased subjective tenderness ($P < 0.01$) and led to a quadratic response of overall like ratings ($P = 0.01$) and flavor like ratings ($P = 0.12$). Feeding peas did not alter ($P \geq 0.64$) juiciness, but decreased shear force values linearly when levels were increased ($P = 0.02$). These data suggest that feeding peas does not impact steer performance or carcass characteristics differently from dry-rolled corn, but does improve objective and subjective tenderness, overall desirability and flavor of beef. Field peas could be fed to cattle and give positive attributes to the quality of the meat up to 30 % inclusion in the diet.

Table 3. Sensory attributes¹ and Warner-Bratzler shear force of *M. longissimus* from steers fed varying levels whole field peas

Item	Treatments (Pea %, DM basis)				SEM ²	P - value ³	
	0	10	20	30		L	Q
Overall Like	6.32 ^b	6.47 ^{ab}	6.34 ^b	6.66 ^a	0.10	0.02	0.01
Tenderness	5.99	6.26	6.09	6.45	0.14	0.002	0.06
Warner-Bratzler							
Shear force, kg	3.95	3.87	3.65	3.61	0.12	0.02	0.86
Juiciness	5.73	5.78	5.72	6.02	0.14	0.67	0.64
Flavor	6.39 ^b	6.45 ^{ab}	6.36 ^b	6.63 ^a	0.087	0.23	0.12

¹ Overall Like (1 - dislike extremely, 9 - like extremely), Tenderness (1 - extremely tough, 9 - extremely tender), Juiciness (1 - extremely dry, 9 - extremely juicy), and Flavor (1 - dislike extremely, 9 - like extremely).

² Standard error of the treatment means.

³ Observed significance levels for orthogonal contrasts: L= linear effects of increasing levels of field peas; Q = quadratic effects of increasing levels of field peas

^{a,b} Means in the same row having different superscripts are significant at $P \leq 0.05$.

Research Updates

West Texas A&M University

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Effects of wet corn distiller's grains with solubles on degradable N needs by growing and finishing cattle (*in collaboration with N.A. Cole*). Two experiments were conducted to better define the concentration of NPN needed to support optimum performance. In Exp. 1, yearling steers ($n = 525$; initial weight = 822 ± 28 lb) were housed in 56 pens (9 to 10 steers/pen) and received treatments in a $2 \times 3 + 1$ factorial. Factors included wet corn distiller's grains with solubles (WCDGS; 15 or 30% of DM) and non-protein N (NPN; 0, 1.5, or 3.0% of DM) from urea. The control diet without WCDGS contained 3.0% NPN (1.06% urea) and cottonseed meal. Steers were fed twice daily for 129 d and WCDGS was obtained three times/week from a local plant. Steers received Revalor-IS on day 1 and Revalor-S on day 55. Overall DMI (Table 1) was not different ($P > 0.31$) between the control diet and 15 or 30% WCDGS, but overall DMI increased linearly ($P = 0.04$) as NPN increased. Overall ADG and gain efficiency were affected by both WCDGS and NPN (interaction, $P < 0.12$). Overall ADG for steers fed 15% WCDGS was greater for 1.5 and 3.0% NPN than for 0% NPN ($P < 0.07$, quadratic); however, ADG was not influenced by NPN for 30% WCDGS. Overall ADG was not different between the control and 15% WCDGS, but ADG was lower ($P < 0.02$) for 30% than for 15% WCDGS. Overall gain efficiency among steers fed 15% WCDGS was greatest for 1.5% NPN and least for those fed 0% ($P < 0.07$, quadratic), whereas gain efficiency decreased linearly ($P < 0.09$) as NPN increased in 30% WCDGS diets. No interactions between WCDGS and NPN were evident for carcass traits. Dressing percent was greater ($P < 0.01$) for the control diet than for 15% or 30% WCDGS (65.1, 64.2, and 63.9% for control, 15% WCDGS, and 30% WCDGS, respectively). Hot carcass weight was not different between the control and 15% WCDGS ($P = 0.44$), whereas carcass weight was less for 30% WCDGS than for 15% WCDGS ($P < 0.01$). Other carcass measurements were not different among treatments. Optimum performance for cattle fed 15% WCDG occurred when the diet contained between 1.5 and 3.0% non-protein N, but removing all supplemental non-protein N was necessary to optimize performance in diets containing 30% WCDG. The WCDG was estimated to contain 97 to 101% of the NE_g value used for steam-flaked corn based on actual animal performance.

In Exp. 2, steer calves ($n = 296$; initial BW = 758 lb) previously grown for approximately 75 d were adapted to a common finishing diet, blocked by BW, and assigned to 36 soil-surfaced pens (18 m^2 of pen space and 33 cm of bunk space/animal). Treatments included a control diet without WDGS (contained 3% NPN from urea, and cottonseed meal) and 15% WDGS with either 1.5, 2.25, or 3.0% NPN (0.52, 0.78, and 1.04% urea, respectively). Steers were implanted on d 1 with Revalor-XS and were fed twice daily for 165 d. The WDGS was obtained 3 times/wk from a local plant, and grain composition of WDGS averaged 22% sorghum and 78% corn (Table 2). Overall DMI was 6.1% higher ($P = 0.001$) for steers receiving WDGS than for the control (Table 3). Similarly, steers fed WDGS had 8% greater ADG ($P < 0.008$) on either a live or a carcass-adjusted basis than the control. However, overall gain efficiency on either a live or adjusted basis was not different among treatments ($P > 0.15$). Dietary NPN concentration did

Table 1. Effects of wet corn distiller’s grains with solubles and non-protein nitrogen on growth performance by yearling steers

Item	Control	Wet corn distiller’s grains with solubles, % DM						SE	DG*U
		15%			30%				
		Dietary non-protein N, % DM			Dietary non-protein N, % DM				
		0	1.5	3.0	0	1.5	3.0		
Pens	8	8	8	8	8	8	8	-	-
Animals	75	75	75	75	75	75	75	-	-
Initial weight, lb ^a	822	824	821	821	820	822	821	28	-
Shrunk final weight, lb ^d	1322	1316	1346	1317	1297	1294	1297	26	0.31
Adjusted final weight, lb ^{b,d}	1322	1302	1322	1318	1292	1290	1292	20	0.47
Day 1 to slaughter									
Days on feed	129	129	129	129	129	129	129	-	-
DMI, lb/d ^c	21.49	20.87	21.55	21.65	20.84	20.83	21.52	0.57	0.55
ADG, live basis ^{d,e}	3.77	3.69	3.92	3.85	3.70	3.66	3.69	0.09	0.12
DMI:ADG, live basis ^{d,e,f}	5.70	5.67	5.50	5.62	5.63	5.69	5.85	0.08	0.06
ADG, lb/d, adjusted basis ^d	3.88	3.69	3.86	3.84	3.65	3.63	3.63	0.09	0.37
DMI:ADG, adjusted basis ^{d,f}	5.54	5.66	5.58	5.64	5.71	5.76	5.94	0.12	0.37

^aA pencil shrink of 4% was applied to actual weight.

^bCalculated as (hot carcass weight ÷ (overall average dressing percentage of 64.22/100)).

^cLinear urea effect (P < 0.05).

^d15 vs 30% DG (P < 0.02).

^eQuadratic effect of non-protein N within 15% wet corn distiller’s grains (P < 0.07).

^fLinear effect of non-protein N within 30% wet corn distiller’s grains (P < 0.09).

^{g,h}Means differ within 15% wet corn distiller’s grains (P < 0.10).

Table 2. Analyzed chemical composition of wet distiller's grains with solubles^a.

Item	90:10 ^b	80:20 ^b	70:30 ^b
DM, %			
CP, %	33.00	32.45	32.37
ADF, %	16	16.6	16.95
NDF, %	32.6	34.85	33.3
Crude fat, %	13.45	14.65	14.5
Ash, %	5.14	5.135	5.13
Ca, %	0.07	0.08	0.04
P, %	0.86	0.83	0.80
K, %	0.95	0.91	0.91
Mg, %	0.34	0.32	0.30
Na, %	0.15	0.17	0.18
Cl, %	0.18	0.21	0.20
S, %	0.68	0.69	0.74
Cu, mg/kg	7.5	7.0	7.0
Fe, mg/kg	138.5	122	126
Mn, mg/kg	25.5	20	16.5
Zn, mg/kg	57	55	56

^a From WDGS composite samples collected weekly throughout the study.

^b Ratio of corn:milo inclusion rates of WCDGS. 90:10, 80:20 and 70:30 were fed for 13, 95, 83 days respectively.

Table 3. Effects of non-protein nitrogen on performance by finishing steers fed 15% wet distiller's grains with solubles.

Item	15% wet distillers grains with solubles				SE	Contrasts ^c		
	Control	1.5	2.25	3.0		1	2	3
Pens	9	9	9	9	-	-	-	-
Initial wt, lb ^a	760	760	759	758	27	0.33	0.23	0.56
Final wt, lb ^a	1270	1313	1305	1307	20	0.0028	0.70	0.68
Adj. final wt, lb ^b	1270	1312	1300	1313	23	<0.01	0.92	0.39
Day 1 to slaughter								
DMI, lb/d	17.33	18.65	18.29	18.20	0.34	0.001	0.22	0.65
ADG, lb/d	3.08	3.35	3.32	3.32	0.07	0.002	0.65	0.81
Adj. ADG, lb/d ^b	3.06	3.35	3.29	3.35	0.08	0.005	0.99	0.49
DMI:ADG	5.65	5.57	5.52	5.50	0.10	0.14	0.40	0.88
Adj. DMI:ADG ^b	5.69	5.59	5.58	5.46	0.12	0.15	0.25	0.58

^a A pencil shrink of 4% was applied.

^b Adjusted BW was calculated as hot carcass weight divided by the overall average observed dressing percent (65.2%).

^c Contrasts included: 1) control vs average WDGS; 2) linear effect of NPN among WDGS, and 3) quadratic effect of NPN among WDGS.

not influence growth performance ($P > 0.21$). Hot carcass weight was 24 lb lighter for the control than for 15% WDGS ($P = 0.01$), whereas dressing percentage tended ($P = 0.12$) to increase in a linear manner as NPN increased in diets with WDGS. Remaining measured carcass characteristics were not altered by treatment ($P > 0.16$). The control group tended to have ($P < 0.12$) fewer average Choice and higher and more low Choice carcasses than those fed WDGS, but the distribution of remaining quality and yield grades did not differ among treatments. Data suggest that growth performance may not be improved by including more than 1.5% added NPN in diets with 15% WDGS derived from a blend of corn and sorghum grains.

Effects of forage source and dry distiller's grains on growth performance and carcass characteristics of yearling steers (*in collaboration with N. A. Cole*).

Physical attributes of roughages used in finishing diets may impact the extent of ruminal digestion of dried distiller's grains (DDG) and growth performance. Crossbred steers ($n=380$) were adapted to a common finishing diet, blocked by BW, implanted with Revalor-S, and assigned to treatments of roughage source (sorghum-sudan hay [Hay] or sorghum-sudan silage [Silage]) and DDG concentration (0 or 20% of diet DM). Cattle were housed in 40 soil-surfaced pens with at least 180 ft² of pen space and 12 in. of bunk space/animal. Roughages were included on an equal NDF basis. Composite samples collected over the course of the study contained 61.1% (Hay) and 60.0% NDF (Silage). All diets contained 3.4% non-protein N from urea (1.2% urea) and cottonseed meal was utilized as a protein source in 0% DDG diets. Cattle were fed twice/d for 108 d (initial BW = 905 ± 28 lb). Steers fed 20% DDG ate 4.1% more DM than steers fed 0% DDG (23.93 vs. 22.99 lb, $P = <0.01$), but silage or hay did not influence DMI ($P = 0.56$). Overall shrunk ADG on a live basis was not altered by treatment ($P > 0.56$). Gain efficiency on a live basis was not altered by silage or hay ($P = 0.77$), but steers fed 0% DDG were 2.8% more efficient than steers fed 20% DDG ($P < 0.01$). There was a roughage source x DDG interaction for carcass-adjusted ADG and gain efficiency, dressing percentage, hot carcass weight, and LM area ($P < 0.07$). Adjusted ADG was increased 6.8% by silage with 20% DDG ($P = 0.05$), but forage source did not alter ADG when 0% DDG was fed ($P = 0.38$). Adjusted gain efficiency was reduced ($P = 0.03$) 3.5% by hay with 20% DDG, but efficiency was not altered ($P = 0.63$) by forage source at 0% DDG. Dressing percentage was reduced by hay at 20% DDG (63.0 vs. 62.5, $P = 0.02$) and increased by silage at 20% DDG (62.5 vs. 63.4, $P < 0.001$). Hot carcass weight was not altered by DDG with hay ($P = 0.37$), but was increased 16 lb with 20% DDG when silage was fed ($P=0.05$). The LM area was increased by silage with 20% DDG ($P = 0.02$), but forage source did not alter LM area at 0% DDG ($P = 0.29$). Marbling score was higher when DDG was fed with either silage or hay (380 vs. 390, $P = 0.06$). Results suggest that rate of gain on a carcass basis can be improved by feeding DDG with silage, whereas forage source was less important when no DDG was fed.

Effects of the dietary concentration of wet distiller's grains with solubles on visceral organ mass, trace mineral balance, and activity of antioxidant and energy metabolism enzymes

(*in collaboration with J. Osterstock, J. MacDonald, and T. Lawrence*). Steers ($n = 24$; initial BW = 847 lb) were blocked by weight, randomly assigned to dietary treatments (0, 30, and 60% of DM as WDGS; averaged 22% sorghum and 78% corn), and were fed individually for an average of 158 d (range of 125 to 192 d across 4 slaughter dates, 2 blocks/slaughter date). Steers fed 30% WDGS had greater liver S and Mn concentrations and lower liver Fe concentrations than the control ($P < 0.10$; initial values used as a covariate). However, feeding 60% WDGS

decreased liver Cu and increased liver Fe ($P < 0.10$) compared to those fed 30% WDGS. Cytochrome c oxidase activity in brain tissue was decreased when feeding 60% WDGS compared to 30% WDGS ($P = 0.10$), and cytochrome c oxidase activity decreased linearly ($P = 0.06$) in lung tissue as WDGS increased. Feeding WDGS increased gut fill in a linear manner ($P = 0.01$). Feeding 30% WDGS increased fractional mass (g/kg of EBW) of the small intestine ($P < 0.10$) compared to the control, whereas 60% WDGS increased fractional kidney mass ($P < 0.10$) compared to those fed 30% WDGS. Data suggest that dressed yield, Cu absorption or retention, and cytochrome c oxidase activity may be reduced by WDGS when fed at higher levels in diets based on steam-flaked corn.

Effects of Probios FS Daily on growth performance and carcass characteristics of steer calves fed 15% wet corn distiller's grains with solubles. Crossbred steer calves ($n = 222$) were used to assess the effects of two direct-fed microbials on growth performance and carcass characteristics during a 165-day feeding period. Calves were initially procured at auction barns in the Southeast US, used in a 45-day receiving study, allowed a 30-day washout period, and then allocated to treatments in the present experiment. Treatments (9 pens/treatment, 8 to 9 steers/pen) included a basal 91% concentrate diet based on steam-flaked corn, and the same diet supplemented with 0.05 g/animal daily of Probios FS Daily (Enterococcus faecium SF273 and CH212 and Lactobacillus acidophilus LA5; 1×10^9 CFU/day). Cattle were fed twice daily and the DFM was added in dry form into the mixer at the time of feed manufacturing. All diets contained 15% of DM as wet corn distiller's grains with solubles. Steers were implanted with Revalor-XS on day 1 of the experiment and were fed treatments until slaughter. Overall dry matter intake, ADG, and feed efficiency did not differ between the control and Probios FS Daily ($P > 0.24$). Growth performance was not influenced by Probios FS Daily under the conditions of the study.

Research Updates

Kansas State University - Manhattan

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Our research group has focused on a range of research activities during the past 18 months that relate to nutrition and management of growing and finishing cattle. Some of these activities are summarized in the paragraphs that follow:

- Low-moisture block supplements for forage-fed cattle:
 - Supplementation of stocker cattle with monosaccharides to stimulate establishment of ruminal populations of lactate-utilizing bacteria before introduction to grain-based diets
 - Supplementing low quality forage with high-protein blocks to stimulate fiber digestion
 - Growth performance of yearling bulls fed a low-moisture block containing flaxseed and linseed oil
- Preparation of proteinaceous, protective films to enhance ruminal bypass of nutrients.
- Oral inoculation with *Megasphaera elsdenii* to facilitate rapid transition to high-grain finishing diets.
- Zilmax in finishing cattle:
 - Effects of initial body composition of steers
 - Effects of withdrawal period on performance, shear force, and marbling
- Sulfur levels in distiller's grains for finishing cattle
- Effects of crude glycerin on diet digestion and finishing cattle performance
- Effects of intestinal mucus and its components on *E. coli* O157:H7

Supplementing Fructose-Based Block Supplements to Forage-Fed Cattle. Twelve ruminally cannulated heifers were fed prairie hay and loose salt. Half of the heifers were given a 2-lb aliquot of the fructose-based block supplement via the ruminal cannula for 3 consecutive days. Ruminal fluid was collected from each animal at 30-minute intervals for 8 hours after feeding on days 1 and 3 of the experiment. Lactic acid and volatile fatty acid concentrations, ruminal pH, and growth of lactate-utilizing bacteria were measured. Feeding fructose-based block supplements increased lactic acid production in the rumen (Figure 1) for a short period of time, allowing for establishment of a population of lactic-acid-metabolizing bacteria in the rumen. This research provides a basis for future development of management strategies aimed at preconditioning calves to avoid acidosis when grains are introduced into the diet.

SmartLic Block Supplements Improve Forage Digestion. Four ruminally fistulated steers fed prairie hay were used to evaluate effects of the SmartLic Hi-Pro 40 block supplement on ruminal fermentation and microbial growth. Two of the steers were provided free-choice access to the block supplements, and the other two steers received no supplement (control). Ruminal fluid was

obtained from each animal and used to compare differences in microbial populations and capacity for cellulose digestion. Feeding supplements substantially increased microbial growth within the rumen, as evidenced by greater bacterial colonization of cellulose and increased numbers of protozoa. Furthermore, digestive activity was improved markedly, resulting in faster disappearance of cellulose from the rumen.

