THE PLAINS NUTRITION COUNCIL

2015 SPRING CONFERENCE

2014-15 OFFICERS AND EXECUTIVE COMMITTEE

TONY BRYANT, PRESIDENT
ALLEN MCDONALD, 1ST VICE PRESIDENT
CHRIS REINHARDT, 2ND VICE PRESIDENT
BRITT HICKS, PAST PRESIDENT
TED MCCOLLUM III, SECRETARY/ TREASURER

THE PLAINS NUTRITION COUNCIL
6500 AMARILLO BLVD WEST
AMARILLO, TEXAS 79106
We appreciate the continued support of our 2015-16 Plains Nutrition Council Sponsors

PLATINUM
MERCK
RAMP - SWEET BRAN

GOLD PLUS
DR. KENNETH AND CAROLINE MCDONALD ENG FOUNDATION
ZOETIS

GOLD
ALLTECH
CONESTOGA ENERGY
ELANCO
GLOBAL ANIMAL PRODUCTS
HUVEPHARMA
LALLEMAND ANIMAL NUTRITION
LHOIST
NOVA MICROBIAL TECHNOLOGIES
NUTRITION PHYSIOLOGY CORP.
WESTWAY
ZINPRO

SILVER
KEMIN AGRIFOODS
MICRONUTRIENTS
PIONEER HI-BRED INTERNATIONAL
QUALI TECH
ADM ALLIANCE NUTRITION

BRONZE
ANIMAL HEALTH INTERNATIONAL
ARM & HAMMER
CARGILL ANIMAL NUTRITION
DIAMOND V
EW NUTRITION
LESAFFRE FEED ADDITIVES
LIFE PRODUCTS
MICRO
NOVUS INTERNATIONAL
PHIBROANIMAL HEALTH
PURINA ANIMAL NUTRITION
QUALITY DISTILLERS GRAINS
SERVI-TECH LABS
TATE & LYLE
The 2015 Plains Nutrition Council Spring Conference

Thursday, April 16

1:00 PM  Welcome and Introduction - Dr. Tony Bryant, JBS Five Rivers Cattle Feeding, Greeley, CO

1:15  Sustainability and the Beef Industry - Mr. Cameron Bruett, JBS, Greeley, CO

2:10  The Global and Domestic Economies and Ag Sectors - Influences on the US. - Mr. Dan Basse, AgResource Co., Chicago, IL

3:05  Break and Graduate Research Poster Presentations

3:35  Research Update –

4:05  Ethanol co-products - Changes in the last 15 years, changes to come - Dr. Fed Owens, Pioneer Hi-Bred International, Johnston, IA

5:00  View Research Poster Presentations and visit with presenters

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

Friday, April 17

8:00 AM  PNC Business Meeting

8:15  Research Update – Nutritional Management of Confined Cows, University of Nebraska, Scotts Bluff, Dr. Karla Jenkins

8:45  Managing Cows in Confinement - Theory into Practice  Mr. Roberto Eizmendi, Cactus Feeders, Inc., Syracuse, KS

9:15  Dr. Kenneth and Caroline Eng Foundation Graduate Student Recognition - Dr. Kenneth Eng, San Antonio, TX, and Dr. Allen McDonald, Nutrition Physiology, Bushland, TX

9:30  Break and Graduate Research Poster Presentations

10:00  Designing, Analyzing, and Interpreting Feedlot Research - Coordinated by Dr. Robbi Pritchard, South Dakota State University, Brookings

- Experimental design and statistical considerations for feedlot studies- Dr. Mike Ballou, Texas Tech University, Lubbock

- Did I just do feedlot research or was it simply a feedlot show and tell? Dr. Robbi Pritchard, South Dakota State University, Brookings

- Panel Discussion - Relative Roles of Commercial/Private Research and University Research - Dr. Mike Galvean, Texas Tech University, Dr. Spencer Swingle, Cactus Feeders, Inc., Dr. John Hutcheson, Merck Animal Health, and Dr. Steve Armbruster, Armbruster Consulting

12:00PM  Adjourn
Sponsor

2015 Plains Nutrition Council
Pre-conference Symposium
and
Wednesday evening reception

MERCK
Sponsor:
2015 Plains Nutrition Council Spring Conference
Thursday Evening Reception

RAMP
Right to the bunk.

SWEETBRAN
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Invited Presentations</th>
<th>Page</th>
</tr>
</thead>
</table>
| Research Update - Kansas State University/Beef Cattle Institute  
  *Chris Reinhardt,*  
  Kansas State University                                                                 | 19   |
| Ethanol co-products: Changes in the last 15 years, Changes to come  
  *Alfredo DiCostanzo, Alex Hohertz, and Fred Owens,*  
  University of Minnesota- St. Paul and DuPont Pioneer                                | 39   |
| Limit Feeding Production Cows in An Intensively Managed System  
  *Karla H. Jenkins, Jason Warner, Rick Rasby, and Terry Klopfenstein,*  
  University of Nebraska Panhandle Research and Extension Center and University of  
  Nebraska-Lincoln                                                                     | 58   |
| Managing Cows in Confinement - Theory into Practice  
  *Roberto E. Eizmendi,* Cactus Feeders Cow-Calf Division                            | 70   |
| Designing, Analyzing, and Interpreting Feedlot Research --  
  *Did I just do research or was it simply a feedlot show and tell?*  
  *R.H. Pritchard,* South Dakota State University                                     | 80   |
| Experimental Design and Statistical Considerations for Feedlot Studies  
  *Michael A. Ballou, Michael L. Galyean, and Matthew D. Sellers,* Texas Tech University | 89   |

<table>
<thead>
<tr>
<th>Graduate Student Research Poster Presentations</th>
<th></th>
</tr>
</thead>
</table>
| Effects of monensin and dietary energy intake on maintenance requirements in beef  
  *C. J. Boardman, T. A. Wickersham, L. A. Trubenbach and J. E. Sawyer,* Texas  
  A&M University, College Station                                                   | 106  |
| Carcass gain, efficiency, deposition changes, and profitability in steers at extended  
  days on feed  
  *R. G. Bondurant¹, J. C. MacDonald¹, G. E. Erickson¹, K. Brooks², R. N. Funston³,  
  and K. Bruns³,*  
  ¹Department of Animal Sciences and ²Department of Agricultural Economics, University of  
  Nebraska, Lincoln, ³West Central Research and Extension Center, University of  
  Nebraska, North Platte                                                            | 106  |
| Effects of shade and feeding zilpaterol hydrochloride to finishing steers on  
  performance, carcass quality, mobility, and body temperature  
  *B.M. Boyd¹, S.D. Shackelford², K.E. Hales², T.M. Brown-Brandt², M.L. Bremer¹,  
  M.L. Spangler¹, and G.E. Erickson¹,*  
  ¹University of Nebraska-Lincoln, ²US Meat Animal Research Center, Clay  
  Center, NE                                                                         | 107  |
Graduate Student Research Presentation
Recognition