FlaxLic Supplementation Improves Growth Performance of Angus Bulls. A study was conducted to 1) evaluate effects of feeding FlaxLic, a source of omega-3 fatty acids, on breeding soundness and growth performance of bulls, and 2) compare performance of bulls supplemented with FlaxLic or an alternative block formulation containing corn steep liquor. Yearling Angus bulls (n = 120; initial body weight = 1,115 lb) were assigned randomly to three treatment groups: control (forage-based diet), FlaxLic (control diet with free access to FlaxLic), and corn steep block (control diet with free access to an alternative block formulation in which a portion of the molasses was replaced by corn steep liquor). Bulls were fed free choice for 70 days. Daily feed consumption was monitored using the GrowSafe electronic feed intake monitoring system. The 60-lb blocks for the FlaxLic and corn steep block treatments were placed in GrowSafe feeders for the designated pen. One pen of 40 bulls was used for each treatment. Rate of gain and feed intake were monitored for each animal, breeding soundness exams were performed, and blood and semen samples were analyzed for fatty acid composition. Feeding FlaxLic or the corn steep block did not alter breeding soundness. However, FlaxLic increased plasma concentrations of omega-3 fatty acids, and improved growth performance and efficiency of gain. Substituting 15% corn steep liquor for molasses had a negative effect on nutritional value of the corn steep block.

Wheat Gluten Films Prepared at High Temperature and Low pH are Resistant to Degradation by Rumen Microorganisms. We conducted an in vitro study to investigate effects of three pH levels (3.0, 5.0, and 7.5) and three temperature levels (104°F, 131°F, and 167°F) of the film-forming solution on final film stability in the rumen. Acidity of film-forming solutions was altered by adding glacial acetic acid or ammonium hydroxide. Temperature of the film-forming solutions was adjusted with a hot plate, and films were held at the appropriate temperature for 10 minutes. Susceptibility of the films to digestion by bacteria was evaluated with an in vitro protein degradation assay. In vitro protein degradation was determined after 0, 2, 4, 6, and 8 hours of fermentation. Wheat gluten films manufactured at high temperature (167°F) and low pH (pH 3) were substantially resistant to degradation by ruminal microorganisms.

***Megasphaera elsdenii* for Accelerated Step-up Programs.** Following acclimation to individual feeding pens, crossbred yearling steers (n=80) were assigned randomly to treatments consisting of an oral dose of liquid culture media containing 10^{11} viable *Megasphaera elsdenii*, or a control consisting of an equal volume of the culture media containing no organism (Control). Half of the cattle in each group were assigned to two different step-up regimens (8 or 17 days). The first step-up regimen (5-step) consisted of four transition diets (containing 45, 35, 25, and 15 roughage), each fed for a period of 4 days in making the transition to a final finishing diet with 6% roughage. The 5-step regimen was compared to an accelerated step-up program (3-step) that provided for a 3-day adaptation to an initial diet containing 45% roughage, followed by 4 days of a transition diet containing 25% roughage before achieving the final diet of 6% roughage on day 8. Overall, cattle dosed with *Megasphaera* maintained higher intakes

throughout the experiment. During the initial phases of the experiment, intakes of the cattle fed the 3-step regimen were somewhat erratic, as perhaps would be expected. Our analysis of intake variation indicated that cattle inoculated with *Megasphaera elsdenii* maintained more consistent intakes ($P=0.07$) during the initial 3 days of the experiment compared to the Control cattle. This trend toward higher intakes and less feed intake variation was maintained throughout the entire study, though the differences were not significant. Cattle inoculated with *Megasphaera* achieved numerically greater body weights by day 63 ($P=0.11$). When expressed on a carcass-adjusted basis using a common dressing percentage, overall weight gain was improved as a consequence of the single oral dose of *Megasphaera elsdenii*. With the more rigorous step-up regimen, the incidence of liver abscess was increased by 2- to 4-fold, with the largest percentage occurring in Control group. Carcass weights increased by 9 to 24 lb ($P=0.10$) with the single inoculation of *Megasphaera*, and tended ($P=0.13$) to be greater for cattle fed the 5-step compared to the 3-step regimen. Cattle inoculated with *Megasphaera* and fed the 3-step regimen achieved carcass weights comparable to those of cattle fed the traditional step-up programs without *Megasphaera*, suggesting that it may be possible to reduce overall roughage use in feedlot diets.

Initial Body Composition of Heifers Has Little Impact on Response to Zilmax. Crossbred heifers ($n = 353$, 941 lb average body weight) were used to determine effects of initial body composition on response to Zilmax. We hypothesized that fat heifers would respond more favorably to Zilmax than lean heifers. Before Zilmax was fed, cattle were weighed; an ultrasound machine was used to measure ribeye area, rump fat thickness, and 12th rib fat thickness; and hot carcass weights were estimated with a previously published mathematical formula. Zilmax was fed for 23 days followed by a 3-day withdrawal. Heifers were weighed and carcass data were collected at slaughter. Mathematical formulas were developed to describe relationships between initial carcass measurements and post-Zilmax changes in muscling, fatness, carcass weight, and efficiency of carcass weight gain. Generally speaking, differences in initial body fat content had little or no impact on changes in carcass gain or efficiency when cattle were fed Zilmax.

Effects of Extended Zilmax Withdrawal on Performance and Carcass Traits of Finishing Beef Heifers. Crossbred heifers ($n = 450$; 1025 ± 59 lb) were blocked into two groups on the basis of initial weight. A total of 54 feedlot pens were arranged in a 2×3 factorial arrangement. Factors were Zilmax fed to provide 0 or 7.56 g of zilpaterol-HCl per ton of diet dry matter and withdrawal times of 3, 10, or 17 days. Zilmax was fed for 20 days. Feeding Zilmax increased carcass weights, and the greatest difference from controls occurred with a 3-day withdrawal time.

High Sulfur Content in Distillers Grains Alters Ruminal Fermentation and Diet Digestibility in Beef Steers. Our objective in study 1 was to evaluate the effects of dietary sulfur content in distillers grains with solubles on ruminal fermentation and diet digestibility in feedlot cattle. Twelve ruminally cannulated crossbred steers were fed finishing diets based on steam-flaked corn or dry-rolled corn containing 30% (dry matter basis) dried distillers grains with solubles. The dried distillers grains contained either 1% or 1.7% sulfur and yielded finishing diets that contained either moderate (0.42%) or high (0.65%) levels of sulfur (dry matter basis). The study was conducted in two periods, and three animals were assigned to each treatment during each period. Feed intake, diet digestion, ruminal pH, and ruminal concentrations of volatile fatty acids, ammonia, and lactate were measured. High levels of dietary sulfur decreased

feed intake, but there was a compensatory increase in diet digestibility. In study 2, eighty crossbred yearling steers were used in a 140-day finishing trial to evaluate effects of sulfur content in dried distillers grains with solubles on ruminal gas concentrations, feedlot performance, and carcass characteristics of finishing steers fed diets based on steam-flaked corn or dry-rolled corn. Steers were fed finishing diets based on steam-flaked corn or dry-rolled corn containing 30% (dry matter basis) dried distillers grains with solubles with 0.42% or 0.65% (dry matter basis) dietary sulfur. Steers were housed in individual pens. Ruminal gas samples were aspirated from the ruminal head space and analyzed for hydrogen sulfide concentration. Animals were evaluated daily for symptoms of polioencephalomalacia. Feeding distillers grains with a high sulfur content decreased feed intake and compromised growth performance and carcass characteristics of feedlot cattle.

Effects of Crude Glycerin on Ruminal Metabolism and Diet Digestibility in Flaked-Corn Finishing Diets. Crossbred steers ($n = 9$; $1,373 \pm 176$ lb) fitted with ruminal cannulae were used in a replicated, complete block experiment with three treatments: steam-flaked corn diets containing 0%, 2%, and 4% crude glycerin (dry matter basis). Our objective was to determine the effects of crude glycerin on apparent total tract digestibility and measure changes in ruminal pH and ruminal concentrations of ammonia and volatile fatty acids. Steers had ad libitum access to finishing diets fed once daily. Periods consisted of a 10-day acclimation phase followed by a 3-day collection phase. Chromic oxide was used as an indigestible marker to estimate total fecal output. Feeding glycerin at up to 4% of the diet had no effect on feed intake or total tract dry matter digestibility, but tended to decrease digestion of fiber.

Effects of Feeding Low Levels of Crude Glycerin on Performance and Carcass Characteristics of Feedlot Heifers. Yearling crossbred heifers ($n = 295$; 941 ± 20 lb) were fed corn-based finishing diets containing 0%, 0.5%, or 2% crude glycerin or by-product based diets with 0% or 2% crude glycerin to evaluate the effects of feeding different levels of crude glycerin on feedlot performance and carcass characteristics. All diets were based on dry-rolled corn for the first 37 days of the feeding period, after which cattle were gradually transitioned to diets based on steam-flaked corn. All final diets contained 3% alfalfa hay and 6% corn silage and provided 300 mg Rumensin, 90 mg Tylan, and 0.5 mg MGA per heifer daily. In the by-product diets, soybean meal and portions of the steam-flaked corn were replaced by adding 25% soybean hulls and 15% wet distiller's grains (dry matter basis). Heifers were fed Zilmax for 21 days before harvest. Cattle were given free choice access to feed for a total of 89 days on feed. Adding low concentrations of glycerin reduced dry matter intake in grain-based diets but had no effect in rations containing byproducts.

Capacity of Bovine Intestinal Mucus and Its Components to Support *E. coli* O157:H7 Growth. In study 1, *E. coli* O157:H7 strains resistant to nalidixic acid were added to tubes containing buffer and mucus from the small or large intestine. Bovine feces were added to determine if bacterial competition affected *E. coli* O157:H7 growth. Cultures were incubated at 104°F, and samples were plated after 0, 6, 8 and 12 hours of incubation. Anaerobic fecal bacteria and *E. coli* O157:H7 counts (CFU/mL) were determined. Growth of *E. coli* O157:H7 increased linearly ($P < 0.01$) in response to increasing concentrations of mucus, but total anaerobic counts remained unchanged ($P > 0.05$). These results suggest mucus may provide a medium that favors growth of the pathogen. In study 2, *E. coli* O157:H7 was incubated for 0, 6, 8, or 12 hours in the

presence or absence of feces to evaluate the capacity of intestinal mucus and mucus components (galactose, galacturonic acid, gluconic acid, glucuronic acid, mannose, L-alpha-phosphatidylserine, N-acetyl-D-glucosamine, and sialic acid) to support growth of the pathogen. Enzymes and enzyme inhibitors known to degrade intestinal mucus into its components also were evaluated. After incubation at 104°F, samples were diluted and plated on agar selective for *E. coli* O157:H7. Growth was expressed in Log10 of colony forming units. *E. coli* O157:H7 appears able to metabolize all fractions of mucus. However, whole mucus from the large and small intestines demonstrated a greater capacity to support growth compared with individual mucus components.

The logo for Elanco Animal Health is presented on a blue, trapezoidal background that is wider at the top and tapers towards the bottom. The word "ELANCO" is written in a large, bold, white, sans-serif font. The letter "L" is stylized, with its vertical stroke extending downwards and slightly to the left, creating a sense of motion or a checkmark-like shape.

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Bovine intestinal mucus as a substrate for growth of *E. coli* O157:H7 C. C. Aperce, J. M. Heidenreich, and J. S. Drouillard, Kansas State University, Manhattan

The objective of this study was to evaluate the capacity of bovine intestinal mucus and its constituents to support growth of *E. coli* O157:H7, and to evaluate the role of various enzymes and enzyme inhibitors in this growth process. Intestinal tissues were obtained from freshly slaughtered cattle and transported to our laboratory in chilled saline. Sections of the ileum and colon were washed with buffer solution and mucus was harvested by gently scraping the epithelium. Harvested intestinal mucus or its components (galactose, D-galacturonic acid, D-gluconic acid, D-glucuronic acid, mannose, L-alpha-phosphatidylserine and N-acetyl-D-glucosamine) were added to buffer solutions with or without fecal inoculum collected from a steer fed a high-concentrate diet. Culture tubes were inoculated with 10^3 CFU/mL of a 5-strain mixture of nalidixic acid-resistant Na^r *E. coli* O157:H7. Cultures were incubated anaerobically at 40°C on a laboratory shaker for 0, 6, 8 or 12 h. In response to increasing concentration of mucus, Na^r *E. coli* O157:H7 growth increased linearly ($P < 0.01$), but total anaerobic plate counts were unchanged ($P > 0.05$). Growth of Na^r *E. coli* O157:H7 was greater with whole intestinal mucus compared to individual constituents of mucus, the exception being gluconic acid, which yielded growth equal ($P > 0.50$) to that of whole mucus. The incorporations of protease, lipase, endoglycosidase, or sialidase had no effects on the growth of *E. coli* O157:H7 ($P > 0.05$). Conversely, the addition of the beta-galactosidase inhibitor, phenylethyl beta-D-thiogalactopyranoside, resulted in substantial increases in growth of *E. coli* O157:H7. Our results indicated that *E. coli* O157:H7 can utilize mucus and its components as substrates to support its growth. Further investigations are needed to evaluate if enzymes and inhibitors of enzymes can influence colonization of the bovine gastrointestinal tract by important food-borne pathogens.

Increasing days on the finishing diet equalizes carcass grade distributions of zilpaterol-HCl fed heifers B. C. Bernhard¹, R. S. Swingle², T. E. Lawrence³, W. T. Nichols⁴, D. A. Yates⁴, J. P. Hutcheson⁴, M. N. Streeter⁴, J. C. Brooks¹, M. F. Miller¹, B. J. Johnson¹, and R. J. Rathmann¹; ¹Texas Tech University, Lubbock, ²Cactus Research Ltd., Amarillo, TX, ³West Texas A&M University, Canyon, ⁴Intervet Schering Plough Animal Health, DeSoto, KS

British x Continental heifers (n = 3,382; 677 lbs) were serially slaughtered to determine if increasing days on the finishing diet (DOF) mitigates negative consequences of zilpaterol-HCl (ZH) on quality grade and tenderness. A 2 x 3 factorial arrangement of treatments in a completely randomized block design (36 pens; 6 pens/treatment) was used. Zilpaterol-HCl (7.56 g/ton DM) was fed 0 and 20-22 d before slaughter plus a 3-5 d withdrawal to heifers spending 127, 148, and 167 DOF. Feedlot and carcass performance data were analyzed with pen as the experimental unit. Three hundred sixty carcasses (60 carcasses/treatment) were randomly subsampled and strip loin steaks aged for 7, 14, and 21 d for assessment of Warner-Bratzler shear force (WBSF) with carcass serving as the experimental unit for analysis. No relevant ZH x DOF interactions were detected ($P > 0.05$). Feeding ZH increased ADG (3.55 vs. 3.23 lb; $P < 0.01$), G:F (0.178 vs. 0.159; $P < 0.01$), carcass ADG (3.15 vs. 2.36 lb; $P < 0.01$), carcass G:F (0.159 vs. 0.117; $P < 0.01$), carcass ADG:live ADG (88.7 vs. 73.1%; $P < 0.01$), HCW (785 vs. 760 lb; $P < 0.01$), dressing percent (65.1 vs. 63.5%; $P < 0.01$), LM area (14.2 vs. 13.4 in²; $P <$

0.01) and WBSF at 7 (4.25 vs. 3.47 kg; $P < 0.01$), 14 (3.57 vs. 3.05 kg; $P < 0.01$), and 21 d (3.50 vs. 3.03 kg; $P < 0.01$); decreased 12th-rib fat (0.57 vs. 0.60 in; $P < 0.01$), YG (2.69 vs. 2.96; $P < 0.01$) and KPH (1.90 vs. 1.93%; $P = 0.05$); and tended to decrease marbling score (437 vs. 442; $P = 0.10$). Feeding ZH decreased empty body fat percentage (EBF) (29.7 vs. 30.3%; $P < 0.01$) and increased 28% EBF adjusted final BW (1044 vs. 992 lb; $P < 0.01$). Analysis of interactive means indicated that the ZH x 148 DOF group had a similar percentage of USDA Prime, Premium Choice, Low Choice and YG 1, 2, 3, 4, and 5 carcasses ($P > 0.10$); and decreased percentage of Select (30.4 vs. 36.6%; $P = 0.03$) and Standard (0.2 vs. 0.9%; $P = 0.05$) compared to the Control x 127 DOF group. Based upon WBSF values, the ZH x 148 DOF group was tougher than the Control x 127 DOF group at 7 (4.32 vs. 3.18 kg; $P < 0.01$), 14 (3.59 vs. 2.74 kg; $P < 0.01$), and 21 d (3.39 vs. 3.09 kg; $P = 0.01$). As a result of ZH shifting body composition, extending the DOF of beef heifers is an effective feeding strategy to equalize carcass grade distributions. This can be accomplished while still sustaining the ZH mediated advantages in feedlot and carcass weight gain.

Effects of a slow-release urea product on performance and N balance of growing cattle fed steam-flaked corn

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Two experiments were conducted to examine the impact of source, urea (U) or Optigen II (O), and level of dietary NPN on performance and N balance of growing cattle. Sixty Angus crossbred steers (initial BW = 353 ± 13.9 kg) were used to evaluate performance, and fed 1 of 3 steam-flaked corn based diets: U (T1, 1.2% NPN), O (T2, 1.3% NPN), or O without cottonseed meal (T3, 3.1% NPN). T1 and T2 contained cottonseed meal and NPN as CP sources, while T3 contained only NPN. Steers were blocked by post-weaning BW and assigned to treatments (TRT) and pens within block (5 pens/TRT). BW was collected bi-weekly during the 105-d trial. Six steers from each TRT were harvested and carcass and organ measurements were obtained. Cumulative animal performance was evaluated in 3 periods (0-35, 0-70, and 0-105 d) using a mixed model with initial BW as a covariate. Orthogonal contrasts were used to evaluate differences between T1 and T2, and T1 plus T2 with T3. Five ruminally-cannulated Holstein steers in a 5 x 5 Latin square design were used to evaluate N balance. Steers were fed a steam-flaked corn based diet with either no supplemental NPN, 0.75% U or N equivalent O, or 1.5% U or N equivalent O. Intake was measured, and feed, orts, urine, and fecal samples were obtained and composited for each steer by period. Data were analyzed using PROC mixed of SAS. Orthogonal contrasts were used to evaluate differences between O and U, and high and low level of NPN. For the performance trial, there were no differences in initial BW, final BW, ADG, or DMI among TRT for any of the periods. However, for period 1 steers on T3 had lower F:G than T1 (5.71 vs. 7.39; $P = 0.03$), and steers fed T2 tended to have lower F:G than those fed T1 (6.07 vs. 7.39; $P = 0.07$). In period 2, T3 had lower F:G than T1 (5.58 vs. 6.56; $P = 0.03$), but did not differ from T2 (5.97). Steers fed T3 were leaner ($P = 0.04$) than T1 and T2 (1.04 vs. 1.21 and 1.16 cm fat thickness, respectively). Steers fed T3 had lighter heart and kidney weights than T1 and T2 combined ($P < 0.05$; heart: 1.59, 1.57, and 1.42 kg, respectively, and kidney: 0.93, 0.85, and 0.76 kg, respectively). Liver and spleen weights and 9-11 rib chemical composition did not differ among TRT. For the N balance trial, steers fed O tended ($P = 0.06$) to have lower N intake than those fed U, with N intake increasing as NPN level increased for both U and O. There were

no differences in DMI among TRT. However, steers fed O had less TDOMI ($P = 0.05$) than steers fed U, but there were no differences in TDOMI between high and low levels of U or O. Steers fed high O tended ($P = 0.08$) to have greater fecal N excretion than low O; 46.8 and 36.3 g/d, respectively. There were no differences in fecal N excretion between U and O TRT. As expected, for both U and O, high TRT N levels had greater urinary N excretion ($P < 0.05$) than low TRT N levels, while urinary N did not differ between U and O. N absorption differed ($P < 0.05$) for both source and level of NPN. N retention did not differ between high O and low O (58.0 vs 46.0 g/d), while steers fed high U tended ($P = 0.08$) to have greater N retention than steers fed low U (78.3 vs 55.9 g/d). There was no difference ($P = 0.09$) in N retention between U and O TRT. The ratio of N absorbed to N intake differed between high and low U ($P = 0.03$), but not between high and low O or between U and O. In summary, no major differences on performance and carcass composition were observed between U and O diets. Steers had better initial F:G when O was used as the only source of feed N (T3), suggesting that O may replace both NPN and true protein feeds in finishing cattle diets. High levels of either NPN source had greater N intake and urinary N excretion, as well as N absorption and no major differences were observed between O and U, suggesting that O can replace U at different levels of N intake.

Impact of distillers grains moisture and inclusion level on greenhouse gas emissions in the corn-ethanol-livestock life cycle *Virgil R. Bremer, Adam J. Liska, Galen E. Erickson, Kenneth G. Cassman, Kathy J. Hanford, and Terry J. Klopfenstein, University of Nebraska-Lincoln*

New meta analysis equations of feedlot cattle performance fed 0 to 50% of diet DM as corn wet (WDGS, 32% DM), modified (MDGS, partially dried WDGS, 46% DM), or dry (DDGS, 90% DM) distillers grains plus solubles replacing dry rolled and high moisture corn were incorporated into the Biofuel Energy Systems Simulator (BESS; www.bess.unl.edu) to evaluate impact of DGS moisture and inclusion level on greenhouse gas (GHG) emissions from the corn-ethanol-livestock life cycle. Equations were derived from pen-level performance for 19 trials feeding WDGS ($n = 338$ pens and 3,270 steers), 4 trials feeding MDGS ($n = 85$ pens and 680 steers), and 4 trials feeding DDGS ($n = 66$ pens and 581 steers) conducted at University of Nebraska research feedlots. Feeding value of WDGS was 145 to 131% of the corn replaced in diets from 20 to 40% of diet DM. Using the same approach, feeding value of MDGS was 124 to 117% and 110 to 112% for DDGS. No performance response was detected when DGS was fed to swine and dairy cows. Midwest corn-ethanol-livestock life cycle GHG reduction relative to gasoline (97.7 gCO₂e/MJ ethanol) was greatest when WDGS was fed to feedlot cattle and decreased from 61 to 57% for 20 to 40% of diet DM as WDGS. GHG reduction from MDGS and DDGS when fed to feedlot cattle was 53 to 50% and 46 to 41%, respectively. Life cycle GHG reduction of 10% of diet DM as WDGS, MDGS, or DDGS for dairy cows was 53, 48, and 43%, respectively, and from 10% of diet DM as DDGS for swine was 42%. These data show that ethanol plants located within 161 km of cattle feeding areas should produce WDGS to have the greatest GHG reduction potential regardless of DGS inclusion level. GHG reduction of DDGS was smaller than for WDGS and MDGS for beef or dairy, but was comparable for all three livestock classes when fed as DDGS. Partial drying (MDGS) or complete drying (DDGS) of DGS reduces both feeding value and GHG reduction of corn-ethanol relative to gasoline. Feeding WDGS to feedlot cattle is the optimum feed use of DGS based on feeding performance and GHG reduction.

Two ration blending vs. traditional step-up adaptation to finishing diets:

Performance and carcass characteristics *D. B. Burken^{1*}, J. L. Wahrmond¹, B. P. Holland², C. R. Krehbiel¹, and C. J. Richards¹, ¹Oklahoma State University, Stillwater and ²South Dakota State University, Brookings*

The objective of this study was to compare feedlot performance, carcass characteristics, and final value of heifers adapted over a 28 d period to a 94% concentrate diet with two different adaptation programs. One hundred forty-four heifers (BW = 343 ± 41 kg) were blocked by BW and randomly assigned to either a two ration blending (2RB) or traditional step up (TRAD) grain adaptation program. During the adaptation period, all heifers were fed a 70% concentrate diet from d 0-6. From d 7-28, 2RB heifers were fed the daily feed call based on a predetermined program that decreased the proportion of a 70% concentrate diet in the AM feeding, and increased the proportion of the feed call as a 94% concentrate diet in the PM feeding. TRAD heifers were fed a 76% concentrate diet (d 7-13), an 82% concentrate diet (d 14-20), and an 88% concentrate diet (d 21-28). All heifers received a 94% concentrate finishing diet from d 29 until harvest. Two blocks each were fed for a total of 153 d and 179 d. Individual BW were measured initially, d 28, d 78, and 1-2 d before harvest. Carcass data were collected at harvest. Data were analyzed using the Mixed procedure of SAS with pen as the experimental unit, grain adaptation program as a fixed effect and weight block as a random effect. Dry matter intake for d 0-28 was greater ($P < 0.05$) for 2RB than for TRAD heifers. There was no difference in DMI for d 29-78, d 29-end, or d 0-end. Body weight, ADG, and G:F data were not affected by grain adaptation program ($P \geq 0.25$). Percentage of cattle grading USDA choice and select or premium program acceptance did not differ ($P \geq 0.42$), nor did percentage USDA yield grade 2, 3, and 4 ($P \geq 0.39$). Final value was not affected by grain adaptation program ($P \geq 0.61$). Data from this study illustrate that a two ration blending adaptation program can be substituted for a traditional step-up program without reducing cattle performance, carcass characteristics, or final value. Due to a reduction in rations to be milled and delivered, feedlot operational efficiency should be improved, although increased management may be required for feed calling, timing and delivery.

Use of dried distillers grains throughout a beef production system *E.K. Buttrey^{1,2}, F.T. McCollum III¹, J.C. MacDonald^{2,3}, and K.H. Jenkins³, ¹Texas AgriLife Extension Service, Amarillo, ²West Texas A&M University, Canyon, ³Texas AgriLife Research, Amarillo*

To evaluate the effects of feeding dried distillers grains throughout a beef production system, a 2-yr study was conducted using a 3 X 2 factorial arrangement of treatments. Factors were wheat pasture supplement (no supplement, dry-rolled corn, and dried distillers grains; CON, DRC, and DDG, respectively) and finishing diet (steam-flaked corn based diet containing 0 or 35% dried distillers grains, SFC and 35DDG, respectively). Each yr, 60 preconditioned Hereford steers (initial BW = 437 ± 6 lb) were stratified by BW and randomly assigned to one of fifteen 5.5-acre wheat pastures (4 steers/pasture). Supplements were assigned within five blocks of three pastures. Supplements were fed at 0.5% BW daily, pro-rated and delivered 6 d/wk. Following the grazing period, pastures within supplement treatment were randomly assigned to SFC or 35DDG. Steers were fed once daily *ad libitum* and pens of steers were harvested when estimated fat thickness reached 0.5 in. A 3-way interaction between supplement, finishing diet, and yr was detected for days on feed ($P = 0.03$), HCW ($P = 0.08$) and carcass-adjusted total system weight gain ($P = 0.04$). Wheat pasture ADG was greater for DDG steers compared to CON and DRC steers ($P < 0.01$; 3.09, 2.84, and 2.88 lb/d for DDG, CON and DRC, respectively). With the

exception of carcass-adjusted G:F for which DRC was greater than CON and DDG was intermediate ($P = 0.03$; 0.161 vs. 0.150, DRC and CON, respectively, 0.154 DDG), finishing performance and carcass traits were not affected by wheat pasture supplement ($P \geq 0.12$). Initial and final BW, DMI, and ADG were similar for SFC and 35DDG steers ($P \geq 0.20$). Steers receiving SFC had greater carcass-adjusted G:F ($P < 0.01$, 0.160 vs. 0.149), dressing percent ($P = 0.01$, 63.6 vs. 62.8), and twelfth rib fat thickness ($P < 0.01$, 0.50 vs. 0.44 in) than 35DDG steers. The use of dried distillers grains as a supplement to wheat pasture results in greater ADG on wheat. However dried distillers grains included in steam-flaked corn based finishing diets appears to reduce G:F and dressing percent.

Evaluation of cooked blocks as a means of stimulating forage utilization in steers

consuming bermudagrass hay *M.S. Cabaniss, J.E. Sawyer, and T.A. Wickersham, Texas A&M University, College Station*

Fifteen steers fitted with ruminal cannulas (average BW 238) were stratified by BW and assigned to one of four treatments: control (CON), cottonseed meal (CSM), high-protein block (HB), and low-protein block (LB). Steers were provided ad libitum access to bermudagrass hay (6.7% CP, 71% NDF) throughout the project. Cottonseed meal (45 % CP) was provided at 350 g per d, whereas LB (15% CP) and HB (35% CP) were provided at 500 g per d. Supplements were designed for CSM and HB to provide equal amounts of CP. The experiment was 18 d long with 10 d for adaptation. Intake was determined from hay and ort samples collected on d 11 to d 16, corresponding with total fecal collection on d 12 to d 17. Rumen fluid was sampled for ruminal ammonia, pH and VFA concentrations prior to feeding (0 h) and 2, 4, 6, 9, 12, and 18 h post feeding on d 18. Plasma samples were collected on d 18 prior to feeding (0 h) and 6 h post feeding to determine plasma urea concentration. Supplemental CP intake was 0, 145, 154, and 69 g/d for CON, CSM, HB, and LB, respectively. Forage OM intake, total OM intake, total digestible OM intake, and OM digestibility were similar ($P > 0.17$) among CON steers and supplemented steers. There were no significant differences ($P > 0.06$) in ruminal pH, total VFA concentration, and molar percentages of all VFA's with exception of acetate ($P = 0.05$). Supplementation resulted in reduced acetate percentages relative to control. A significant treatment \times hour interaction existed for ruminal ammonia concentration ($P < 0.01$). Ruminal ammonia concentrations were greater for CSM and HB than for CON ($P < 0.05$; 2.37, 2.44, and 0.87 mM, respectively). There was no difference ($P = 0.28$) in ruminal ammonia concentration between LB and CON. Forage utilization, intake and digestion, did not increase in response to supplemental CP provision, irrespective of form of delivery, indicating that forage quality may have been sufficient to meet degradable intake protein requirements.

The accuracy of real-time ultrasound to measure carcass traits in beef cattle prior to

slaughter *J. A. Carter¹, C. A. Hughes¹, L. O. Tedeschi², G. E. Cartens², R. K. Miller², S. B. Smith², R. D. Rhoades³, B. M. Bourg², F. R. B. Ribeiro¹, ¹Texas A&M University-Commerce, Commerce, ²Texas A&M University, College Station, ³Texas A&M University-Kingsville, Kingsville*

The objective of this study was to determine the adequacy of real-time ultrasound (RTU) to measure carcass traits prior to slaughter in beef cattle (N = 228). Data from 5 studies were used in this study and consisted of 118 Santa Gertrudis steers, 32 Angus bulls and heifers, 18 Angus cross steers, 36 crossbred steers, and 24 Angus steers. Data from 17 animals were deleted from the analyses due to poor image analysis of ribeye areas. The RTU measurements were taken

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 the imaging sites to enhance image quality. Ultrasound measurements were collected within 7 days of slaughter and consisted of 12-13th rib backfat thickness (**uBF**, mean = 0.93 cm), 12-13th *Longissimus dorsi* muscle area (**uREA**, mean = 76.9 cm²), and percentage of i.m. fat (**uIMF**, mean = 3.35 %). Intramuscular fat was converted to ultrasound marbling score (**uMARB**) by using the equation: $uMARB = ((769.7 + (56.69 \times uIMF)) / 100) - 5$. Overall means for 48-h chill carcass data were HCW (313 kg), 12-13th rib backfat thickness (**cBF**, 1.04 cm), 12-13th *Longissimus dorsi* muscle area (**cREA**, 74.1 cm²), and marbling score (**cMARB**, 4.96). Marbling score were converted to a numeric cMARB (Slight⁰⁰ = 4, Small⁰⁰ = 5, and Modest⁰⁰ = 6). Data were analyzed using the PROC MEANS and PROC CORR procedures of SAS and accuracy RTU data determined by the Model Evaluation System software. Results show that uBF, uREA, and uMARB were highly correlated to cBF, cREA, and cMARB (0.85, 0.67, and 0.63, respectively). Carcass BF and cMARB were under predicted by uBF and uMARB (0.10 cm, and 0.37 marbling units, respectively). However cREA was over predicted by uREA by 2.85 cm². Ultrasound BW (mean = 486 kg) was highly correlated ($P < 0.001$) with uBF, uREA, cBF, and cREA (0.76, 0.42, 0.37, and 0.67, respectively). The large number of images rejected due to poor quality could be related to breed type as *Bos indicus* animals tended to scan a little darker than *Bos taurus*. These results show that RTU can accurately measure carcass traits in beef cattle prior to slaughter and are in agreement with results previously reported in the literature. More work is needed in order to explain the differences in accuracy between *Bos indicus* and *Bos taurus* cattle.

Effects of limit feeding corn or dried distillers grains (DDGS) at two intakes during the growing phase on feedlot cattle performance *T.L. Felix and S.C. Loerch, The Ohio State University, Wooster*

Energy density in growing diets affects carcass quality of cattle; however, few reports have described impacts of energy source. The objectives of this research were to determine effects of source (DDGS vs. corn) and amount (limit-fed to gain 0.9 vs. 1.4 kg/d) of energy during the growing phase on feedlot performance and marbling. Angus-cross steers (144 hd) were blocked by weight (average initial BW = 252 ± 1.0 kg) and allotted within each block to 8 pens (6 steers/pen, 24 pens total), and randomly assigned to 1 of 4 feeding systems: 1) 65% DDGS fed to gain 0.9 kg/d, 2) 65% DDGS fed to gain 1.4 kg/d, 3) 65% corn fed to gain 0.9 kg/d, and 4) 65% corn fed to gain 1.4 kg/d. After the 98 d growing phase, all steers were fed the same finishing diet containing 25% DDGS. Steers in a pen were slaughtered when the pen weight reached the terminal target weight of 544, 522, and 499 kg for the large, medium, and small blocks, respectively. Average daily gain and DMI differed ($P < 0.001$) by design during the growing phase; ADG for the 4 feeding systems listed above was 0.89, 1.26, 1.24, and 1.68 kg/d, respectively. The ADG was greatest ($P = 0.02$) during the finishing phase in steers fed to gain 0.9 kg/d initially; ADG was 1.97, 1.74, 1.88, and 1.63 kg/d, respectively for the 4 systems. Overall ADG and DMI were affected ($P < 0.06$) by source and amount of energy during the growing phase. Steers fed to gain 0.9 kg/d during the growing phase also had less back fat ($P = 0.08$) and greater ribeye area ($P = 0.003$) than steers fed to gain 1.4 kg/d. This led to lower yield grades ($P = 0.026$) from steers fed to gain 0.9 kg/d during the growing phase, likely because these steers synthesized more protein and less fat at a common end BW. There was an interaction with energy source and amount for marbling scores ($P = 0.016$). Increasing intakes of DDGS

during the growing phase increased marbling while increasing intakes of corn decreased marbling. Steers fed to gain 0.9 kg/d on corn during the growing phase had the highest marbling (590) while those fed to gain 0.9 kg/d on DDGS had the lowest marbling (533); the remaining feeding systems were intermediate. While 65% DDGS can be successfully limit fed in a growing phase diet, the calculated NE for gain was 12% less than corn.

Interactive effects of yeast and yeast cell wall material on steer performance during the receiving period of stressed beef cattle *D.N. Finck¹, S.L. Parr¹, T.R. Young¹, J.A. Carroll², J.R. Corley³, A.G. Estefan³, and B.J. Johnson¹, ¹Texas Tech University, Lubbock, ²USDA-ARS, Livestock Issues Research Unit, Lubbock, ³Lesaffre Feed Additives, Milwaukee, WI*

The receiving period is typically the most challenging in terms of feed consumption, health, and efficiency in newly weaned calves. The objectives of this experiment were to determine the effect of live yeast and yeast cell wall supplements on performance and health of cattle during the receiving period. Newly-weaned crossbred steers (n = 184; 9 pens/treatment; initial BW = 448 kg) were blocked by BW and randomly assigned to pen (4 pens/block; 5 or 6 hd/pen). Pens within a block were randomly assigned to one of four treatments: 1) control (CON; no yeast additive), 2) live yeast (LY; 5 g•hd⁻¹•d⁻¹ live yeast product), 3) yeast cell wall (YCW; 5 g•hd⁻¹•d⁻¹ yeast cell wall product), 4) live yeast + yeast cell wall (LY+YCW; 5 g•hd⁻¹•d⁻¹ live yeast and 5 g•hd⁻¹•d⁻¹ yeast cell wall). A randomized complete block design was used; data were analyzed either as 4 separate treatments, or treatments 2 and 3 were combined to analyze the overall effect of yeast product inclusion level (0, 5, and 10 g inclusion). Daily DMI was recorded and individual BW were collected every 14 d for the 56 d feeding period. Respiratory illness was monitored daily and cattle were treated according to symptoms. Steer interim and cumulative BW, ADG, and G:F was similar ($P > 0.10$) among treatments. However, steers receiving 5 g of LY or YCW showed a 7% numerical increase in ADG and a 16.9 lb increase in BW at d 56. Despite statistical insignificance, a 7% increase in gain could contribute positive economic results. Cumulative DMI was increased ($P < 0.05$) for the LY, YCW, and LY+YCW compared to CON (12.06, 13.27, 13.14, and 12.98 lb/d, respectively). Interim DMI differed for d 0 to 28 (11.07, 12.32, and 11.95 lb/d for 0, 5, or 10 g LY or YCW, respectively; $P = 0.02$, quadratic), d 0 to 42 (11.40, 12.67, and 12.37 lb/d; $P = 0.02$), and cumulative (12.03, 13.20, and 13.96 lb/d; $P = 0.03$). Steer morbidity and mortality were not affected by LY or YCW supplementation ($P > 0.10$). Collectively, these data indicated that the use of LY or YCW additives increase total feed consumed by the steers during the first 56 d of the feeding period, which contributed to a trend for increased growth rate.