The
Dr. Kenneth and Caroline McDonald
Eng
Foundation
**TABLE OF CONTENTS (cont'd)**

<table>
<thead>
<tr>
<th>Graduate Student Research Presentations</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modifying different components of distillers grains and the impact on feedlot performance <em>Z. E. Carlson, C. J. Bittner, D. B. Burken, G. E. Erickson, and J. C. MacDonald, University of Nebraska, Lincoln</em></td>
<td>108</td>
</tr>
<tr>
<td>Impact of feeding distillers grains or isolated components in distillers grains on feedlot performance and carcass traits <em>Brianna B Conroy¹, Jacob A Hansen¹, Galen E. Erickson² and Matt K Luebbe¹, ¹University of Nebraska, Scottsbluff, ²University of Nebraska, Lincoln</em></td>
<td>109</td>
</tr>
<tr>
<td>Effects of rotating antibiotic and ionophore feed additives on enteric methane and volatile fatty acid production of steers consuming a high forage diet <em>W. L. Crossland¹, L. O. Tedeschi¹, T. R. Callaway², M. Miller¹, W. B. Smith¹ and M. Cravey³, ¹Texas A&amp;M University, College Station, ²USDA-ARS, College Station, ³Huvepharma Inc., Amarillo, TX</em></td>
<td>109</td>
</tr>
<tr>
<td>Effect of condensed tannin extract supplementation on beef cattle performance and nitrogen balance II: Finishing phase <em>P. J. Ebert¹, A. L. Shreck², J. S. Jennings³, N. A. Cole¹, and E. A. Bailey¹, ¹West Texas A&amp;M University, Canyon, ²USDA-Agricultural Research Service, Bushland, TX, ³Texas A&amp;M AgriLife Research, Amarillo</em></td>
<td>110</td>
</tr>
<tr>
<td>Effect of high stress and low stress cattle handling on selected blood chemistry parameters in finishing steers <em>D.A. Frese¹, C.D. Reinhardt², J.P. Hutcheson³, S.J. Bartle⁴, D.N. Rethorst⁴, B.E. Deppenbusch⁵, M.E. Corrigan¹, and D.U. Thomson¹, ¹College of Veterinary Medicine, Kansas State University, Manhattan, ²College of Agriculture, Kansas State University, Manhattan, ³Merck Animal Health Amarillo, ⁴Beef Cattle Institute, Kansas State University, Manhattan, ⁵Innovative Livestock Services, Inc., Great Bend, KS</em></td>
<td>111</td>
</tr>
<tr>
<td>Effects of bambermycin or monensin on health and performance of receiving cattle <em>W. L. Galyen¹, T. Hess², D. S. Hubble², M. S. Gadberry², E. B. Kegley¹, M. Cravey⁴, J. G. Powell¹, E. A. Backes¹, L. R. Meyer¹, and P.A. Beck⁵, ¹University of Arkansas, Fayetteville, ²University of Arkansas LFRS, Batesville, ³University of Arkansas Cooperative Extension Service, Little Rock, ⁴Huvepharma, Inc., Amarillo, TX, ⁵University of Arkansas SWREC, Hope</em></td>
<td>111</td>
</tr>
<tr>
<td>The effects of high-stress verses low-stress cattle handling at the time of shipping to slaughter on physiological responses in cattle fed ractopamine hydrochloride <em>J.A. Hagenmaier, S.J. Bartle, C.D. Reinhardt, D.U. Thomson, M.J. Ritter, G.J. Vogel, C.A. Guthrie, R. Starkey, M.G. Siemens, Kansas State University, Manhattan</em></td>
<td>112</td>
</tr>
<tr>
<td>Comparison of heat stress mitigation techniques and production systems used in feedlot cattle <em>C.L. Haviland, B. C. Bernhard, C.L. Maxwell, B. K. Wilson, D. L. Step, C. R. Krehbiel, and C. J. Richards, Oklahoma State University, Stillwater</em></td>
<td>113</td>
</tr>
</tbody>
</table>
THE PROVEN PROBIOTIC™
TABLE OF CONTENTS (cont'd)