Relationships between feed efficiency traits and serum metabolites, cortisol and IGF-I in growing Brangus heifers *R.R. Gomez, G.E. Carstens, T.H. Welsh, Jr., P.A. Lancaster, L.J. Slay and W.K. Krueger, Texas A&M University, College Station*

Physiological indicator traits that are biologically associated with residual feed intake (RFI) may be useful indicator traits for selection of efficient cattle. The objective of this study was to examine the relationships between RFI, and serum metabolites and hormones in growing heifers. A 4 yr study (n = 114-119 heifers/yr) was conducted with Brangus heifers (Initial BW = 273 ± 28 kg) that were weaned for 26 ± 9 d prior to being adapted to a high roughage diet (ME = 2.0 Mcal/kg DM) diet. Individual DMI were measured using Calan gate feeders and BW measured

at 7-d intervals during the 70-d studies. RFI was calculated as the residual from the linear regression of DMI on mid-test $BW^{0.75}$ and ADG. On day 0 of the studies, blood samples were collected. Serum samples were assayed for complete blood counts (WBC, RBC, hemoglobin, Hb), metabolites (total protein, TP, glucose, creatinine, blood urea nitrogen, BUN; β -hydroxybutyrate, BHB) and hormones (cortisol, insulin-like growth hormone I, IGF-I). Across all heifers, RFI was positively correlated with DMI (0.67) and F:G (0.52), but not with ADG or initial BW. Heifers with low RFI (< 0.5 SD from mean RFI) consumed 15% less DMI and had 15% lower F:G than heifers with high RFI (> 0.50 SD from mean RFI). RFI was weakly correlated ($P < 0.05$) multiple serum parameters including WBC (0.16), RBC (-0.10), Hb (-0.12), total protein (-0.12), BUN (0.11), creatinine (-0.12) and β -hydroxybutyrate (0.12). Hb was weakly correlated ($P < 0.05$) with all feed efficiency traits. No phenotypic correlation was found between serum cortisol and IGF-I with either RFI or F:G. Between RFI groups, low RFI heifers had lower WBC, BUN and BHB than high RFI heifers, but had higher RBC, HB, total protein, and Creatinine levels. These results suggest that the serum metabolites and hormones evaluated in this study have limited utility as indicator traits for RFI in growing heifers.

Effect of byproduct feeds on fecal shedding of *Escherichia coli* O157 in cattle

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Two experiments were conducted to evaluate effects of diet composition on fecal shedding of *Escherichia coli* O157:H7 in cattle. In study 1, corn-based finishing diets with 0, 0.5, or 2% added glycerin (GLY), and diets containing 40% byproducts (BYPR; 15% wet distiller's grains and 25% soybean hulls) with 0 or 2% GLY were fed to crossbred heifers ($n=353$). Cattle were stratified by weight and assigned to 48 pens (7 to 8 heifers/pen; 8 pens/treatment). Treatments were administered for 50 d prior to sampling. Fecal samples were collected randomly from 5 heifers in each pen by removing freshly defecated feces from the pen floor every 4 days for 24 days. Prevalence of *E. coli* O157 in feces was determined by enrichment, immunomagnetic separation, plating and identification (non-sorbitol fermenting, indole production, agglutination test, and API 20E identification kit). In study 2, steers ($n=144$; 809 ± 4 kg) grazing native tallgrass pastures were fed dried distiller's grains (DDGS) at 0 or 1% of body weight. Cattle were stratified by weight and assigned to 12 pastures. Fecal samples were obtained via rectal palpitation on days 0, 30, 45, and 90, and prevalence of *E. coli* was characterized using procedures described for study 1. Addition of GLY to BYPR or corn-based diets in study 1 did not ($P = 0.51$) influence fecal shedding of *E. coli* O157 from feedlot cattle. Cattle fed diets with corn, BYPR, and BYPR with 2% GLY diets had numerically higher percentages of pens positive for *E. coli* O157 (14.3, 14.3, and 12.5%) than cattle fed corn diets supplemented with 0.5 or 2% GLY (7.1 and 3.6%). Prevalence of *E. coli* O157 was greater on days 0 and 16 compared to days 12 and 20 ($P < 0.05$). We observed a tendency for a diet \times day interaction ($P = 0.06$), due in part to greater prevalence on days 0 and 16. In study 2, feeding DDGS to grazing steers did not ($P = 0.21$) increase fecal shedding of *E. coli* O157 compared to unsupplemented cattle, with average prevalences of 7.3 and 4.6%, respectively. An effect of sampling day was observed ($P < 0.05$), with prevalence being greatest on day 0 and declining steadily thereafter. These data suggest feeding byproducts (wet distiller's grains and soybean hulls) and glycerin had minimal impact on prevalence of *E. coli* O157 in grazing or feedlot cattle.

Use of real-time ultrasound (RTU) measurements and carcass traits to assess internal fat in residual feed intake (RFI)-indexed Brahman bulls under grazing conditions C.A. Hughes¹, J.A. Carter¹, T.D.A. Forbes², F.M., Rouquette³, Jr., L.O. Tedeschi⁴, R.D. Randel³, F.R.B. Ribeiro¹,¹Texas A&M University-Commerce, Commerce, ²Texas AgriLife Research, Uvalde, ³Texas AgriLife Research, Overton, ⁴Texas A&M University, College Station

This study evaluated RTU and carcass traits to determine total internal fat (IFAT) of Brahman bulls (n = 16) grazing Coastal bermudagrass (*Cynodon dactylon* (L.) Pers]) at two stocking rates (SR) for 60 d. Prior to the grazing trial, animals were fed a high roughage diet for 70 d, stratified as efficient (LRFI) or inefficient (HRFI), and randomly assigned to high (HSR) or low (LSR) SR pastures. RTU measurements were collected 5 d prior to harvest off pasture and consisted of KPH depth (uKPH), backfat thickness (uBF), ribeye area (uREA), rump fat (uRUMP), i.m. (uIMF), and BW. Bulls were harvested at 16 to 18 mo of age and about 450 kg. Shrunken BW (SBW) was recorded after an 18 h fast prior to harvest. At harvest KPH and internal organs were separated, dissected, and weighed. Total internal fat was determined by adding the KPH and physically separated organ fat weights. After a 48-h chill complete carcass data was collected. Data were analyzed using a split-plot design in a 2×2 factorial arrangement with pastures within SR as random factors. Prediction equations were developed using the PROC REG procedure with the stepwise selection. There were no interactions or main effects of SR (P > 0.05) and RFI (P > 0.05) on any of the carcass traits or RTU measured; except for carcass backfat that was significant (P = 0.051) with LRFI bulls having more backfat than HRFI bulls (0.22 vs. 0.13 cm, respectively). A linear regression to predict IFAT from KPH and uRUMP (R² of 0.61 and square root of mean square error of 1.54 kg) was developed. The stepwise selection indicated a partial R² of 0.53 for KPH and 0.08 for uRUMP. A previously published equation to predict IFAT from KPH accounted for 53% of the IFAT variation of our data. No differences between RFI and SR using RTU were detected for Brahman bulls harvested direct off pasture. The RTU may improve the predictions of IFAT when KPH is available. A second year of data will be used to improve the precision of the IFAT predictive equations.

Nutrient concentration as affected by supplement form (liquid vs dry) in a high moisture finishing ration J.P. Jaderborg, G.I. Crawford, C. Lahr, H. Blalock, and A. DiCostanzo. University of Minnesota, St. Paul and Quality Liquid Feeds, Dodgeville, WI

We conducted a randomized block design study with repeated measures in time and in location to determine effects of supplement form (dry vs liquid) on consistency and variability in total mixed ration (TMR) nutrient concentration. Feedlot TMR batches were mixed using (loading order; % as-fed) 22.6% or 22.7% corn silage, 2.8% or 3.0% hay, 53.5% or 53.4% 52%-moisture distillers grains and solubles, 19.3% dry rolled corn, and either a 1.7% pelletized (DRY) or 1.9% liquid (LIQ) supplement. Batch totals were based on ration totals determined from bunk scores (0, slick bunk, to 4, crown untouched) for each of two bunks (pens) per supplement form for four consecutive days. Each batch was delivered first to a short (7 m; 15 or 17 head) and then to a long (18.3 m; 51 or 56 head) concrete bunk. Using a sub-sample of TMR ingredients, standard DRY and LIQ batches were made in a Hobart mixer with a flat beater attachment. Concurrently, DRY and LIQ rations were mixed in a 4-auger mixer. Bunk samples were collected in each of three locations within the bunk. Samples were collected at time 0, 1, 3, and 6 h post-delivery. Samples were analyzed for CP, ADF, Ca and Zn concentration. Standard batches were similar (P > 0.05) in CP and ADF across supplement form for, but were greater (P < 0.03) for DRY Ca

and Zn content. Similar results were obtained from analyses of TMR samples, but TMR nutrient content SE were greater, and Ca and Zn concentration tended ($P < 0.10$) to be lower for DRY. Samples collected from the long bunk for DRY TMR tended ($P < 0.10$) to be lower in CP than those from the short bunk. Concentration of ADF in the three sample sites from the short bunk were lower ($P < 0.05$) for LIQ TMR ADF than that in the first and last sample location from the long bunk. Pooled within-bunk variance was numerically ($P = 0.15$) greater for DRY TMR Zn concentrations, and significantly ($P = 0.02$) greater for DRY TMR ADF concentrations. Batches prepared with LIQ appeared to be more consistent across bunks and within bunks, albeit off target for CP and ADF, and less variable for ADF.

Effects of supplemental manganese on ruminal pH and hydrogen sulfide concentration in beef steers fed high-sulfur diets containing distillers grains plus solubles *J.M. Kelzer¹, T.D. Maddock², M. Ruiz-Moreno¹, A. DiCostanzo¹, G.I. Crawford³, and G.C. Lamb². ¹University of Minnesota, St. Paul, ²University of Florida, Marianna, ³Extension Regional Office, University of Minnesota, Hutchinson*

Effects of including 1000 ppm manganese (**Mn**; supplied as manganese oxide) in high dietary sulfur (**S**) feedlot diets containing distillers grains plus solubles on ruminal parameters and hydrogen sulfide (**H₂S**) concentration were examined. Seven ruminally cannulated beef steers (964 ± 135 lb initial BW) were assigned randomly to treatments in a switchback design (two, 14-d periods). Treatments included a base finishing diet (65% rolled corn, 20% dried distillers grains plus solubles, 8.2% grass hay, 15% CP, 0.59 Mcal NE_g/lb DM, 0.46% S) containing either 0 ppm Mn (**CON**) or 1000 ppm Mn (**MNO**). To achieve targeted levels of S and Mn, calcium sulfate and manganese oxide were added to the diets. Steers were allowed access to dietary treatments from 0730 to 1630 daily and were adapted to diets on d 1-10. Wireless rumen sensors (Kahne Limited; Auckland, NZ) programmed to record pH every 5 min were inserted into the rumen on d 10 and removed on d 14. Ruminal gas samples were collected at -1, 1, 2, 3, 4, and 6 h post-feeding on d 11-12 and analyzed for H₂S concentration. Ruminal fluid was collected at -1, 1, 2, 3, 4, and 6 h post-feeding on d 13-14 for analysis of ruminal ammonia-N concentration. Ruminal pH was higher ($P = 0.02$) at 1 h prior to feeding in steers consuming MNO (6.29) compared to steers consuming CON (6.01). However, no pH differences were observed ($P > 0.17$) between treatments at other time points (5.90 vs. 5.77, 5.81 vs. 5.66, 5.74 vs. 5.62, 5.70 vs. 5.62, and 5.62 vs. 5.61 ± 0.08 for MNO vs. CON at 1, 2, 3, 4, and 6 h post-feeding, respectively). Ruminal H₂S concentration was similar ($P = 0.24$) between treatments at all time points (0.35 vs. 0.36, 1.55 vs. 1.76, 2.42 vs. 3.16, 2.77 vs. 3.74, 3.59 vs. 3.63, and 3.98 vs. 4.18 ± 0.31 $\mu\text{g/mL}$ for MNO vs. CON at -1, 1, 2, 3, 4, and 6 h post-feeding, respectively). Cumulative ruminal H₂S concentration tended to be reduced ($P = 0.09$) with MNO compared to CON (6.47 vs. 7.74 ± 0.53 $\mu\text{g/mL}$). Area under the curve for ruminal H₂S concentration was similar ($P = 0.26$) and averaged 18.4 ± 1.4 $\mu\text{g}\cdot\text{h/mL}$ between treatments. There tended to be a treatment x h interaction ($P = 0.09$) for ruminal ammonia-N concentration. Steer DMI was similar ($P = 0.61$) and averaged 19.3 ± 1.2 lb/d between treatments. Results suggest supplementing 1000 ppm Mn (supplied as manganese oxide) in high-S finishing diets containing dried distillers grains plus solubles may initially maintain higher ruminal pH to reduce cumulative ruminal hydrogen sulfide gas concentration without affecting DMI in feedlot cattle.

Effects of spaying and terminal implant strategy on performance and carcass characteristics of beef feedlot heifers *J.M. Kelzer¹, C.R Dahlen², G.I. Crawford³, and A. DiCostanzo¹, ¹University of Minnesota, St. Paul, ²Northwest Research and Outreach Center, University of Minnesota, Crookston, ³Extension Regional Office, University of Minnesota, Hutchinson*

Crossbred beef heifers (n = 139) averaging 602 ± 48 lb initial BW were blocked by weight (**Heavy** vs. **Light**) and assigned to 1 of 16 pens in a randomized complete block design with a 2 x 2 factorial arrangement of treatments. Pen was assigned randomly to treatments within block to evaluate effects of reproductive status (spayed, **SPAY** vs. intact, **INTACT**) and terminal implant strategy (moderate implant containing 200 mg testosterone propionate + 20 mg estradiol benzoate; **MODR** vs. aggressive implant containing 200 mg trenbolone acetate + 28 mg estradiol benzoate; **AGGR**) on performance and carcass characteristics of feedlot heifers. On d -14, eight pens of heifers (n = 70) were spayed via the ovarian-drop technique. On d 1, all heifers were implanted (100 mg progesterone + 10 mg estradiol benzoate) and were fed backgrounding diets (0.50 Mcal NEg/lb DM, 14.2% CP) at 2.0% BW for 65 or 85 d (Heavy and Light heifers, respectively). On d 66 and 86 respectively, Heavy and Light heifers received terminal implants to begin the finishing phase. Heifers were fed diets (0.60 Mcal NEg/lb DM, 11.4% CP, 360 mg/d monensin, 90 mg/d tylosin) ad libitum. Intact heifers received melengestrol acetate (0.5 mg/d) for estrus suppression throughout the entire experiment. On d 146 and 174 respectively, Heavy and Light heifers were harvested at a commercial abattoir, and carcass characteristics were collected following a 24-h chill. During backgrounding, **INTACT** heifers had greater DMI ($P = 0.02$; 14.5 vs. 14.2 ± 0.1 lb/d), greater ADG ($P = 0.02$; 3.53 vs. 3.23 ± 0.10 lb), tended to have improved F:G ($P = 0.06$; 4.101 vs. 4.415 ± 0.115), and heavier end BW ($P = 0.04$; 862 vs. 842 ± 9 lb). During finishing, no status x implant interactions occurred ($P > 0.86$) for performance. Heifers receiving **MODR** implants had greater DMI ($P = 0.05$; 19.7 vs. 18.8 ± 0.5 lb/d) compared to heifers with **AGGR** implants, but ADG was similar ($P > 0.17$) among all heifers. Heifers receiving **AGGR** implants had improved ($P = 0.05$) F:G over heifers with **MODR** implants (5.698 vs. 5.986 ± 0.098). Final live BW, HCW, 12th rib fat thickness, LM area, marbling score, and yield grade were not influenced ($P > 0.15$) by spaying or implanting. Intact heifers receiving melengestrol acetate had improved performance over spayed heifers during backgrounding; however, appropriate implanting may allow similar performance during finishing. While not impacting carcass characteristics, aggressive implants reduced DMI but improved feed efficiency in feedlot heifers. Thus, terminal implant strategy should be carefully considered to replace lost endogenous anabolic effects due to spaying without compromising feedlot performance and carcass quality.

Effects of roughage source and dried corn distiller's grains concentration on feedlot performance and carcass characteristics of finishing beef steers *C. L. Maxwell¹, M. S. Brown¹, N. A. Cole², B. Coufal¹, J. O. Wallace¹, J. Simroth-Rodriguez¹, and S. Pratt¹, ¹Feedlot Research Group, West Texas A&M University, Canyon, ²USDA ARS Conservation and Production Research Laboratory, Bushland*

Physical attributes of roughages used in finishing diets may impact the extent of ruminal digestion of dried distiller's grains (**DDG**) and growth performance. Crossbred steers (n=380) were adapted to a common finishing diet, blocked by BW, implanted with Revalor-S (120 mg of trenbolone acetate and 24 mg of estradiol), and assigned to treatments of roughage source

(sorghum-sudan hay [**Hay**] or sorghum-sudan silage [**Silage**]) and DDG concentration (0 or 20% of diet DM). Cattle were housed in 40 soil-surfaced pens with at least 179.76 ft² of pen space and 12.0 in. of bunk space/animal. Roughages were included on an equal NDF basis. All diets contained 3.4% non-protein N from urea (1.2% urea) and cottonseed meal was utilized as a protein source in 0% DDG diets. Cattle were fed twice/d for 108 d (initial BW = 905 ± 27.81 lb). Steers fed 20% DDG ate 4.1% more DM than steers fed 0% DDG (23.93 vs. 22.99 lb, $P < 0.01$), but silage or hay did not influence DMI ($P = 0.56$). Overall shrunk ADG on a live basis was not altered by treatment ($P > 0.56$). Gain efficiency on a live basis was not altered by silage or hay ($P = 0.77$), but steers fed 0% DDG were 2.8% more efficient than steers fed 20% DDG ($P < 0.01$). There was a roughage source x DDG interaction for carcass-adjusted ADG and gain efficiency, dressing percentage, hot carcass weight, and LM area ($P < 0.07$). Adjusted ADG was increased 6.8% by silage with 20% DDG ($P = 0.05$), but forage source did not alter ADG when 0% DDG was fed ($P = 0.38$). Adjusted gain efficiency was reduced ($P = 0.03$) 3.5% by hay with 20% DDG, but efficiency was not altered ($P = 0.63$) by forage source at 0% DDG. Dressing percentage was reduced by hay at 20% DDG (63.0 vs. 62.5, $P = 0.02$) and increased by silage at 20% DDG (62.5 vs. 63.4, $P < 0.001$). Hot carcass weight was not altered by DDG with hay ($P = 0.37$), but was increased 16 lb with 20% DDG when silage was fed ($P = 0.05$). The LM area was increased by silage with 20% DDG ($P = 0.02$), but forage source did not alter LM area at 0% DDG ($P = 0.29$). Marbling score was higher when DDG was fed with either silage or hay (380 vs. 390, $P = 0.06$). Results suggest that rate of gain on a carcass basis can be improved by feeding DDG with silage, whereas forage source was less important when no DDG was fed.

Effects of roughage and wet distillers grains with solubles concentrations in steam-flaked corn-based diets on feedlot cattle performance and carcass characteristics *M. L. May, M. J. Quinn, N. DiLorenzo, D. R. Smith, and M. L. Galyean, Texas Tech University, Lubbock*
Effects of wet distillers grains with solubles (WDG) and dietary concentration of alfalfa hay (AH) on feedlot performance and carcass characteristics were evaluated in a randomized complete block design with a 2 × 3 + 1 factorial arrangement of treatments. Factors were dietary concentrations (DM basis) of WDG (15 or 30%) and AH (7.5, 10, or 12.5%) plus a steam-flaked corn-based control diet that contained 10% AH and no WDG. A total of 224 British crossbred steers (initial BW 755 ± 20.6 lb) was used, with 4 steers/pen and 8 pens/treatment. Treatments did not affect ($P > 0.15$) final shrunk BW or ADG. There was a tendency ($P = 0.06$) for cattle fed 15 vs. 30% WDG to have greater DMI from d 0 to 35, and DMI was greater DMI from d 0 to 70 ($P < 0.05$) with the lower WDG level; however, DMI did not differ with WDG level from d 0 to 105 ($P > 0.17$) or for the overall feeding period ($P > 0.38$). Similarly, G:F for the overall feeding period was not affected by WDG level ($P > 0.25$). Increasing dietary AH tended ($P < 0.08$) to linearly increase DMI, and decrease ($P < 0.05$) G:F and calculated NEm and NEg concentrations. Carcasses from cattle fed 15 vs. 30% WDG had greater yield grades ($P = 0.01$), with tendencies for greater 12th rib fat ($P = 0.05$) and marbling score ($P = 0.053$). There were no differences among treatments ($P > 0.15$) in HCW, dressing percent, LM area, KPH, proportions of cattle grading USDA Choice, and incidence of liver abscess. Results indicate that including 15 or 30% WDG in SFC-based diets did not result in major changes in feedlot performance or carcass characteristics, but increasing AH concentration from 7.5 to 12.5% in diets containing WDG decreased G:F.

Effects of rumen-protected methionine on performance and health of growing feedlot heifers *M.R. McDaniel, D.A. Walker, K.M. Taylor, C.A. Loest, New Mexico State University, Las Cruces*

Methionine is a limiting amino acid in growing cattle fed diets low in rumen undegradable protein. An experiment at the Clayton Livestock Research Center (Clayton, NM) evaluated the effects of supplementing rumen-protected methionine (METHIOPLUS, Kemin AgriFoods, Des Moines, IA) on performance and health of 718 Angus-cross heifers (average BW = 265 ± 27.8 kg). Heifers were housed in dirt floor pens equipped with fence line bunks and automatic waterers. Heifers were randomly assigned to 4 treatments in 36 pens (18-20 head/pen, 9 pens/treatment), and were fed once daily diets that consisted of 77% Sweet Bran (courtesy of Cargill Inc., Minneapolis, MN), 19.8% wheat silage, 0.25% urea, 2.95% supplement, and treatments (DM basis). Treatments were daily supplementation with 0, 7.5, 15.0, and 22.5 g of METHIOPLUS per head (estimated to supply 0, 4, 8, and 12 g/d of metabolizable DL-methionine, respectively) that was mixed with the diet for a treatment group of cattle before feeding. Feed bunks were managed to maintain *ad libitum* intake. Performance and health were monitored for 56 d. Supplementation at any level resulted in increased average daily gain ($P < 0.01$), and feed conversion ($P = 0.04$) when compared to heifers in the control group. Addition of METHIOPLUS increased dry matter intake quadratically ($P = 0.02$), with a negative response beyond 15.0 g/d. Average daily gain of heifers increased linearly ($P = 0.02$) with the addition of up to 15.0 g/d of METHIOPLUS, and declined with an increase to 22.5 g/d. Feed conversion increased linearly ($P = 0.04$) from 0 to 22.5 g/d of METHIOPLUS. No effects of supplementation were noted relevant to mortality ($P = 0.38$) or morbidity ($P = 0.19$). With no further improvements of productivity, other than feed conversion, it appears that 15 g/day of METHIOPLUS is the most feasible level of METHIOPLUS supplementation. Supplementing a wet corn-gluten feed-based diet with rumen-protected methionine improves performance of heifers during the growing phase. Performance is optimized by supplementing 15.0 g/d of METHIOPLUS.

Effects of stocker phase grazing system and implanting on performance and carcass characteristics of fall born calves *C. P. McMurphy, G. L. Mourer, D. A. Williams, B. P. Holland, G. W. Horn, and D. L. Lalman, Oklahoma State University, Stillwater*

Grazing system during the stocker phase can dramatically affect feedlot entry weight, feedlot performance, and hot carcass weight. It is also commonly suggested that implanting beef calves during the post-weaning stocker phase has a negative effect on quality grade. Therefore, a 2 x 2 factorial design was used to determine effects of stocker phase grazing system and stocker phase growth promoting implants on performance and carcass characteristics of fall-born calves. Angus and Angus x Hereford fall-born steers (n = 64) were sorted by weight and randomly allotted to one of four treatment combinations. The two levels of stocker phase grazing system included late season, tallgrass native range with protein supplementation from June 4, 2008 to December 1, 2008 (**NR**) and NR followed by wheat pasture grazing from December 1, 2008 to March 12, 2009 (**NR-WP**). The two levels of stocker phase implant included Component[®] TE-G administered on June 4, 2008 (**Implant**) and no implant (**Control**). Steers assigned to NR were implanted with Component[®] E-S upon feedlot arrival and implanted with Revalor[®] S after 90 days on feed. Steers assigned to NR-WP were re-implanted with Component[®] E-S on December 1, 2008, prior to turnout on wheat, and implanted with Revalor[®] S upon arrival at the feedlot.

Interactions for stocker phase grazing system by stocker phase implant were not detected and therefore main effect means are presented. Feedlot ADG and DMI were greater ($P < 0.01$) for NR-WP steers while feed efficiencies were lower (5.64 vs. 5.06 F:G; $P = 0.04$). Rib-eye area (86.8 vs. 77.3 cm²; $P < 0.01$) was increased, resulting in a tendency ($P = 0.06$) for reduced calculated yield grade for steers managed in NR-WP system. Conversely, the NR-WP system reduced marbling score (47.1 vs. 43.0; $P = 0.03$). Stocker phase implants increased ($P < 0.05$) ADG during both grazing periods by 9 to 15%. However, grazing implants tended to have a negative impact on marbling score (43.0 vs. 46.7; $P = 0.09$). Implanting fall born calves increased performance when steers grazed tallgrass native range and during subsequent wheat pasture grazing. However, stocker phase implants and extended stocker phase grazing (wheat pasture) may reduce carcass marbling scores in fall-born steers.

Within and between breed variation in feed efficiency and behavioral traits in heifers fed a high-grain diet *E.D.M. Mendes, G.E. Carstens, L.O. Tedeschi, Texas A&M University, College Station*

Objectives of this study were to examine the effects of breedtype on feed efficiency, and to evaluate phenotypic associations between efficiency and feeding behavioral traits in heifers fed a high-grain diet (ME = 3.1 Mcal/kg DM). An electronic feed intake system (GrowSafe; DAQ4000E 9.25) was used to record individual intake, and the frequency (events/d) and duration (min/d) of bunk visits (**BV**) in 16 Angus, 35 Brangus, 34 Braford and 42 Simbrah heifers (initial BW = 286 ± 30 kg) for 81 d. A mixture 2-pool distribution model (R mixdist package 0.5-2) was fitted to log₁₀ transformed non-feeding intervals between BV. The intersection of the 2 distributions, which represents intervals within and between meals, was determined to be the meal criteria, which is defined as the longest nonfeeding interval included as part of a meal. Analysis revealed that meal criteria in the current study were 13 ± 7 min, which is substantially greater than the estimate of 5 min based on previous research. A meal criterion of 13 min was used to compute meal duration (**MD**) and frequency (**MF**) in heifers. The ratio of BV to meal events, meal eating rate (**MER**, g/min), and average meal size was also calculated for each animal. Residual feed intake (**RFI**) was calculated as the difference between actual and expected DMI from linear regression of DMI and ADG and mid-test BW^{0.75}, with pen included as random effect. RFI was positively correlated with DMI (0.66) and F:G (0.73), but was phenotypically independent of ADG and BW. The DMI was similar for all breeds, but Angus and Simbrah heifers had lower ($P < 0.01$) F:G than Braford and Brangus heifers (6.07, 6.22, 6.65, 6.58 ± 0.22, respectively). Simbrah heifers had lower ($P < 0.001$) RFI (-0.49 kg/d) than Brangus and Braford (0.29, 0.31 kg/d) with Angus heifers being intermediate (-0.06 ± 0.04 kg/d). Simbrah and Angus heifers had lower ($P < 0.001$) MF than Brangus and Braford heifers, and BV durations were lower in Simbrah than other heifer breedtypes. The daily frequency and duration of BV and meal events, and the ratio of BV per meal were more strongly correlated with RFI than with F:G. Heifers with low RFI phenotypes (< 0.50 SD from mean RFI) consumed 20% less ($P < 0.001$) DMI and had 23% lower F:G compared to high-RFI heifers (> 0.5 SD from mean RFI). The low-RFI heifers had lower BV frequencies (47 vs 55 events/d), lower BV durations (49 vs 67 min/d), lower MD (126 vs 141 min/d), fewer BV per meal (5.9 vs 7.1), and had smaller sized meals (1.2 vs 1.55 kg) compared to high-RFI heifers. The inclusion of BV frequency and duration traits in the base model used to compute RFI increased the R² from 0.52 to 0.72. Thus, the additional variation in DMI explained by these 2 traits as a proportion of the

variation in DMI not explained by ADG and BW was 38%. While the differences in feed efficiency between breeds were small, the inter-animal variation in feed efficiency within breed was considerable. Moreover, results from this study demonstrate that feeding behavior traits were more tightly associated with RFI than F:G, and that feeding behavior traits may have useful applications for individual-cattle management systems.

Effectiveness of ractopamine when fed as a top dress in beef steers *K. L. Neuhold¹, P. T. Grubb¹, J. J. Wagner¹, T. E. Engle¹, R. K. Peel¹, and A. L. Schroeder², ¹Colorado State University, Fort Collins and ²Elanco Animal Health, Greenfield, IN*

A clinical trial was conducted to investigate the effectiveness of Ractopamine (RAC) as a top dress (TD) pellet during the final 42 d of feeding. Crossbred yearling steers (n = 144) were selected for the study. Steers were housed in 9 head pens with 8 pens per treatment. Treatments consisted of a steam-flaked corn based feedlot diet plus 0.9 kg per head per day of TD containing 1) no RAC (Control) or 2) 400 mg per head/d of RAC (400-RAC). Steers were fed 3 times daily. Top dress was applied evenly over the top of the total mixed ration immediately after the second feeding. Initial steer weights (526.8 kg) were similar ($P > 0.94$) between treatments. Final steer weight ($P < 0.03$) and ADG ($P < 0.02$) were greater for 400-RAC when compared to control (615.8 vs 605.2 \pm 6.3 kg and 2.1 vs 1.86 \pm 0.13 kg/d, respectively). Steers consuming 400-RAC had lower daily DMI ($P < 0.04$) compared to control (10.9 vs 11.4 \pm 0.32 kg/hd/day). Gain to feed ratio was greater ($P < 0.001$) in steers fed 400-RAC (0.194 vs 0.164 \pm 0.46). Dressing percentages ($P > 0.96$) were similar across treatments resulting in greater HCW ($P < 0.002$) for 400-RAC supplemented steers (373.5 vs 367.4 \pm 2.3 kg). There were no differences between treatment groups for 12th rib fat depth ($P > 0.54$) and KPH ($P > 0.69$). Steers receiving 400-RAC had increased ($P < 0.007$) LM area than controls (96.39 vs 91.03 \pm 0.19 cm²). Longissimus muscle area expressed per unit HCW was greater ($P < 0.04$) for 400-Rac steers compared to control steers indicating that RAC increased carcass muscling. Yield grades tended ($P < 0.19$) to be lower in the RAC-400 steers compared to controls (2.34 vs 2.52 \pm 0.08). No differences in marbling score or carcass quality grade were observed between treatments. These data indicate that feeding RAC in a TD application for the final 42 d of the finishing period will increase rate of gain, final weight, HCW and G:F while maintaining carcass quality.

Comparing dry, wet, or modified distillers grains plus solubles on feedlot cattle performance and metabolism characteristics *B.L. Nuttelman, W.A.Griffin, J.R. Benton, K.M. Rolfe, G.E. Erickson, T.J. Klopfenstein, University of Nebraska, Lincoln*

Two experiments were conducted to compare dry, wet, and modified (partially dried) distillers grains plus solubles. During Exp. 1, crossbred, yearling steers (n=440; initial BW = 778 \pm 44 lb) were utilized in a RCBD with steers stratified within block, and assigned randomly to one of 55 pens (8 steers/pen). Pens were assigned randomly to one of ten treatments as a 3x3+1 factorial. Diet treatments were based on 3 inclusions (20, 30, or 40%) of 3 different types of distillers grains plus solubles. A corn, control was also fed. Distillers types were: wet distillers grains plus solubles (WDGS, 34.8% DM), modified distillers grains plus solubles (MDGS, 50.6% DM), or dried distillers grains plus solubles (DDGS, 91.4% DM). Six ruminally cannulated steers were used in Exp. 2 in a 4 x 6 unbalanced Latin square (4 diets, 4 periods, 6 steers) digestion and metabolism study. Diets contained 40% WDGS, MDGS, or DDGS from the same source as Exp. 1, or a corn control containing no distillers grains. Basal ingredients consisted of high-moisture and dry-rolled corn fed at a 60:40 ratio (DM basis), 15% corn silage, and 5% dry

supplement (DM basis) for both experiments with distillers grains replacing corn. No interactions between type and inclusion level ($P > 0.16$) were observed in Exp. 1 for any variables. No difference was observed in ADG ($P = 0.30$) between WDGS, MDGS, or DDGS. Steers fed WDGS had 1.61 and 2.29 lb/d less ($P < 0.01$) DMI than MDGS and DDGS, respectively. Steers fed WDGS (0.165) had greater G:F ($P < 0.01$) compared to steers fed MDGS or DDGS (0.158 or 0.150, respectively). Type had no impact ($P > 0.15$) on carcass traits. A linear increase ($P = 0.01$) in DMI, quadratic response ($P = 0.04$) in ADG, and a linear increase ($P < 0.01$) in G:F were observed as distillers grains increased from 0 to 40%. Increased levels of distillers grains increased HCW quadratically ($P = 0.05$) and increased fat depth ($P < 0.01$). Based on G:F, the feeding value of WDGS was 35.4 and 17.8% greater than DDGS and MDGS, respectively. For Exp. 2 there were no differences observed for DMI, or for DM, OM, or fat digestibility ($P > 0.73$). Steers fed diets containing distillers grains had greater NDF intake compared to CON ($P < 0.01$). There were no differences for NDF digestibility between WDGS, MDGS, and DDGS ($P > 0.37$). However, CON diets had lower NDF digestibility ($P < 0.06$) than WDGS and DDGS. Average ruminal pH tended to be impacted ($P = 0.14$) by dietary treatment with steers fed DDGS having a greater pH ($P < 0.09$) than steers fed CON, MDGS, and WDGS, which were not different from one another ($P > 0.73$). Drying WDGS to either MDGS or DDGS has a negative impact on the feeding value relative to DRC. However, including distillers grains up to 40% of the diet will increase animal performance compared to a corn based diet.