<table>
<thead>
<tr>
<th>Graduate Student Research Presentations</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The effect of delayed corn silage harvest on corn silage yield and finishing performance in yearling steers</td>
<td>114</td>
</tr>
<tr>
<td>F. H. Hilscher¹, D.B. Burken¹, C.J. Bittner and, G. E. Erickson, University of Nebraska, Lincoln</td>
<td></td>
</tr>
<tr>
<td>Determining energy value of oil-extracted corn distillers grains with solubles in feedlot diets</td>
<td>114</td>
</tr>
<tr>
<td>A. Hohertz¹, C. Zellmer¹, F. Owens² and A. DiCostanzo¹, University of Minnesota, St. Paul, Dupont</td>
<td></td>
</tr>
<tr>
<td>Pioneer Nutrition, Johnston, IA</td>
<td></td>
</tr>
<tr>
<td>Effect of growth implant regimen on health, performance, and immunity of high risk, newly received stocker</td>
<td>115</td>
</tr>
<tr>
<td>cattle H. D. Hughes¹, P. A. Beck², D. S. Hubbell³, M. S. Gadberry⁴, E. B. Kegley⁵, J. G. Powell⁶,</td>
<td></td>
</tr>
<tr>
<td>F. L. Prouty⁷, and J. T. Richeson¹, West Texas A&amp;M University, Canyon, University of Arkansas, Fayetteville,</td>
<td></td>
</tr>
<tr>
<td>Batesville, University of Arkansas, Little Rock, Zoetis, Louisburg, KS</td>
<td></td>
</tr>
<tr>
<td>Effects of \textit{Saccharomyces cerevisiae boulardii} supplementation during the receiving period on</td>
<td>116</td>
</tr>
<tr>
<td>growth efficiency, and behavioral and health responses in newly weaned beef heifers M.L. Jenks¹, G.E.</td>
<td></td>
</tr>
<tr>
<td>Carstens¹, A.G. Cupples¹, J.E. Sawyer¹, W.E. Pinchak², K.S. Barling³, E. Chevaux³, Texas A&amp;M University,</td>
<td></td>
</tr>
<tr>
<td>College Station, Lallemand Animal Nutrition, Milwaukee, WI</td>
<td></td>
</tr>
<tr>
<td>Evaluation of a feed additive mixture of direct fed microbials, prebiotics, and enzymes on \textit{in vitro}</td>
<td>116</td>
</tr>
<tr>
<td>true digestibility of feeds H. Larson, N.M. Kenney-Rambo and A. DiCostanzo, University of Minnesota,</td>
<td></td>
</tr>
<tr>
<td>St. Paul</td>
<td></td>
</tr>
<tr>
<td>Current feedlot cattle health and well-being program recommendations in the United States and Canada:</td>
<td>117</td>
</tr>
<tr>
<td>The 2014 Feedlot Veterinary Consultant Survey T. L. Lee, S.P. Terrell, M. D. Aplex, and D. U. Thomson,</td>
<td></td>
</tr>
<tr>
<td>Kansas State University, Manhattan</td>
<td></td>
</tr>
<tr>
<td>Ionophore and non-ionophore growth promoters on no roughage finishing diet</td>
<td>118</td>
</tr>
<tr>
<td>Barbara J M Lemos¹, Flavio G F Castro², Bruno P C Mendonça², Carlos E Dambros¹, Dheividy B Fernandes²,</td>
<td></td>
</tr>
<tr>
<td>Antenor L Braga Neto², Victor R M Couto¹, Julioan J R Fernandes¹, Universidade Federal de Goiás, Brazil,</td>
<td></td>
</tr>
<tr>
<td>AgroCria, Brazil</td>
<td></td>
</tr>
<tr>
<td>Influence of wet distillers grains produced from a novel cellulosic ethanol process utilizing corn</td>
<td>118</td>
</tr>
<tr>
<td>University, Ames</td>
<td></td>
</tr>
<tr>
<td>Effect of inclusion of post-extraction algal residue on nutrient utilization, carcass</td>
<td>119</td>
</tr>
<tr>
<td>performance, and beef flavor in finishing steers J.C. Morrill, J.E. Sawyer, J.R. Baber, R.K. Smith,</td>
<td></td>
</tr>
<tr>
<td>R.K. Miller, and T.A. Wickersham, Texas A&amp;M University, College Station</td>
<td></td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS (cont'd)

<table>
<thead>
<tr>
<th>Graduate Student Research Presentations</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding alkaline-treated corn stover to lightweight steers during the back-grounding phase K. Nenn, E. Mousel, G.A. Bridges, S. Bird, and A. DiCostanzo, University of Minnesota, St. Paul</td>
<td>120</td>
</tr>
<tr>
<td>Effects of vaccination program on antibody response, health, and performance of receiving calves E.R. Oosthuysen¹, M.E. Hubbert, J.R. Graves, A.K. Ashley, and C.A. Løest, ¹New Mexico State University, Las Cruces, ²Clayton Livestock Research Center, New Mexico State University, Clayton</td>
<td>120</td>
</tr>
<tr>
<td>Behavioral evaluation when using wet corn gluten feed or wet distillers grains plus solubles to adapt cattle to finishing diets L. Ovinge, J.O. Sarturi, G. E. Erickson, and T. J. Klopfenstein, ¹Texas Tech University, Lubbock, ²University of Nebraska, Lincoln</td>
<td>122</td>
</tr>
<tr>
<td>Evaluation of glycerol inclusion in receiving diets of feeder calves E. M. Rife, A. R. Taylor, and R. H. Pritchard, South Dakota State University, Brookings</td>
<td>123</td>
</tr>
<tr>
<td>Effect of injectable trace mineral administration on health, performance and vaccine response of newly received beef cattle S. L. Roberts, N. D. May, C. L. Brauer, W. W. Gentry, C. P. Weiss, J. S. Jennings, and J. T. Richeson, ¹West Texas A&amp;M University, Canyon, ²Texas A&amp;M AgriLife Research, Amarillo</td>
<td>124</td>
</tr>
<tr>
<td>Effect of corn silage bacterial inoculation on feedlot performance with or without the addition of yeast product C. A. Row, C. J. Bittner, J. L. Harding, D. B. Burken, J. C. MacDonald, T. J. Klopfenstein, A.A. Aguilar, R. Schmidt, G. E. Erickson, University of Nebraska, Lincoln</td>
<td>125</td>
</tr>
<tr>
<td>Influence of feed efficiency ranking on diet digestibility and performance of beef steers J. R. Russell, N. O. Minton, W. J. Sexten, M. S. Kerley, and S. L. Hansen, ¹Iowa State University, Ames, ²University of Missouri, Columbia</td>
<td>125</td>
</tr>
<tr>
<td>TABLE OF CONTENTS (cont'd)</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Graduate Student Research Presentations</strong></td>
<td><strong>Page</strong></td>
</tr>
<tr>
<td>Effect of zilpaterol hydrochloride on carcass characteristics of beef steers fed at maintenance or <em>ad libitum</em> intake</td>
<td>A.N. Schmitz¹, L.J. Walter¹, W.T. Nichols², J.P. Hutcheson², and T.E. Lawrence¹, ¹West Texas A&amp;M University, Canyon, ²Merck Animal Health, Summit, NJ</td>
</tr>
<tr>
<td>The effect of dry-rolled corn particle size on feed efficiency in feedlot finishing diets containing wet distiller’s grains</td>
<td>E. F. Schwandt¹, C. D. Reinhardt¹, D. U. Thomson², S. J. Bartle², T. E. Engle³, and J. J. Wagner³, ¹Kansas State University, Manhattan, ²College of Veterinary Medicine, Kansas State University, Manhattan, ³Colorado State University, Fort Collins</td>
</tr>
<tr>
<td>Effects of level of DDG supplemented on pasture to performance in feedlot and carcass traits</td>
<td>W.B. Smith¹, T.J. Machado², L.O. Tedeschi³, J.P. Banta¹, J.L. Foster⁵, K.C. McCuistion², C.R. Long¹ and F.M. Rouquette, Jr.¹, ¹Texas A&amp;M AgriLife Research, Overton, ²Texas A&amp;M University - Kingsville, Kingsville, ³Texas A&amp;M University, College Station, ⁴Texas A&amp;M AgriLife Extension Service, Overton, ⁵Texas A&amp;M AgriLife Research, Beeville, ⁶Department of Animal Science, Texas A&amp;M AgriLife Research, Overton</td>
</tr>
<tr>
<td>Alternative nutritional management strategies affect finishing residual feed intake, lung mass and carcass marbling score of finished steers</td>
<td>J. K. Smith¹, H. S. Cassell¹, D. D. Harmon¹, M. D. Hanigan², S. W. El-Kadi¹, S. E. Johnson¹, S. P. Greiner¹, M. A. McCann¹, Virginia Tech, Blacksburg</td>
</tr>
<tr>
<td>Evaluation of chromium propionate to feedlot steers at various physiological states</td>
<td>Z. K. Smith, A. R. Taylor, and R. H. Pritchard, South Dakota State University, Brookings</td>
</tr>
<tr>
<td>A comparison of performance, carcass characteristics and meat quality from intact male beef cattle to castrated male beef cattle administered growth promotion technology</td>
<td>M.E. Stephens¹, S.J. Bartle¹, D.N. Rethorst¹, C.D. Reinhardt¹, M.G. Siemens², and D.U. Thomson¹, ¹Kansas State University, Manhattan, ²Cargill Meat Solutions, Wichita, KS</td>
</tr>
<tr>
<td>Effects of increased inclusion of algae meal on finishing steer performance and carcass characteristics</td>
<td>Rebecca S Stokes, Daniel D. Loy, and Stephanie L. Hansen, Iowa State University, Ames</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (cont'd)

<table>
<thead>
<tr>
<th>Graduate Student Research Presentations</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of transportation and commingling on calf health and performance during a forty-two-day receiving period</td>
<td>131</td>
</tr>
<tr>
<td>L. A. Trubenbach, T. A. Wickersham, and J. E. Sawyer, Texas A&amp;M University, College Station</td>
<td></td>
</tr>
<tr>
<td>The effect of energy intake level and zilpaterol hydrochloride supplementation on empty body composition and energetics of beef steers</td>
<td>132</td>
</tr>
<tr>
<td>L. J. Walter¹, A. N. Schmitz¹, W. T. Nichols², J. P. Hutcheson², and T. E. Lawrence¹, ¹West Texas A&amp;M University, Canyon, ² Merck Animal Health, Summit, NJ</td>
<td></td>
</tr>
<tr>
<td>Weaning strategies for beef cows fed in intensive management (confinement): Effects of calf age on cow-calf performance and feed utilization by cow-calf pair</td>
<td>133</td>
</tr>
<tr>
<td>J. M. Warner¹, K. H. Jenkins², R. J. Rasby¹, M. K. Luebbe², G. E. Erickson¹, and T. J. Klopfenstein¹, ¹University of Nebraska, Lincoln, ²Panhandle Research and Extension Center, University of Nebraska, Scottsbluff</td>
<td></td>
</tr>
</tbody>
</table>
Research Update:
Kansas State University

Kansas State University
Beef Cattle Institute Research Update
Plains Nutrition Council
April, 2015

Fatigued Cattle Syndrome (Part I)
Daniel A. Frese, DVM, Dan Thomson, Chris Reinhardt, Steve Bartle, David Rethorst, John Hutcheson, Wade Nichols, Brandon Depenbusch, and Mark Corrigan

Introduction
• The issue in the Northwest
  – More questions than answers
• Fatigued Pig Syndrome (FPS)
  – Finished, heavy muscled swine
  – Exposed to high-stress, aggressive handling
  – Transport
  – Reluctant to move, downers
  – ↑Lactate, ↑Creatine Kinase, ↑Glucose

Acknowledgements
• The issue in the Northwest – More questions than answers
• Fatigued Pig Syndrome (FPS)
  – Finished, heavy muscled swine
  – Exposed to high-stress, aggressive handling
  – Transport
  – Reluctant to move, downers
  – ↑Lactate, ↑Creatine Kinase, ↑Glucose

Objective
• Aggressive vs. low-stress handling
• Physiological response, serum chemistry, & clinical signs
• End of the feeding period
• NOT fed a beta agonist.

Materials and Methods
• 5 commercial pens; Central Kansas; August
• 8 black-hided steers selected per pen
  – n=40
  – 4 / treatment per pen
• Blocked by backfat
  – Ultrasound
  – Two blocks

Materials and Methods
• 5 commercial pens; Central Kansas; August
• 8 black-hided steers selected per pen
  – n=40
  – 4 / treatment per pen
• Blocked by backfat
  – Ultrasound
  – Two blocks
Materials and Methods

• Animals handled around ~400 meter course
  – 4 laps
• Walk vs. Constant trot
  – 4-wheelers and hot shot as needed
• Sample collections
  – Baseline
  – 800 m
  – 1,600 m
  – 1 hour rest
  – 2 hours rest

Exercise-Stop Criteria

• Extreme reluctance to move
• Open-mouthed breathing
• Stridor (raspy breathing)
• Agonistic behavior
• Lameness
• Heart rate > 170 bpm
• Respiratory rate > 120 bpm
• Rectal temperature > 108°F

Respiration Rate

Heart Rate

Rectal Temperature Values

Plasma Lactate

Similar to downer pigs
2 steers = 38.7!
Walked cattle never raise above baseline!
Fatigued Cattle Syndrome (Part II)
Jacob Hagenmeier, DU Thomson, CD Reinhardt, SJ Bartle, D Rethorst, and D Frese
Summer 2014

Acknowledgements
- Elanco Animal Health
- Cargill Meat Solutions

Objective
- Aggressive vs. low-stress handling
- Immediately prior to shipping to slaughter
- Physiological response
- Fed ractopamine HCL
Research Update:
Kansas State University