Evaluation of high-intensity and low-intensity preconditioning systems *A.N.Orsak¹, J.D.Sugg¹, J.S.Horn¹, T.A.Wickersham¹, C.P.Mathis², C.A.Loest², and J.E.Sawyer¹*,
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Steer calves (n=345; 230 ± 33 kg initial BW) were used to evaluate 56-d preconditioning systems in each of two years. Angus and Charolais-sired calves out of crossbred dams were assigned to systems within breed and BW strata. Systems consisted of ad libitum access to a self-fed milo-based diet in drylot (**DL**); ad libitum access to the same self-fed diet while grazing dormant warm season pasture (**SF**); and hand-fed 20% CP pellets (3 times/wk; 0.9 kg/hd per d) while grazing dormant warm season pasture (**HF**). Steers were weighed after overnight shrink on d 0, 28, and 56. Economic analysis was based on current local prices for cattle and inputs. Morbidity and mortality rates were similar among treatments. In yr 1, one steer was removed from SF (mechanical) and one from DL (chronic bloat). In yr 2, two steers were treated for respiratory disease (DL and HF) and mortalities occurred in DL (1 hd, digestive), HF (1 hd, unknown) and SF (1 hd, mechanical). Shrink from weaning to d 0 averaged 4.45% across years and was similar ($P = 0.70$) among treatments. Across years, ADG was lower in HF vs. SF or DL-fed steers ($P < 0.01$), which had similar rates of gain ($P = 0.67$; 0.14, 0.85, and $.88 \pm 0.07$ kg/d for HF, SF, and DL, respectively). In yr 1, daily feed intake was similar (9.03 vs. 10.0 ± 0.96 kg/hd; $P = 0.17$) among SF and DL systems. In yr 2, intake was greater for DL than SF (10.1 vs. 8.3 ± 0.25 ; $P < 0.01$). Feed efficiency (G:F) across years was greater for HF steers than for SF or DL steers ($P = 0.04$). ($P=0.91$; 0.15, 0.05, 0.04 ± 0.04 for HF, SF, and DL). Forage utilization was not quantified; these values represent gain per unit of purchased feed delivered, a metric favoring groups fed at lower rates. Preconditioning costs were 89.72, 173.51 and 160.19 \$/hd (yr 1) and 52.17, 151.31, and 140.27 \$/hd (yr 2; HF, SF, and DL respectively). These systems resulted in losses of -74.11, -66.18, and -51.78 \$/hd (SE = 5.02; $P= 0.05$) in yr 1, and -26.94, -78.59, and -63.14 \$/hd (SE = 17.39; $P=.18$) in yr 2 for HF, SF, and DL. Price premiums of 13.58,

10.29, and 8.09 \$/45.4 kg (SE = 0.85; P=0.01) in yr 1 and 5.50, 13.76, and 11.06 \$/45.4 kg (SE = 3.25; P=0.26) in yr 2 would be required for HF, SF, and DL to be par with sale at weaning.

Biological responses of beef steers to anabolic implants and zilpaterol hydrochloride

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Our objectives were to evaluate the dose/payout of trenbolone acetate (TBA) and estradiol-17 β (E₂) and feeding of zilpaterol hydrochloride (ZH) on performance, carcass characteristics, serum urea-N (SUN) and NEFA concentrations, and β_1 & β_2 -adrenergic receptor (AR) mRNA expression of finishing beef steers. A randomized complete block design was used with a 3 \times 2 factorial arrangement of treatments. Crossbred steers (initial BW = 798 lb) were blocked by BW and allotted to 42 pens (6 pens/block). Main effects of treatment were implant (no implant [NI]; Revalor-S [REV-S; 120 mg of TBA + 24 mg of E₂]; and Revalor-XS [REV-X; 200 mg of TBA + 40 mg of E₂]) and ZH (0 or 7.56 g/ton of DM for 20 d with a 3-d withdrawal before slaughter). Steers were fed for 153 or 174 d depending on block. Blood was collected (2 steers/pen) at d -1, 2, 6, 13, 27, 55, 83, 111, and 131 relative to implanting; LM biopsies (1 steer/pen) were collected at d -1, 27, 55, and 111. Blood and LM samples were collected at d -1, 11 and 19 relative to ZH feeding. Overall final BW (1250, 1336, and 1376 lb for NI, REV-S and REV-X, respectively), ADG (2.76, 3.32, and 3.53 lb) and gain efficiency were increased (P < 0.05) as TBA and E₂ dose increased. From d 112 to end, ADG increased by 19% (P < 0.05) and F/G was 18% less (P < 0.05) for REV-X vs. REV-S. Final BW did not differ among ZH treatments, but ADG (0.14 lb/d difference) tended to be greater (P < 0.10) and F/G was improved (2.8%; P < 0.05) by feeding ZH. Hot carcass weight was increased (P < 0.05) by feeding ZH (41-lb difference) and implanting. Marbling score, 12th-rib fat, and KPH were not affected (P > 0.10) by implant or ZH. Implanting decreased (P < 0.05) SUN from d 2 through d 131 but SUN did not differ between implants. Feeding ZH decreased (P < 0.05) SUN. A day \times ZH interaction (P = 0.06) was noted for NEFA; NEFA concentrations did not differ (P > 0.10) in steers not fed ZH, whereas steers fed ZH had greater (P < 0.01) NEFA at d 11 of ZH feeding. Expression of β_1 & β_2 -AR mRNA were greater (P < 0.05) for REV-X than for REV-S at d 111, and these expression differences may aid in explaining performance differences between REV-S and REV-X. A greater dose of TBA and E₂ in combination with ZH increased ADG and HCW in an additive manner, suggesting a different mechanism of action for ZH and steroidal implants. Both implanting and feeding ZH decreased SUN, but a greater dose of TBA + E₂ did not result in further decreases. In addition, feeding ZH increased serum NEFA levels. Metabolic changes resulting from implanting and feeding ZH may aid in explaining steer performance and carcass responses to these growth promotants.

Effects of Monensin Concentration and Accelerated Step-up Regimens on Performance and Carcass Traits *G. L. Parsons, C. E. Walker, K. A. Miller, L. K. Thompson, J. J. Higgins, and J. S. Drouillard, Kansas State University, Manhattan*

Crossbred steers (n=720; initial BW = 804 \pm 49 lb) were used to evaluate effects of monensin concentration and step-up regimen on feedlot performance and carcass traits in a randomized complete block experiment with a 2 \times 2 factorial treatment arrangement. Factor 1 consisted of 30 or 40 g/ton monensin (MON) fed for the entire 153 d trial; and factor 2 was length of the step-up period (10 or 21 d). Cattle from wheat pastures were received into the feedlot and fed chopped

hay and salt for 2 wk. On d 1 of the study, cattle were stratified by BW and allotted to pens of 15 cattle each, with 12 pens/treatment. Starting d 1, a 3-diet (60, 77, and 93% concentrate) step-up system was used in which cattle were fed ad libitum 60% concentrate am (0900 h) and pm (1300 h) for step 1; 60% concentrate am and 77% concentrate pm for step 2; 77% concentrate am/pm for step 3; 77% concentrate am and 93% concentrate pm for step 4; and 94% concentrate am/pm for the final finishing diet. Diet changes were implemented on d 6, 11, 16, and 21 for the traditional regimen, and on d 4, 6, 8, and 10 for the accelerated regimen. BW were determined on d 0, 56, and before shipping to a commercial abattoir on d 153. There were no interactions between level of MON and step-up regimen ($P > 0.10$) and no effects of step-up regimen on performance or carcass traits ($P > 0.10$), but steers on the accelerated regimen consumed less roughage ($P < 0.05$). Increasing MON from 30 to 40 g/ton decreased DMI during the first 56 d ($P < 0.01$) and the entire 153-d study period ($P < 0.01$), and improved gain efficiency by 8% for the first 56 d ($P < 0.10$) and by 3% for the 153-d trial ($P < 0.05$). Feeding increased levels of monensin is the most beneficial during the initial step-up phase. Cattle on the accelerated step-up program tended to have an increase in liver abscess ($P = 0.09$). Yield grades were lower for steers fed 40 g/ton MON compared to steers fed 30 g/ton MON ($P < 0.05$), but other carcass traits were not affected ($P > 0.10$). Steers can be transitioned to high-concentrate diets in 10 d without compromising performance, and less roughage is used. Steers fed 40 g/ton MON were more efficient than steers fed 30 g/ton MON.

Evaluation of Algae as Livestock Feed *C.P. Payne, J.E. Sawyer, and T.A. Wickersham*
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Cultivation of algae for biofuel would result in the production of significant amounts of post-extraction algal residue (**PEAR**). The economic viability of algae as source of biofuel is dependent on deriving value from PEAR. Livestock feed is an attractive option for PEAR because of the successful utilization of other coproducts by ruminants. While sufficient quantities of PEAR were not available for analysis, we evaluated two strains of algae that based on their lipid content and growth characteristics possess potential as a source of biofuel. Algae samples were analyzed for ash, crude protein, amino acid profile, total lipid content, fatty acid profile, fat soluble vitamins, macro- and micro-minerals, and heavy metals. Algae samples were unknown wild algae (**WA**) and *Neochloris oleoabundans* (**NO**). Samples were observed to have relatively high levels of ash 30.5 and 43.2% for WA and NO, respectively. As expected, Na content of each sample was high 10.3 (WA) and 10.8% (NO). The Ca and P contents were 0.67 and 0.43% for WA and 1.02 and 0.26% for NO, accordingly. Algae samples WA and NO contained 34.2 and 48.6 ppm Cu, 848 and 756 ppm Fe, and 20.1 and 62.3 ppm Zn, respectively. WA and NO contained significant quantities of aluminum at 840 and 858 ppm, accordingly. Analysis of algal CP content, 17.4 WA and 20.6% NO, indicates that PEAR may serve as a source of N in ruminant diets. Samples contained similar amounts of methionine (0.31 and 0.32%; WA and NO, respectively) and lysine (1.00 and 1.18%; WA and NO, respectively). Total fat content was 9.1 and 11.8% WA and NO, respectively. Fatty acids (% total fat) were profiled for WA and NO, correspondingly: Palmitic, 21.3 and 32.0; Oleic, 34.1 and 15.6; Trans-vaccenic, 7.7 and 5.6; Linoleic, 11.3 and 19.8; α -Linolenic, 16.3 and 15.4%. Vitamin A content was high for both samples, with WA measured to be 6614 and 5203 IU/kg for NO. Vitamin E content was 56.5 for WA and 87.7 IU/kg for NO. Future nutritive evaluations of algae and the resulting PEAR should focus on its value as a source of N in ruminant diets.

Effects of non-protein nitrogen and wet distiller's grains with solubles on growth performance, carcass merit, mineral status, tissue enzyme activities, and visceral organ mass by feedlot cattle C. Ponce¹, M. Brown^{1,2}, J. Osterstock², N. A. Cole³, T. Lawrence¹, J. MacDonald^{1,2}, C. Maxwell¹, J. Wallace¹ and B. Coufal¹, ¹Feedlot Research Group, West Texas A&M University, Canyon, ²Texas AgriLife Research, Amarillo, TX and ³USDA Conservation and Production Research Laboratory, Bushland, TX

Our previous data suggest that the non-protein nitrogen (NPN) need in diets with 15% wet distiller's grains with solubles (WDGS) for optimum growth performance may be slightly less than in 0% WDGS diets and a potential for reduced dressed yield with higher levels of WDGS. In Exp. 1, steer calves (n = 296; initial BW = 759 lb) were adapted to a common finishing diet, blocked by BW, and assigned to 36 soil-surfaced pens (18 m² of pen space and 33 cm of bunk space/animal). Treatments included a control diet without WDGS (contained 3% NPN from urea, and cottonseed meal) and 15% WDGS with either 1.5, 2.25, or 3.0% NPN (0.52, 0.78, and 1.06% urea, respectively). The WDGS was obtained three times/week and averaged 75:25 corn:sorghum over the study. Steers were implanted on d 1 with Revalor-XS and were fed twice daily for an average of 165 d. Overall DMI was 6.1% higher (P = 0.001) for steers receiving WDGS than for the control. Similarly, steers fed WDGS had 8% greater ADG (P < 0.01) on either a live or a carcass-adjusted basis than the control. However, overall gain efficiency on either a live or adjusted basis was not different among treatments (P > 0.15). Dietary NPN did not influence growth performance by cattle fed WDGS (P > 0.21). Hot carcass weight was 3% lighter for the control than for the average of WDGS (P = 0.01). Remaining measured carcass characteristics were not altered by treatment (P > 0.16). In Exp. 2, 24 steers (initial BW = 847 lb) were blocked by weight, randomly assigned to dietary treatments (0, 30, and 60% of DM as WDGS), and were fed individually for 125, 150, 164 and 192 d (2 blocks/slaughter date). Steers fed 30% WDGS had greater liver S and Mn concentrations and lower liver Fe concentrations than the control (P < 0.10; initial values used as a covariate). However, feeding 60% WDGS decreased liver Cu and increased liver Fe (P < 0.10) compared to those fed 30% WDGS. Cytochrome c oxidase activity in brain tissue was decreased when feeding 60% WDGS compared to 30% WDGS (P = 0.10), and cytochrome c oxidase activity decreased linearly (P = 0.06) in lung tissue as WDGS increased. Feeding WDGS increased gut fill in a linear manner (P = 0.01). Feeding 30% WDGS increased fractional mass (g/kg of EBW) of the small intestine (P < 0.10) compared to the control, whereas 60% WDGS increased fractional kidney mass (P < 0.10) compared to those fed 30% WDGS. Data suggest that growth performance may not be improved by including more than 1.5% added NPN in diets with 15% WDGS. Dressed yield, Cu absorption or retention, and cytochrome c oxidase activity may be reduced by WDGS when fed at higher levels in diets based on steam-flaked corn.

Comparison of a single Revalor XS implant with a Synovex Choice-Synovex Plus implant combination on feedlot steer performance and carcass characteristics J. M. Popowski^{*1}, G. I. Crawford¹, R. Gilland², C. G. Campbell³, D. Fedders³, ¹University of Minnesota, Twin Cities, ²Gilland Feedlot, Morgan, MN, ³Fort Dodge Animal Health, Overland Park, KS

Crossbred beef steers (n = 751; initial BW = 703 ± 18 lb) were utilized in a commercial feedlot experiment to compare the effect of a single dose of Revalor XS (200-mg trenbolone acetate, 40-mg estradiol; **REV**) with a Synovex Choice (100-mg trenbolone acetate, 14-mg estradiol benzoate) followed by Synovex Plus (200-mg trenbolone acetate, 28-mg estradiol benzoate);

SYN) combination on feedlot steer performance and carcass characteristics. At feedlot arrival, steers were stratified by BW and allotted to 8 pens, with 6 pens of 72 to 75 head and 2 pens of 144 to 145 head. Pens were assigned randomly to treatment within pen size, with 4 pens/treatment. Steers were fed a finishing ration containing (DM-basis) 51% corn earlage, 30% modified distillers grains, 16% dry-rolled corn, and 3% supplement. The experiment began at initial implant, and re-implant for SYN steers occurred, on average, 80 d after initial implant. Cattle were harvested in paired groups of SYN and REV from the same initial implant date, and carcass characteristics were measured after a 48-h chill. Days on feed ranged from 159 to 185 d and averaged 174 d. Carcass-adjusted final BW averaged 1,309 and 1,283 lb for SYN and REV, respectively ($P = 0.17$). Average daily gain tended ($P = 0.07$) to be greater with SYN (3.49 lb) than with REV (3.34 lb). No treatment differences were observed for DMI ($P = 0.24$) or G:F ($P = 0.41$). Percentage of carcasses grading USDA Choice or higher was greater ($P = 0.004$) for REV (68.7%) than SYN (55.9%). Percentage of carcasses grading USDA Yield Grades (YG) 1 and 2 was greater ($P = 0.04$) with SYN (44.4%) than with REV (32.8%). No treatment differences ($P > 0.13$) occurred for LM area, 12th rib fat thickness, marbling score, percentage of carcasses grading USDA YG 3 or USDA YG 4 and 5. Results indicate steers implanted with a Synovex Choice-Synovex Plus combination tended to have greater ADG, and also produced a greater percentage of USDA YG 1 and 2 carcasses and a lower percentage of carcasses grading USDA Choice and higher than steers receiving a single Revalor XS implant.

Effects of the Ratio of Distillers Grains to Solubles on In Vitro Dry Matter Disappearance, Gas Production Kinetics, Hydrogen Sulfide Production, and Osmolality *M. J. Quinn, M. L. May, N. DiLorenzo, D. R. Smith, C. H. Ponce, and M. L. Galyean, Texas Tech University, Lubbock*

Effects of substrates containing different proportions of distillers grains (**DG**) and distillers solubles (**DS**) on in vitro DM disappearance (**IVDMD**), H₂S production, gas production kinetics, volatile fatty acid proportions (**VFA**), and osmolality were evaluated in a randomized block design with a 2 x 3 + 1 arrangement of treatments. Treatment substrates consisted of 15 or 30% DG with DS blended in each DG level to yield proportions of DG:DS of 100:0, 75:25, and 50:50; the steam-flaked corn (**SFC**)-based control treatment contained no DG. Two ruminally cannulated Jersey crossbred steers (BW = 1301 lbs) fed a 60% concentrate, SFC-based diet were used as ruminal fluid donors. Duplicate cultures were incubated for 24 h for IVDMD and 48 h for gas production kinetics with incubations replicated on separate days (blocks). No differences were observed among treatments for IVDMD ($P > 0.15$), but adding DG to substrates increased ($P < 0.01$) H₂S by 39 and 73% for 15 and 30% DG, respectively. Moreover, H₂S production increased linearly as the proportion of DS increased ($P < 0.01$). Osmolality was greater for control ($P < 0.001$) than for other treatments, decreased ($P < 0.001$) with increasing DG concentration, increased linearly ($P < 0.001$) with increased DS in substrates, and increased over time ($P < 0.001$). Fractional rate of gas production (%/h) was less ($P = 0.01$) for 30 vs. 15% DG, and lag time of fermentation decreased as DS increased in substrates (linear, $P = 0.02$). Molar proportion of acetate was least ($P = 0.02$), propionate was greatest ($P < 0.01$), and acetate:propionate ratio was least ($P = 0.02$) for control vs. other treatments. In general, including DG in substrates and increasing proportions of DS increased H₂S production, reflecting increased S concentrations. For both 15 and 30% DG, substrates with greater proportions of DS had increased gas production, osmolality, and rate of gas production.