Treatments
- Aggressive
  - 4 / time
  - Minimum trot; 4-wheelers
  - Electric prod used as needed
- Low-stress
  - 4 / time
  - Walk only
  - Lead rider

Materials and Methods
- August 20th and 21st
- Western Kansas
- Commercial cattle feeding facility

Materials and Methods
- 10 pens of predominantly black-hided steers
  - 400 mg/hd/day ractopamine hydrochloride
  - 8 animals selected / pen
  - BW = 1,470 ± 79 lb
  - Day of shipment
- 4 / treatment within each pen
  - Stratified by weight within pen

Materials and Methods
- 400 meter course
  - 4 laps
- Sample collections
  - Baseline
  - Post-handling
  - Abattoir
- Shipped to packing facility
  - 124 miles
  - Lairage

Heart Rate
- Baseline (n = 80)
- Post-handling (n = 80)

Respiration Rate
- Baseline (n = 80)
- Post-handling (n = 80)
Research Update: Kansas State University

Rectal Temperature

<table>
<thead>
<tr>
<th>Temperature (ºC)</th>
<th>Baseline (n = 80)</th>
<th>Post-handling (n = 80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>36.86</td>
<td>39.2</td>
</tr>
<tr>
<td>Post-handling</td>
<td>40.5</td>
<td>42.0</td>
</tr>
<tr>
<td>SEM</td>
<td>0.09</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Plasma Cortisol

<table>
<thead>
<tr>
<th>Cortisol (ng/mL)</th>
<th>Baseline</th>
<th>Post-handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>33.5</td>
<td>35.1</td>
</tr>
<tr>
<td>Post-handling</td>
<td>40.6</td>
<td>40.3</td>
</tr>
<tr>
<td>Post-transport</td>
<td>97.5</td>
<td>103.3</td>
</tr>
<tr>
<td>SEM</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Plasma Epinephrine

<table>
<thead>
<tr>
<th>Epinephrine (pg/mL)</th>
<th>Baseline</th>
<th>Post-handling</th>
<th>Post-transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>12.2</td>
<td>15.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.05</td>
<td>0.06</td>
<td>0.08</td>
</tr>
<tr>
<td>+2000% Stress</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>

Blood Glucose

<table>
<thead>
<tr>
<th>Blood Glucose (mg/dL)</th>
<th>Baseline</th>
<th>Post-handling</th>
<th>Post-transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>94.7</td>
<td>102.2</td>
<td>103.3</td>
</tr>
<tr>
<td>+2000% Stress</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>

Blood Lactate

<table>
<thead>
<tr>
<th>Blood Lactate (mmol/L)</th>
<th>Baseline</th>
<th>Post-handling</th>
<th>Post-transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>4.7</td>
<td>5.3</td>
<td>4.7</td>
</tr>
<tr>
<td>+2000% Stress</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>

Plasma Norepinephrine

<table>
<thead>
<tr>
<th>Norepinephrine (pg/mL)</th>
<th>Baseline</th>
<th>Post-handling</th>
<th>Post-transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>148.6</td>
<td>150.5</td>
<td>148.6</td>
</tr>
<tr>
<td>Smoking</td>
<td>3.435</td>
<td>2.011</td>
<td>3.435</td>
</tr>
<tr>
<td>+2000% Stress</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>

Blood Lactate

<table>
<thead>
<tr>
<th>Blood Lactate (mmol/L)</th>
<th>Baseline</th>
<th>Post-handling</th>
<th>Post-transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>4.7</td>
<td>5.3</td>
<td>4.7</td>
</tr>
<tr>
<td>+2000% Stress</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>
Research Update:
Kansas State University

**Blood pH**

- Baseline (n = 80): 7.38
- Post-handling (n = 80): 7.29
- Lowest = 7.03

**Conclusions**

- Aggressive handling → acute metabolic acidosis
- Aggressive handling
  - ↑ cortisol, epinephrine, norepinephrine
  - ↑ lactate,
  - ↑ heart rates
  - but NOT respiratory rate

**Feedlot Shades in South Central Kansas Feedlot**

Jacob Hagenmaier,
S.J. Bartle, C.D. Reinhardt, D.U. Thomson

**Acknowledgements**

- Pratt Feeders
Materials and Methods

- n = 1,395
- BW = 1,250 ± 95 lb
  - Zilpaterol HCL @ 7.6 g/ton DMB
- 7 pens (~200 hd) of black-hided steers and heifers
  - Alley sorted into 2 new pens
- Cattle randomly assigned to 1 of 2 treatments:
  - 1) Shade and 2) No Shade.
- Pen served as the experimental unit (n = 7 / trt)
Shade vs No Shade

<table>
<thead>
<tr>
<th>Shade vs No Shade</th>
<th>Shade</th>
<th>No Shade</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>caADG</td>
<td>4.26</td>
<td>4.41</td>
<td>P = 0.35</td>
</tr>
<tr>
<td>caF:G</td>
<td>5.49</td>
<td>5.48</td>
<td>P = 0.95</td>
</tr>
</tbody>
</table>

Shades vs. Carcass traits

<table>
<thead>
<tr>
<th>Traits</th>
<th>Shade</th>
<th>No shade</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCW, lb</td>
<td>890</td>
<td>885</td>
<td>68</td>
<td>0.30</td>
</tr>
<tr>
<td>DP, %</td>
<td>65.41</td>
<td>65.05</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td>Choice, %</td>
<td>72</td>
<td>67</td>
<td>8.0</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Conclusions

• Shade
  - ↓ open-mouth breathing
  - ↑ DMI
  - ↑ DP%
  - No effect on ADG, HCW
  • Relatively cool, windy summer

THI by Year

Dry-rolled corn particle size and fecal starch in Midwestern U.S. feedlots

Research Update:
Kansas State University

**Objective**
- Particle size of dry-rolled corn
- Fecal starch
- Feedlots across the corn-belt of the U.S.

**Corn Particle Size**

<table>
<thead>
<tr>
<th>Dgw (mm)</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.20</td>
<td>1.17 - 6.82</td>
</tr>
</tbody>
</table>