Effect of feeding greater than 70% wet distillers grains plus solubles on feedlot cattle performance and nutrient mass balance *A.R. Rich, G. E. Erickson, T. J. Klopfenstein, M. K. Luebke, J. R. Benton, and W. A. Griffin, University of Nebraska-Lincoln*

A winter (Exp. 1) and a summer (Exp. 2) finishing study were conducted to evaluate the effects of a high level of distillers grains (70%) with a high inclusion level of wheat straw (25%) on cattle performance and nutrient mass balance compared to a corn-based control diet. In each Exp, 128 crossbred steers (801 lb) were stratified by BW, and assigned randomly to 16 pens (8 steers/pen). Four treatments were tested as a 2X2 factorial with factors being diet and pen cleaning frequency (monthly or at the end of the feeding period). Diets consisted of 85% corn, 5% molasses, and 5% wheat straw (CON) or 70% WDGS and 25% wheat straw (BYP). Both diets contained 5% supplement. Nitrogen excretion was determined by difference between N intake and N retention. Total N lost was calculated by subtracting manure and runoff N from excreted N. Total N lost was calculated by subtracting manure and runoff N from excreted N. Runoff was quantified and analyzed from retention ponds when rainfall occurred. No interactions ($P > 0.25$) between diet and cleaning frequency were observed for performance or mass balance in either Exp. 1 or Exp. 2. For Exp. 1, cleaning monthly compared to once at the end did not increase manure N ($P = 0.24$) despite increasing ($P = 0.05$) manure OM removed from pens. For Exp. 2, cleaning pens monthly almost doubled ($P < 0.01$) DM, OM, and N removed in manure resulting in decreased ($P < 0.01$) N losses by 16.5 lb and % N lost from 72.5 to 49.4% compared to cleaning once at the end. A finishing study (Exp. 3) evaluated inclusion of corn wet distillers grains plus solubles (WDGS) and wheat straw on the performance and carcass characteristics of 336 (595 \pm 20 lb) crossbred steers. Seven treatments included: 1) control (CON) containing 85% corn and 4.7% wheat straw, 2) 40% WDGS and 4.7% wheat straw (40-5), 3) 70% WDGS and 8.23% wheat straw (70-8), 4) 77.5% WDGS and 9.1% wheat straw (77-9), 5) 85% WDGS and 10% wheat straw (85-10), 6) 77.5% and 17.5% wheat straw (77-17), 7) 70% WDGS and 25% wheat straw (70-25). Wheat straw was increased to increase roughage and to offset the risk of the greater dietary S levels. Six pens per treatment (8 steers/pen) were used in the RCBD experiment with two weight blocks. The CON, 40-25, 70-8, and 77-9 were fed for 183 d and the 70-25, 77-17, and 85-10 treatments were fed 225 d to target similar final BW. Steers fed the 40-5 had the greatest ($P < 0.01$) ADG, G:F, and HCW; however, G:F was similar to 77-9. Steers fed 70-25 had the least ($P < 0.01$) ADG, G:F, and HCW. Steers being fed the CON, 70-8, and 77-9 had similar ADG, followed by steers fed 77-17, then 85-10, which were different ($P < 0.01$). Steers fed CON, 85-10, and 77-17 had similar G:F ($P > 0.10$) but less ($P < 0.05$) than 40-5, 70-8, and 77-9. Feeding 70 to 77% WDGS with some inclusion of corn resulted in similar ADG and improved G:F compared to the control diet. Increasing straw above 10% or WDGS above 77% depressed ADG, G:F, or both compared to corn.

Exp. 3- Performance of steers

Item	Con	40-5	70-8	77-9	85-10	77-17	70-25	SEM
DOF	183	183	183	183	225	225	225	
ADG, lb/d	3.62 ^b	4.34 ^a	3.66 ^b	3.55 ^b	2.89 ^d	3.09 ^c	2.49 ^e	0.132
G:F	0.160 ^c	0.189 ^a	0.181 ^b	0.187 ^{ab}	0.162 ^c	0.157 ^c	0.138 ^d	0.002
HCW, lb	792 ^b	876 ^a	796 ^b	787 ^b	785 ^b	809 ^b	728 ^c	22

^{a,b,c} Within a row, means without common superscript differ ($P < 0.05$)

Pre-arrival management of newly received beef calves with or without exposure to a persistently infected bovine viral diarrhea virus type I calf affects health, performance, bovine viral diarrhea virus type I titers, and circulating leukocytes J. T. Richeson¹, E. B. Kegley¹, B. L. Vander Ley², and J. F. Ridpath³. ¹University of Arkansas, Fayetteville, ²Iowa State University, Ames, ³USDA, National Animal Disease Center, Ames, IA

Calves persistently infected (PI) with bovine viral diarrhea virus (BVDV) are a major source of the virus; however, consequences of exposure to a PI-BVDV calf in single source, preconditioned (PC) vs. commingled, auction market (AM) cattle may differ. Our objective was to compare treatments of PC or AM origin, with (PI) or without (CON) exposure to a PI-BVDV calf in a 2 x 2 factorial arrangement to evaluate effects on health and performance. Four sets (block) of crossbred PC steers (n = 236) from 3 ranches were selected randomly, weaned, dewormed, vaccinated, tested for PI-BVDV status, and kept on the ranch for ≥ 42 d. Subsequently, PC steers were transported to a stocker receiving unit (SU), weighed (251 ± 2 kg), bled, and assigned randomly to treatment (PCPI or PCCON) with no additional processing. Simultaneously, 4 sets of crossbred AM calves (n = 292) were assembled from regional auction markets for delivery to the SU within 24 h of PC arrival. The AM calves were weighed (245 ± 1.3 kg) and administered the same processing procedures as PC; however, bull calves were castrated, stratified by gender, then AM calves were assigned randomly to treatment (AMPI or AMCON). Treatments were arranged spatially so that PI did not have fence-line contact with CON. Calves were fed identically and followed the same antibiotic treatment protocol. Daily gain for the entire 42 d receiving trial was greater ($P < 0.001$) for PC (1.2 kg) than AM (0.85 kg). There was an exposure effect ($P = 0.002$) on ADG from d 28 to 42; CON gained 1.12 kg vs. 0.90 kg for PI. Morbidity rate was greater ($P < 0.001$) in AM (70%) than PC (7%). Treatment with a third antibiotic occurred more often ($P = 0.04$) for PI, likewise antibiotic treatment cost ($P = 0.05$) and the percentage of chronic cattle ($P = 0.06$) were greatest for AMPI. BVDV type I titer levels were greater on d 0 for PC (treatment x day, $P < 0.001$), and seroconversion to BVDV type I on d 0 was 100% for PC vs. 23% in AM. Circulating leukocytes were greater ($P < 0.001$) for PC on d 0, 14, and 28. The neutrophil:lymphocyte ratio was greater ($P < 0.001$) for AM on d 14 and 28. Results suggest that PC gain faster and require fewer antibiotic treatments; whereas, PI-BVDV exposure reduced gain from d 28 to 42 and increased antibiotic treatment cost in AM.

Sulfur content of wet or dry distillers grains plus solubles in beef cattle finishing diets: Performance, metabolism, and hydrogen sulfide production J.O. Sarturi, G.E. Erickson, T.J. Klopfenstein, J.T. Vasconcelos, K.M. Rolfe, W.A. Griffin, University of Nebraska-Lincoln

Two studies were conducted to evaluate the effects of sulfur concentration [S] in wet or dry distillers grains plus solubles (DGS) on performance, intake, ruminal pH and hydrogen sulfide (H₂S) production in beef cattle finishing diets. Wet or dry DGS had similar [S] within source that was either 0.82 or 1.16%. All steers were fed ad libitum, once daily, and diets contained 15% corn silage, 5% supplement and a blend (60:40) of high-moisture and dry-rolled corn. In Exp. 1, steers (n = 120, BW=760 \pm 75lb) were assigned to 1 of 13 treatments (20, 30, and 40% DGS, wet or dry, and high or low [S], plus a control diet, resulting in a 3x2x2+1 factorial treatment design) in a RCBD (9 steers/diet, except 12 steers for control) and fed for 151 d using Calan individual bunks. In Exp. 2, 6 ruminally cannulated steers (BW=840 \pm 68 lb) were assigned to 1 of 5 treatments (wet or dry DGS, at high or low [S], included at 40% of diet DM, plus a diet containing wet DGS from high [S] provided at 32% of diet DM to match the low S wet DGS, resulting in a 2x2+1 factorial treatment design) in an unbalanced Latin square design (6 steers

and 5 diets) and fed for 5, 14-d periods. Continuous DMI and pH (wireless pH probes) data were collected the last 7 d, H₂S was analyzed from ruminal gas samples collected 8 h post feeding on the last 3 d, and Cr₂O₃ bolused twice daily to estimate DM digestibility (DMD). Data were analyzed using the GLIMMIX procedures of SAS. In Exp. 1, DMI linearly increased ($P=0.02$) when dry 0.82% S DGS was included in the diet, but DMI was not affected when wet 0.82% S DGS was fed. When wet or dry 1.16% S DGS was added, DMI decreased linearly ($P<0.01$) or quadratically ($P<0.01$), respectively. Gain decreased linearly ($P=0.02$) as wet DGS that was 1.16% S increased in the diet. A quadratic response ($P<0.05$) was observed for G:F when wet DGS increased in the diet, with the greatest values at 20 and 30%, regardless of sulfur content. In Exp. 2, no interaction between [S] and dry or wet DGS ($P>0.16$) was observed for DMI, DMD, or H₂S. Greater ($P<0.01$) DMI was observed for steers fed dry vs. wet DGS (23.4 vs. 20.1 lb/d), and low vs. high [S] (22.9 vs. 20.5 lb/d) DGS. Greater ($P=0.06$) H₂S was observed for wet DGS (9.33 vs. 2.87 $\mu\text{mol/L}$ gas) compared to dry DGS. High [S] DGS tended ($P=0.13$) to increase H₂S compared to low S DGS. When 32% inclusion of high S wet DGS was compared to 40% inclusion of low S wet DGS, DMI was greater ($P<0.01$) for low S wet DGS (22.1 vs 19.4 lb/d), while H₂S was not different, although numerically lower (1.87 vs 7.09 $\mu\text{mol/L}$ gas). High sulfur DGS reduces DMI, ADG and impacts H₂S production, but depends on whether fed wet or dry with wet DGS being more prone to conversion of S to H₂S in the rumen.

Crude glycerin in finishing cattle diets C. J. Schneider, G. L. Parsons, K. A. Miller, L. K. Thompson, and J. S. Drouillard, Kansas State University, Manhattan

Two studies were conducted to evaluate the effects of crude glycerin (GLY) in finishing cattle diets. A metabolism study was conducted to determine effects of GLY on apparent total tract digestibility, and to measure diurnal changes in ruminal pH and concentrations of ammonia and volatile fatty acids. Nine crossbred steers (1375 lb) fitted with ruminal cannulae were used in a replicated Latin square design with 3 treatments. Treatments consisted of steam-flaked corn diets containing 0, 2, and 4% crude glycerin. Steers were allowed *ad libitum* access to finishing diets fed once daily. Periods consisted of a 10-day acclimation phase followed by a 3-day collection phase. Chromic oxide (10 g) was used as a marker to estimate total fecal output, and was dosed intraruminally prior to feeding beginning on day 7. Dry matter intakes were similar among treatments ($P > 0.98$). Fecal outputs were 1.21, 1.27, and 1.28 kg/d when glycerin was fed at 0, 2, and 4%, respectively ($P < 0.74$). Apparent total tract digestibilities of NDF were 60.4, 51.8, and 48.1 for cattle fed 0, 2, and 4% GLY, respectively (Lin, $P < 0.13$). No treatment \times time interactions were observed for ruminal parameters ($P > 0.27$). Feeding GLY linearly increased mean ruminal pH from 5.61 in control steers to 5.67 and 5.73 when GLY was added at 2 and 4%, respectively ($P = 0.05$). Concentrations of acetate, butyrate, and valerate decreased as GLY increased in the diet (Lin, $P < 0.05$). When fed at low levels in finishing diets, GLY appears to alter digestion of fiber, but has little impact on other components of the diet. The second study was conducted to evaluate finishing performance and carcass traits of heifers ($n = 295$; 941 lb) fed low levels of GLY (0, 0.5, or 2% of diet DM) in flaked corn finishing diets, or diets that combined flaked corn with 25% soybean hulls and 15% wet distiller's grains (0 or 2% GLY). Diets contained steam-flaked corn with 3% alfalfa hay and 6% corn silage, and provided 300 mg Rumensin, 90 mg Tylan, and 0.5 mg MGA per heifer daily. Cattle were stratified by body weight and randomly assigned (within strata) to 40 pens containing 7 to 8 cattle per pen. Cattle were fed *ad libitum* once daily for 89 days. Zilmax was added to the diet for 20 days, followed by a 3-day withdrawal immediately before slaughter. Data were analyzed using the mixed procedure of

SAS with weight block as the random effect, treatment as the fixed effect, and pen as the experimental unit. Increasing GLY levels in grain-based diets tended to decrease feed intake ($P=0.07$). Feeding byproducts increased feed intake when compared to diets without byproducts ($P < 0.01$). ADG was not affected by diet ($P > 0.30$; 2.95, 2.7, and 2.56 lb/day for cattle fed 0, 0.5, and 2% GLY without byproducts, respectively, and 2.56 and 2.87 lb/d for heifers fed diets with byproducts containing 0 or 2% GLY). Carcass adjusted G:F was poorer when byproducts were fed ($P < 0.01$), but was unaffected by GLY concentration ($P > 0.2$). Adding byproducts or GLY to diets without byproducts decreased the percentage of carcasses that graded USDA Choice or higher ($P < 0.05$), and increased the percentage of carcasses that graded USDA Select ($P < 0.05$). In contrast to previous studies, feeding low levels of GLY failed to yield improvements in feedlot performance, and addition to finishing diets may decrease digestion of fiber.

Effect of feeding frequency on feedlot steer performance *J. S. Schutz, E. D. Sharman, N. E. Davis, J. J. Wagner, and T. E. Engle, Colorado State University, Fort Collins*

The ability to determine the effects of feeding methods on dry matter intake could give producers the ability to establish how many times per d steers should be fed in order to achieve maximum profitability by keeping labor, machine, and feed costs to a minimum. Therefore, the objective of this study was to determine the effects of feeding once, twice, or three times per d on overall performance and carcass characteristics of finishing feedlot steers at the Southeastern Colorado Research Center. Two hundred seventy crossbred yearling steers (318 ± 7.05 kg initial BW) were utilized in this experiment. Steers were utilized in a receiving experiment prior to finishing, so steers were re-randomized for this trial. Steers were stratified by BW within the previous receiving experiment and randomly assigned to pens ($n = 9$ steers per pen). Pens were then randomly assigned to one of three treatment groups: (1) once daily feeding; (2) twice daily feeding; or (3) three times per d feeding. Steers were fed a standard high concentrate steamed flaked corn finishing ration for 170 d. Pen served as the experimental unit and cattle were harvested at a constant DOF. Steers were individually weighed at the initiation and termination of the trial on two consecutive d. Pen or individual weights were obtained approximately every 42 d. Average daily gain was similar for steers fed once or twice per d (1.63 and 1.64 ± 0.02 kg/d, respectively). However, ADG ($P < 0.03$) and ADFI ($P < 0.04$) were greater in steers fed three times a d as compared with once or twice daily feeding. Feed efficiency (G:F) was similar for all 3 treatment groups (0.18 ± 0.01). Steers fed three times per d had heavier ($P < 0.01$) HCW than steers fed once or twice per d. There was a linear decrease ($P < 0.03$) in the number of noncondemned livers as the number of times fed per d increased (85.54, 82.14, and 69.88% for treatments 1-3, respectively). No differences were detected between the treatment groups for USDA quality or yield grade. These data indicate similar performance when feeding once or twice a d; however, feeding three times a d increased ADG, ADFI, HCW, and condemned livers relative to feeding steers once or twice a day.

Effect of forage energy intake and supplementation on marbling deposition in growing beef cattle *E. D. Sharman¹, P. A. Lancaster¹, G. G. Hilton¹, C. R. Krehbiel¹, W. A. Phillips², and G. W. Horn¹, ¹Oklahoma Agricultural Experiment Station, Stillwater, ²USDA-ARS, Grazinglands Research Laboratory, El Reno*

Glucose is the primary carbon source for fatty acid synthesis in intramuscular fat, whereas, acetate is primarily utilized by subcutaneous fat. Our objective was to examine the effect of forage energy intake and type of fermentation on marbling deposition by stocker cattle grazing

dormant native range (**DNR**) or winter wheat pasture (**WP**). Angus steer calves ($n = 68$; 258 ± 29 kg) were used in a completely randomized design comparing 4 winter grazing treatments: (1) control, $1.02 \text{ kg} \cdot \text{hd}^{-1} \cdot \text{d}^{-1}$ of a 40% CP supplement to meet their DIP requirement while grazing DNR; (2) control plus corn-based supplement at 1% BW while grazing DNR; (3) WP at a high stocking rate (3.2 steers/ha) to achieve a low rate of BW gain; and (4) WP at a low stocking rate (2.2 steers/ha) to achieve a high rate of BW gain. Supplements were fed individually 5 d/wk during the 138-d winter grazing phase. Following winter grazing, 3 steers per treatment were randomly selected for intermediate harvest for measurement of carcass characteristics and collection of perirenal (**PR**), subcutaneous (**SC**), and intramuscular (**IM**) adipose tissues. Total RNA was extracted from adipose tissues, and gene expression of lipogenic enzymes determined using qRT-PCR. The remaining wheat pasture steers were transitioned to the finishing phase, while the DNR treatments remained on summer native range for 115 d prior to finishing. Steers were fed to a predicted backfat end point of 1.27 cm. During winter grazing, ADG was 0.19, 0.52, 0.68, and $1.37 \pm 0.03 \text{ kg} \cdot \text{d}^{-1}$ ($P < 0.01$) for treatments 1-4, respectively. Steers that grazed WP had heavier HCW and larger REA ($P < 0.01$) at intermediate harvest than steers supplemented on DNR. Backfat was 0.03, 0.10, 0.17, and 0.85 ± 0.07 cm ($P < 0.01$) and marbling scores were 180, 217, 280, and 340 ± 11.67 ($P < 0.01$) for treatments 1-4, respectively. After finishing, treatment 3 had thicker backfat and smaller LM area resulting in higher YG ($P < 0.02$) compared with the other treatments. There were no differences in final marbling scores (423, 428, 427, and 425 ± 14.92 ; $P = 0.99$, respectively). There were no treatment by adipose tissue depot interactions for any genes evaluated indicating that diet did not increase glucose metabolism or triglyceride synthesis in one depot compared with another. mRNA expression of genes involved in triglyceride synthesis (glycerol-3-phosphate dehydrogenase, fatty acid synthase, and diacylglycerol acyltransferase 2) and glucose utilization [ATP citrate lyase (**ACLYS**) and malic enzyme (**ME**)] were greater ($P < 0.05$) for steers grazing WP compared with DNR. ACLYS mRNA expression was greater in SC and PR compared with IM, and ME mRNA expression was greater in PR compared with SC and IM. These data indicate that increased forage energy intake and proportion of propionate increase marbling and rib fat deposition at the end of winter grazing; however, diet did not preferentially improve glucose metabolism or triglyceride synthesis in intramuscular adipose tissue. Furthermore, final marbling scores were similar when cattle were fed to a common fat end point.