**Map of Survey**

**Analysis**

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Starch</td>
<td>18.9</td>
<td>7.0 - 36.6</td>
</tr>
<tr>
<td>Starch, %</td>
<td>26.8</td>
<td>0.0 - 51.0</td>
</tr>
<tr>
<td>By-Product, %</td>
<td>8.5</td>
<td>5.0 - 11.0</td>
</tr>
<tr>
<td>Roughage, %</td>
<td>15.1</td>
<td>12.0 - 19.2</td>
</tr>
<tr>
<td>CP, %</td>
<td>5.12</td>
<td>2.9 - 7.5</td>
</tr>
</tbody>
</table>

**Conclusion**

- Dgw: 4.20 (range = 1.2 – 6.8mm)
- Avg. fecal starch = 18.94 (range = 7 – 37%)
- Reduce particle size; improve total tract digestibility
  - Depends on diet, mgmt., other
Research Update:
Kansas State University

Dry-rolled corn particle size in finishing diets containing 20% wet distillers grains
Erin Schwandt

Objectives
- Dry-rolled corn
  - 4,900, 3,800, 2,400 μm
  - 20% (DMB) wet distillers grains
- Performance,
- carcass characteristics,
- and fecal starch content.

Cross-bred yearling steers
- n = 360;
- initial BW = 872 lb
- 9 pens / trt
- 10-head pens

Survey: avg = 19%; 7 – 37%

Coarse      Medium           Fine

Fecal Starch, %

Part. Size: lin, P < 0.01
DRC vs SFC, P < 0.01

DRC vs SFC (P < 0.05); †DRC particle size linear (P = 0.02)

Part. Size: lin P = 0.77; quad P = 0.79

DMI by treatment

DRC vs SFC P = 0.02
Part. Size: lin P = 0.77; quad P = 0.79
Conclusions

- Performance, Carcass traits not different
- DMI final 5 weeks:
  - linear decrease w/ ↓ DRC particle size
- Fecal starch
  - linear ↓ w/ ↓ DRC particle size
- In situ starch disappearance
  - ↑ linearly w/ ↓ particle size

Materials and Methods

- 4,287 feedlot cattle evaluated
  - 27 lots
  - Heifers and steers
  - beef breeds and Holsteins
- 1 commercial slaughter facility in SW Kansas
- Data collection on 3 separate dates during 2014

Anatomical Location

- Nine regions
Research Update:
Kansas State University

**Bruising Severity**

- Three levels of severity (radius):
  - Minor (-): ≤ 2.0”
  - Moderate (0): 2.0 – 6.0”
  - Severe (+): > 6.0”

**Results**

- 7.4% of cattle had horns
- 53.5% of carcasses had bruises
  - Average = 1.8 bruises/carcass

**Cattle Type**

<table>
<thead>
<tr>
<th>Cattle Type</th>
<th>Horn Prevalence</th>
<th>Bruising Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>6%</td>
<td>51%</td>
</tr>
<tr>
<td>Holstein</td>
<td>11%</td>
<td>70%</td>
</tr>
</tbody>
</table>

- 4,287 evaluated carcasses

**Conclusions**

- Horn prevalence:
  - no relationship to bruising
- 53.5% carcasses: ≥ 1 bruise
- 25.6% of bruises: Severe
- 62% of bruises on *Dorsal midline*
- Further research:
  - Handling practices
  - Trailer design
  - Facilities design
Research Update:
Kansas State University

Horn Growth During Feedlot Finishing Period
Elsie Suhr,
M.E. Stephens, S.J. Bartle,
D. Sjeklocha, D.U. Thomson

Materials and Methods: Animals
- 30 horned heifers
- Mixed beef breeds
  - Some Longhorn and Brahman
- 194 DOF
- Commercial feed
- Southwest Kansas

Horn Complications
- Abattoir
  - Perceived carcass bruising
  - Hide damage

Data Collection
- Collection Times
  - Upon feedlot arrival
  - At abattoir post-exsanguination
- Data Collected
  - Horn length
  - Tip-to-tip spread
  - Base circumference

Horn Growth
- No data on horn growth during the feeding period

Avg Horn Growth
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Growth total</th>
<th>Growth / month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of One Horn, in</td>
<td>2.95</td>
<td>0.46</td>
</tr>
<tr>
<td>Tip-to-Tip Length, in</td>
<td>4.50</td>
<td>0.70</td>
</tr>
<tr>
<td>Base Circumference, in</td>
<td>1.26</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Research Update:
Kansas State University

Length of One Horn: Growth

Tip-to-Tip: Growth

Conclusions
- Horn growth: avg ~0.5 in / mo
- Highly variable
  - Not related to initial horn length
- Tipping decisions on incoming cattle

Feeding Bulls vs. Steers


Materials and Methods
- 24 purebred Red and Black Angus bulls
- Age avg 16 mo
- Initial BW 1,322 ± 35 lb

Treatments
1.) Intact (BULL)
2.) Castrated (STR)
   - Implanted with E₂+TBA implant
   - Fed 300 mg/d Optaflexx the final 28 d of trial
Materials and Methods

- 6 outdoor dirt-floor pens
- 4 animals per pen
- Fed in individual Calan gate bunks

Performance

<table>
<thead>
<tr>
<th></th>
<th>Bull</th>
<th>Steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, lb</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>+33%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Bull</th>
<th>Steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>F:G</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>P = 0.07</td>
<td>P = 0.06</td>
</tr>
</tbody>
</table>

Carcass

<table>
<thead>
<tr>
<th>Item</th>
<th>BULL</th>
<th>STR</th>
<th>SEM</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCW, lb</td>
<td>964</td>
<td>944</td>
<td>23.8</td>
<td>0.40</td>
</tr>
<tr>
<td>Dress %</td>
<td>63.74</td>
<td>63.73</td>
<td>0.97</td>
<td>0.99</td>
</tr>
<tr>
<td>Back Fat, in</td>
<td>0.41</td>
<td>0.40</td>
<td>0.07</td>
<td>0.85</td>
</tr>
<tr>
<td>Quality Grade</td>
<td>Choice</td>
<td>Choice</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Yield Grade</td>
<td>2.73</td>
<td>3.08</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

Longissimus Area, in²

BULL: 15.5 in²
STEER: 14.8 in²

WBSF, kg of Force

BULL: 5.6 kg of Force
STR: 4.8 kg of Force

P = 0.10
Research Update:
Kansas State University

Conclusions

- BULLs had greater ADG and F:G
  - Technologies did not compensate for the loss of testes.
- BULLs had larger LMA,
- Equal marbling score vs. STEERs
- Slight difference between BULL vs STEER
  - WBSF
  - No difference: sensory panel