Effects of grain processing and supplementation with exogenous amylase on nutrient digestibility in feedlot diets *D. R. Smith, N. DiLorenzo, M. J. Quinn, M. L. May, C. H. Ponce, and M. L. Galyean, Texas Tech University, Lubbock*

Starch is the most common energy source in diets fed to ruminants under intensive production systems, typically comprising 50% or more of the dietary DM fed to finishing beef cattle. Given the limitations starch digestion in the small intestine and the low energetic efficiency of starch fermentation in the large intestine, maximizing ruminal starch digestibility, while concurrently minimizing digestive upsets is critical for feedlot production. Grain processing is a common strategy to increase ruminal digestion of starch. Addition of exogenous amylase has been proposed for improving total tract starch digestion, but research on the effects of exogenous amylase in feedlot diets is limited. Thirty-two Angus and Angus-crossbred steers were used in a generalized randomized block design with a 2 x 2 factorial arrangement of treatments. Factors included grain processing method (dry-rolled corn [DRC] or steam-flaked corn [SFC]) without

or with exogenous amylase supplemented at 600 KNU-s/kg of dietary DM (272 KNU-s/lb of dietary DM). Steers were adapted to a 90% concentrate finishing diet for 28 d, during which the DRC and SFC treatments were applied. Amylase was supplemented when steers reached ad libitum intake (d 1 of experimental period). Experimental diets were fed for 42 d, and 0.25% (DM basis) of Cr₂O₃ was included in the diet as an indigestible marker for measurement of nutrient digestibility from d 39 to 42. Supplementation with amylase did not affect nutrient digestibility ($P \geq 0.21$) or DMI, ADG, and feed:gain ratio (F:G) for the 42-d period ($P \geq 0.22$). The SFC diets had 28% less total tract digestibility of NDF ($P < 0.001$) and 39% less total tract digestibility of ADF ($P < 0.001$) than DRC-based diets. Total tract starch digestibility was 6% greater ($P < 0.001$) in SFC-based diets. Steers fed the SFC-based diets ate less DM ($P = 0.04$) and had improved F:G ($P < 0.001$) compared with steers fed the DRC-based diets, but grain processing did not affect ADG ($P = 0.78$). Overall, results suggest that supplementation with exogenous amylase (600 KNU-s/kg dietary DM) did not affect nutrient digestibility or performance by feedlot steers. Decreased total tract digestibility of NDF and ADF was observed when SFC was compared with DRC; however, total tract starch digestibility was greater for SFC than for DRC.

Intake control agents for self-fed distillers' grains *J. D. Sugg, T. A. Wickersham, W.E. Pinchak, S.A. Clement and J. E. Sawyer, Texas A&M University, College Station*

Fifty-nine weanling heifers (initial BW 191 ± 53.1 kg) received one of 12 intake control agents for self-fed dried distillers' grains (DDG). Agents consisted of DDG only (CON) or control plus salt (10% SA), urea (1% UR), limestone (1.68% LI), calcium propionate (3% CA), limestone and urea (1.68% and 1%; LI + UR) alone or in combination with monensin (MO, 187.5 mg/kg supplement). Each heifer had access to supplement and chopped hay. Baseline DDG intake was recorded for 4 d. Treatments were applied during three 14-d periods, with supplement intake recorded daily. After each 14-d period, limiter inclusion (other than MO) was doubled. Period and rate were confounded to minimize initial aversion. Due to period by treatment interactions, data were analyzed within period. Supplement intake vs. time and variance within period were used to evaluate intake stability. Supplement intake during baseline period was constant (slope = zero) among treatments ($P > 0.97$). Intake of DDG for CON was 3.52, 4.43, 5.50, and 5.18 kg for the baseline and periods 1, 2, and 3, respectively. At lowest rates, DDG intake differed among treatments ($P = 0.02$); heifers fed CA consumed the most DDG (4.74 ± 0.30 kg/d), those fed SA + MO consumed the least (2.2 ± 0.10 kg/d). Change in DDG intake over time differed among treatments ($P < 0.01$). Treatments SA, LI, LI + MO, CA, CA + MO, LI + UR, LI + UR + MO, and CON had positive slopes, i.e. intake increased over time. Standard deviation (SD) of intake was similar ($P > 0.10$) among treatments. Increasing limiters to 2X initial rate affected intake ($P < 0.01$). Animals fed LI + MO consumed the most DDG (5.74 ± 0.54 kg/d); those fed SA consumed the least (1.65 ± 0.63 kg/d). Mean intake appeared to increase in heifers fed UR, but all other groups were similar. Intake SD differed ($P < 0.02$) among treatments; the most variation was observed in MO (1.23 ± 0.19), the least was observed for SA + MO (0.52 ± 0.19). Including limiters at 4X initial rate resulted in intake differences ($P < 0.01$). Heifers fed LI consumed the most (5.39 ± 0.59 kg/d), animals fed SA + MO consumed the least supplement (0.42 ± 0.61 kg/d). Neither SD ($P > 0.62$) nor slope ($P > 0.29$) differed among treatments. Effective limiters can be identified to control DDG intake; unregulated intake may be much higher than anticipated.

Initial Heifer Body Composition Has Little Impact on Response to Zilmax L.K. Thompson, C.J. Schneider, G.L. Parsons, K.A. Miller, C.D. Reinhardt, J.S. Drouillard, Kansas State University, Manhattan

A finishing trial was conducted to determine the effects of initial body composition on changes in carcass characteristics in heifers fed Zilmax. Crossbred heifers were fed alfalfa hay free choice at arrival, and then weighed and processed 24 hours later. For 100 days the heifers were fed forage-based diets, and then stepped up over a three week period to a finishing ration. Heifers (353; initial body weight 941 lb) were blocked by initial body weight and assigned randomly, within block, to one of 48 pens so that each pen contained 7 to 8 heifers each. Cattle were fed for 67 days once daily *ad libitum* with high-concentrate diets containing 80% steam-flaked corn or 45% steam-flaked corn with 40% byproducts, along with 6% corn silage and 3% alfalfa hay. Diets also provided 300 mg Rumensin, 90 mg Tylan, and 0.5 mg MGA per animal daily. On day 68 prior to feeding Zilmax, measurements were recorded to characterize initial body composition. Cattle were individually weighed (Pre-Z BW) and longissimus muscle area (REA), rump fat thickness (RMPFT), and 12th rib fat thickness (RBFT) were measured by ultrasound. Preliminary yield grade (PYG) was calculated using RBFT. Average daily gains were calculated for the 66-day period preceding Zilmax feeding (Pre-Z ADG), and pre-Zilmax hot carcass weights (Pre-Z HCW) were estimated using REA, RBFT, and Pre-Z BW as described by Hassen et al., 1999. Zilmax was fed (8.33 g/ton DM) beginning 23 days before harvest and withdrawn for the final 3 days on feed. Heifers were weighed and transported to a commercial abattoir to collect carcass data. Carcass data collected included hot carcass weight, ribeye area, 12th rib fat thickness, yield grade (official USDA grade), kidney pelvic heart fat, quality grade, and marbling scores. Pre-Zilmax body weight, rump fat thickness, rib fat thickness, ribeye area, preliminary yield grade and Pre-Zilmax average daily gain were used as independent variables in stepwise regression models (SAS 9.1) to estimate effects on changes in rib fat thickness, carcass average daily gain, yield grade, and ribeye area. Change in 12th rib fat thickness (in) = $(0.43 \times \text{RMPFT}) - 0.08$; ($R^2 = 0.09$, $P < 0.01$). Change in carcass average daily gain (lb) = $0.007 \times \text{Pre-Z BW} - (0.18 \times \text{REA}) - 3.67$; ($R^2 = 0.13$, $P < 0.01$). Change in yield grade = $(2.21 \times \text{RMPFT}) + (0.002 \times \text{Pre-Z BW}) - (0.10 \times \text{Pre-Z ADG}) - (0.11 \times \text{REA}) - 2.16$; ($R^2 = 0.28$, $P < 0.01$). Change in ribeye area (sq. in) = $(-0.68 \times \text{REA}) - (2.06 \times \text{RMPFT}) - (2.96 \times \text{RBFT}) + (0.004 \times \text{Pre-Z BW}) + (0.26 \times \text{Pre-Z ADG}) + 6.88$; ($R^2 = 0.58$, $P < 0.01$). Estimates of initial body composition bear little relationship to changes in fatness or carcass weight manifested during the feeding of Zilmax. Increases in ribeye area were more pronounced in leaner, heavier heifers with smaller ribeye areas.

Sulfur concentration has no effect on *in vitro* activity of ruminal mixed microorganisms from steers fed a corn-based diet S. Uwituze, L. C. Hollis, and J. S. Drouillard

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We previously reported that elevated levels of dietary sulfur (0.65% S, DM) in finishing diets containing dried distiller's grains with solubles (DDGS) decreased dry matter intake and average daily gains of feedlot cattle. Furthermore high dietary sulfur concentrations yielded low ruminal concentrations of volatile fatty acids (VFA) but were associated with increased ruminal ammonia concentrations, and improved diet digestibility *in vivo*. An *in vitro* titration study was conducted to investigate effects of added sulfur on *in vitro* dry matter disappearance (IVDMD), VFA profiles, and ammonia concentrations from different substrates when fermented by mixed

ruminal organisms. The study was conducted as a randomized complete block design with a 2 × 7 factorial treatment arrangement. Factor 1 consisted of substrate (a 94:4.5:1.5 mixture of ground corn, soybean meal, and urea [GC-SBM] or a 69.4:30.6 mixture of ground corn and DDGS [GC-DDGS]), and factor 2 consisted of the level of added sulfur (0; 0.1; 0.2; 0.3; 0.4; 0.5; or 0.6% of substrate, DM basis) using sodium sulfate as the sulfur source. Basal sulfur levels for substrates were 0.18 and 0.28% of DM for GC-SBM and GC-DDGS, respectively. Isonitrogenous substrates (0.5 g DM) with varying levels of sulfur were combined with a 2:1 mixture of McDougall's buffer and clarified ruminal fluid from a single donor animal and incubated in triplicate for 24 hours at 39°C. The donor steer of ruminal fluid was fed a dry-rolled corn-based diet with 40% alfalfa hay (DM) and contained 300 mg/day Rumensin, 90 mg/day Tylan, 1000 IU/lb vitamin A, 10 IU/lb vitamin E, 0.3% salt, 10 ppm copper, 0.15 ppm cobalt, 0.5 ppm iodine, 60 ppm manganese, 60 ppm zinc, 0.25 ppm selenium, and 0.19% sulfur (DM). The study was repeated daily for 3 days. Volatile fatty acids were analyzed using gas chromatography, and ammonia concentrations were analyzed using an autoanalyzer III. Concentrations of VFA, ammonia, and IVDMD were analyzed using Proc Mixed of SAS (version 9.1) with fixed effects of substrate, sulfur, and substrate × sulfur, and random effects of day, day × substrate, day × sulfur, and day × substrate × sulfur. Significance was declared at $P \leq 0.05$. Concentrations of ammonia, total VFA, individual VFA, acetate:propionate ratio, and IVDMD were unaffected by sulfur × substrate interaction ($P > 0.05$) or by the main effect of sulfur ($P > 0.05$). Cultures with GC-DDGS had higher valerate concentrations, but yielded lower concentrations of ammonia, total VFA, propionate, and butyrate, and had lower IVDMD than GC-SBM cultures ($P < 0.05$). Substrates yielded marked differences in fermentative end products, but elevated sulfur did not alter *in vitro* fermentation of these substrates by mixed ruminal microorganisms. These data suggest that previous *in vivo* changes in diet digestibility and cattle performance associated with high dietary sulfur are likely attributable to host factors such as feed intake level.

Effects of Zilmax on blood metabolites C. L. Van Bibber, L. K. Thompson, G. L. Parsons, K. A. Miller, and J. S. Drouillard, Kansas State University, Manhattan

Effects of Zilmax (Z) on blood metabolites and carcass traits were evaluated in crossbred finishing steers (n=18) that were stratified by BW and randomly assigned, within strata (block), to control (C) or Z treatments. Cattle were fed once daily ad libitum in individual feeding pens (9 pens/treatment). Z was fed 23 d and withdrawn 3 d before harvest. Blood and BW measurements were taken on d 0, 7, 14, and 21. Metabolites were analyzed as repeated measures using Proc Mixed, with fixed effects of treatment, d, and treatment × d, and random effects of block and block × treatment. Live performance and carcass traits were analyzed with treatment as the fixed effect, and block and block × treatment as random effects. Concentrations of beta-hydroxybutyrate (BHB), glucose, and lactate were determined from whole blood, and NEFA, urea nitrogen (PUN), and long-chain fatty acids (LCFA) were analyzed for plasma. Adipose tissue samples were analyzed for LCFA profiles. Addition of Z decreased DMI by 8% ($P < 0.10$), but had no impact on live BW gain or efficiency ($P > 0.10$). Feeding Z resulted in greater HCW and LM area ($P < 0.10$), while decreasing marbling score and yield grade, but did not influence other carcass traits ($P > 0.10$). Z increased plasma concentrations of elaidic, vaccenic, and docosapentaenoic acids ($P < 0.10$), but adipose tissue concentrations of LCFA were unaffected ($P > 0.10$), suggesting no preferential oxidation of specific fatty acids. Blood metabolites for d 0

and 21 of the study are shown in the table below. The symbols † and ‡ denote effects of Z and Z × d interaction, respectively ($P < 0.10$).

Item, mM	C d0	Z d0	C d21	Z d21	SEM
Glucose‡	3.32	3.39	3.48	3.09	0.24
Lactate	2.83	2.80	2.16	1.54	0.48
NEFA	126	175	140	174	36
BHB	0.01	0.08	0.02	0.06	0.83
PUN † ‡	4.15	3.74	4.44	3.26	0.24

Bovine Respiratory Disease identification in newly received feedlot cattle using remote ruminal temperature monitoring: Performance, health, and carcass characteristics

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Comingled heifers were purchased and administered ruminal temperature monitoring devices in LA ($n = 186$, $BW = 248.7 \pm 35.7$ kg) and KY ($n = 167$, $BW = 243.9 \pm 21.4$ kg). Within purchase group, heifers were allotted to twelve pens, which were assigned to three bovine respiratory disease (BRD) management treatments with pulls based on: visual signs (CON), visual signs after metaphylactic tulathromycin treatment (MET), or visual signs and(or) elevated ruminal temperature (TEMP). Antimicrobial treatments for BRD included tulathromycin, fluoroquinolone, and ceftiofur-HCl. Bodyweights were measured at 14-d intervals for 56 d, and prior to shipment at finishing. USDA quality grade was analyzed using the GLIMMIX procedure of SAS, and all other data were analyzed using the MIXED procedure. For health data, heifer was the experimental unit, and for all other analyses, pen was the experimental unit. Fixed effects included management, and the interaction and main effects of management and number of times treated when comparing CON and TEMP heifers only. Random effects included lot, block, and for health data, pen. Heifers managed with the TEMP method were pulled 3.51 times more often ($P = 0.0001$) and treated 1.01 times more often ($P = 0.0002$) than CON and MET. Final BW of TEMP heifers was 5.3 kg greater ($P = 0.05$) than CON, and MET heifers gained 0.12 kg/d more than CON ($P = 0.01$). Intake during the receiving phase did not differ ($P \geq 0.31$) among management types; however, G:F during this time was 8.6% greater ($P = 0.03$) in MET heifers compared to CON. Among heifers not receiving metaphylactic treatment, ADG during the first 56 d was not different in TEMP heifers treated zero, one, or two times and CON heifers treated zero or one time (mean = 1.24 kg/d), with lowest gains observed in CON heifers treated two or three times (mean = 0.73 kg/d, $P < 0.0001$). Overall performance through the finishing period was not different among management methods ($P \geq 0.78$). Management did not affect ($P \geq 0.06$) carcass traits or carcass value. Greater morbidity incidence was discovered through use of ruminal temperature monitoring. Metaphylactic treatment and ruminal temperature monitoring were both effective at improving heifer performance during the receiving phase, but did not affect overall performance or carcass traits. However, ruminal temperature monitoring increased pulls and treatments compared to MET. This indicates that ruminal temperature parameters used for identifying calves affected with BRD were effective, but could benefit from additional adjustments to optimize treatment efficiency.

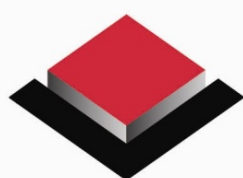
Feeding *Lactobacillus acidophilus* combined with *Propionibacterium freudenreichii* to determine performance and carcass characteristics in feedlot heifers fed with or without wet distiller's grains plus solubles B. K. Wilson¹, B. P. Holland², T. G. Nagaraja³, and C. R. Krehbiel¹, ¹Oklahoma State University, Stillwater, ²South Dakota State University, Brookings, ³Kansas State University, Manhattan

Increasing corn prices related to increased ethanol production have had a significant impact on the cost of gain for cattle producers who rely on corn-based diets, and the inclusion of wet distiller's grains plus solubles (WDGS) in feedlot diets has become a common practice in many regions of the U.S. In addition, direct-fed microbials (DFM) have been shown to improve ADG and feed efficiency, alter ruminal fermentation, and decrease fecal shedding of harmful pathogens in feedlot cattle. The objective of this experiment was to evaluate the effects of *Lactobacillus acidophilus* (LA) combined with *Propionibacterium freudenreichii* (PF) on performance and carcass characteristics in feedlot heifers fed with or without WDGS. Crossbred heifers (n = 288; initial BW = 295 ± 28 kg) were assigned to 1 of 4 treatments in a randomized complete block design with a 2 × 2 factorial arrangement of treatments. Across the feeding period, heifers fed 30% WDGS tended (P = 0.09) to have greater ADG and had greater carcass-adjusted ADG (P = 0.05) compared with heifers fed dry-rolled corn. Dry matter intake was not affected (P = 0.65) by diet, although carcass adjusted F:G tended (P = 0.08) to be improved for heifers fed WDGS. Heifers fed 30% WDGS tended (P ≤ 0.10) to have greater fat thickness at the 12th rib, lower marbling scores, and higher yield grades. The inclusion of LA combined with PF in the diet had no effect (P > 0.10) on performance or carcass merit in the present experiment. Feeding 30% WDGS to feedlot heifers improved animal performance. Similar results can be anticipated when a DFM is included in the diet.

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