Materials & Methods

- 23 consulting veterinarians
- web-based survey system

Demographics

- 86.4% from the U.S.;
- 13.6% from Canada

Objective

- Recommendations by feedlot veterinarians,
- Compare current practices vs. 5 years ago

Receiving & Processing

- 81.8% received high risk calves
  - Range: 11 to 90% of population
- 15” / head Bunk space - high risk cattle
  - Range: 6-24” / head
- 77.3% recommended rest period for long-haul (>8 hr) cattle
  - vs. 47.8% in 2009
**Research Update:**

**Kansas State University**

---

**Receiving & Processing: Viral vaccines – High risk?**

- PI3
- BRSV
- BVD Type 2
- BVD Type 1
- IBR

---

**Castration**

---

**Receiving & Processing: Bacterial – High risk?**

- Leptospira
- Mycoplasma bovis
- Autogenous
- Histophilus
- Pasteurella
- Clostridial
- Mannheimia

---

**Pen Riding (head per cowboy)**

- Surgical
- Banding

---

**Metaphylaxis & Feed-Grade Antibiotics**

- **100%** recommended metaphylaxis for high-risk cattle
  - Only 3 recommended for low-risk cattle
- 77.3% recommended feed-grade AB in high-risk cattle
  - 45.5% recommended use in low-risk cattle

---

**Rank Factors for Predicting Morbidity & Mortality**

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle health risk</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Amount &amp; quality of labor</td>
<td>2 ↑ 4</td>
<td></td>
</tr>
<tr>
<td>Receiving nutrition</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Weather patterns</td>
<td>4 ↓ 2</td>
<td></td>
</tr>
<tr>
<td>Class of AB for metaphylaxis</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Class of AB for treatment</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Brand of vaccine</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

---
Conclusion

- Comparison vs. 2009; changes over time
  - Rest period post-arrival
  - Fewer bacterial vaccines
  - Fewer pen riders/doctors
  - Factors predicting morbidity/mortality

Final Points

- Fatigued Cattle Syndrome
  - Handling practices
  - Stacked stressors
- Bruises
  - Facilities? Trucks?
- Bulls
  - Receiving practices
  - Need more data
- Tipping always needed?

Acknowledgements

Dan Frese
Tiffany Lee
Elsie Suhr
Erin Schwandt
Jorge Simroth
Reggie Stephensen
Dr. Steve Bartle
Ethanol co-products: Changes in the last 15 years, Changes to come

Alfredo DiCostanzo, Alex Hohertz, and Fred Owens
University of Minnesota, St. Paul, MN and DuPont Pioneer, Johnston, IA

Grain residues remaining from ethanol production generally are regarded as by-products. As is typical of by-products, nutrient composition and feeding value can vary widely among ethanol plants and among fermentation batches within a plant. With wet or modified grains, moisture is the primary variable of concern. But with either wet or dry products, removal of various components (e.g., oil, bran) alters their nutrient composition and thereby alters their net energy and feeding value of these by-products. For each 1% fat removed from distillers grain by-products, NEg of the by-product is reduced by 1.8 to 2 Mcal/cwt. This reduces its energy value for inclusion in high concentrate diets. Current and future modifications in the ethanol generation process to increase starch extraction (modified enzyme cocktails to saccharify starch and other carbohydrates including NDF), to recover even more oil, and kernel fractionation to generate corn oil prior to fermentation also will impact the feeding value of distillation by-products. Performance trials show that feed efficiency (gain:feed ratio) is consistently improved with substitution of ethanol by-products for dry rolled or high moisture grain, not only due to its NE (and fat) content, being slightly higher than the grains being displaced, but also due to greater intake of NE by cattle fed diets containing by-products. This apparent “intake stimulation” likely is associated with the higher protein, higher NDF, the added fat, or the reduced starch content of diets containing by-products. Potential reasons behind this intake stimulation are explored.

Background

Numerous articles and summaries of production and utilization of by-products of ethanol production for various classes of ruminants have been published in the past decade. Readers should consult these classical publications from the University of Minnesota (2014), University of Nebraska (2005), Erickson et al. (2005), Klopfenstein et al. (2008), the Nebraska Corn Board (2010), and the U.S. Grains Council (2012) for further detail and updates.

Though nearly half of the corn grain produced annually in the US currently is fermented to produce fuel ethanol, the residues remaining after ethanol production are used widely as economical sources of energy and protein for livestock, particularly ruminants. Numerous additional products derived from corn ranging from face powder to corn are marketed for humankind, but the most widely desired product, ethanol, is touted as a renewable fuel for internal combustion engines as well as an imbibable lubricant for humans. Whenever products or by-products from corn can yield additional products of value for corn processors, engineering methods to separate such components will evolve. Though extracting additional value from corn products often is considered “modern,” scientists from Hiram Walker more than 80 years ago developed industrial procedures to extract corn oil from whiskey distillation by-products and constructed an extraction plant in Peoria in the 1930’s!

Alterations in steps in the ethanol production process to glean additional value have been driven primarily by product value and economics, not by an inherent desire to increase the value or usefulness of a by-product for livestock feeding. Although by-products of ethanol production are
widely marketed for livestock feeding and often are called “co-products,” equipment designs and
day-to-day operations at ethanol plants illustrate that their primary emphasis is on their main
product of value – ethanol.

With the governmental mandate for increased use of renewal biofuels, numerous ethanol plants
have been constructed in the past decade. Techniques to increase ethanol yields, to extract
additional marketable products from by-products, and to reduce production cost have evolved.
The objective of this paper is to highlight some of the manufacturing and handling changes that
have occurred in the dry-grind ethanol production system, to speculate what additional changes
may be forthcoming, and to examine the impact of such changes on nutritional value of ethanol
by-products as a component of ruminant diets.

Products of Interest for Feeding Ruminants

Common feedstuffs as well as ethanol by-products are defined by the American Association of
Feed Control Officials (AAFCO) largely by their derivation, not their composition. Within the
feed industry, AAFCO defined feeds are “generally regarded as safe.” Specific definitions and
abbreviations employed hereafter in this presentation include:

**Corn Distillers Dried Grains (DDG)** is obtained after the removal of ethyl alcohol by
distillation from the yeast fermentation of corn by separation the resultant coarse grain
fraction of the whole stillage and drying it. (27.5)

**Corn Distillers Dried Grains with Solubles (DDGS)** is obtained after the removal of ethyl
alcohol by distillation from the yeast fermentation of corn by condensing and drying at least
¾ of the solids of the resultant whole stillage. (27.6)

**Corn Distillers Wet Grains (DWG)** is the product obtained after the removal of ethyl
alcohol by distillation from the yeast fermentation of corn. (27.8)

**Corn Condensed Distillers Solubles (CDS)** is obtained after the removal of ethyl alcohol
by distillation from the yeast fermentation of corn by condensing the thin stillage fraction to
a semi-solid. (27.7)

AAFCO definitions do not exist for Distillers Wet Grains with Solubles (DWGS) and the
diverse variety of modified distillers grains currently marketed. For simplicity, in this
presentation, the term DGS will be used to imply both DDGS and DWGS.

Note that by-products from production of other fuels (e.g., butanol) are not included in these
definitions nor are products with additional alterations (e.g., reduced-fat DGS or DGS
containing less than ¾ of the solubles readded). Certain ethanol plants market such specialty
products and include designations that reflect modifications (i.e., low-fat distillers grain; high
protein distillers grains). Note that AAFCO definitions do not specify the nutrient content of
products, merely their method of production. Because alterations of DGS such as extent of oil
removal often change nutrient composition, feeding value can vary widely among by-products
from different ethanol plants despite being marketed under the same name. In addition
depending on the starch-substrate being employed, the efficiency of starch extraction, the time
and anomalies among individual fermentation batches, and the fraction of stillage that is included
in DDGS, feeding value of DGS from a specific plant will vary over time. Among these factors,
the largest contributor to the variation in nutrient composition of DGS is the variation from
batch-to-batch within a plant (Belyea et al., 2004), not the composition of the substrate being
fermented although starch content and its availability from the product being fermented sets a ceiling to potential ethanol yield.

**Ethanol Production Steps**

Numerous sources of starch or sugars from grains or sucrose (cane or beet) can be used for generation of ethanol. Although corn, sorghum, and wheat grains are the primary feedstocks employed for ethanol production in North America, other starch-rich feeds (e.g., barley, rye, rice, potatoes, cassava) are used worldwide for production of imbibable beverages. For production of fuel ethanol, most dry grind ethanol plants utilize the stepwise process outlined in Figure 1 as modified from Rausch and Belyea (2006). Specific steps in this process that can be altered most readily to 1) generate additional products of value, or 2) increase ethanol yields and their impact on nutrient composition and feeding value are described below.

![Ethanol Production Steps Diagram](image)

**Figure 1.** Steps in ethanol generation and production of by-products through the dry grind procedure.

Despite its variability in composition, surprisingly few of feeding trials report the nutrient composition or specific derivation of the DGS being fed. Reported values for protein and ADF
concentrations (Table 1) as summarized by DiCostanzo for this publication indicate that the low, medium, and high fat products often have been generated by kernel fractionation prior to fermentation, not simply by centrifugation of the soluble fraction to remove fat from that fraction. Imprecise or complete absence of compositional analysis of a test feed ingredient employed in feeding studies complicates any appraisal of its nutritive value.

Table 1. Reported byproduct nutrient compositions from feeding trials

<table>
<thead>
<tr>
<th>Item</th>
<th>Wet SD</th>
<th>Dry SD</th>
<th>Low fat</th>
<th>Low fat</th>
<th>Medium fat</th>
<th>High fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of DM</td>
<td>DDGS</td>
<td>DDGS1</td>
<td>DDGS2</td>
<td>DDGS2</td>
<td>DDGS</td>
<td>DDGS</td>
</tr>
<tr>
<td>Fat</td>
<td>13.4</td>
<td>13.0</td>
<td>4.0</td>
<td>5.5</td>
<td>8.1</td>
<td>12.9</td>
</tr>
<tr>
<td>CP</td>
<td>31.0</td>
<td>27.5</td>
<td>23.0</td>
<td>32.7</td>
<td>31.9</td>
<td>28.8</td>
</tr>
<tr>
<td>NDF</td>
<td>41.4</td>
<td>42.3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ADF</td>
<td>18.3</td>
<td>25.8</td>
<td>0.4</td>
<td>11.9</td>
<td>16.5</td>
<td>15.7</td>
</tr>
</tbody>
</table>

Oil removal

As shown in Figure 1, oil can be extracted at several points in the process. About one-third of the total oil can be extracted through “back end oil extraction” through centrifuging the solubles. To increase oil yield from solubles, proteases, demulsifiers, and polyols often are added to the soluble fraction prior to centrifugation. Certain ethanol plants have used this method of oil extraction for many years and have marketed a “lower oil” distillers by-product (9 versus 12% ether extract). An additional 60% of total oil can be extracted from the “grains fraction” with solvents that in turn generates by-products with an even lower oil content (4 to 6% ether extract). With both back end extraction and solids oil extraction, the recovered oil is used as a biofuel or blended with diesel fuel. For corn oil used directly by the food industry and in cooking, kernel fractions are separated PRIOR to fermentation. For this, corn kernels are de-germed and oil is extracted from the germ leaving corn bran that may be marketed separately. The remaining fraction, consisting primarily of starch, then is fermented to ethanol. The by-products formed from fermentation of fractioned corn kernels, due to their lower fiber and oil content and higher protein content, can be included at higher concentrations than non-differentiated DGS in diets for poultry and swine and is typically marketed for feeding non-ruminants. However, reduced-oil DGS also is targeted for the dairy market based on the presumption that full-fat DGS contains enough unsaturated fatty acids to allow ruminal microbes to form CLA or CLA precursors that in turn will reduce milk fat synthesis by the mammary gland. Consequently, dairy consultants often allow higher dietary DGS inclusion rates when the DGS has had some of its fat removed.

Based on figures from Musser (2013), the fraction of ethanol plants marketing DDGS with over 10% fat declined from 50% to 17% from 2011 to 2013. Simultaneously, the prevalence of plants marketing DDGS with less than 7% fat has increased from 4 to 30%. Nutrient contents compiled from DairyOne (2015) samples for this manuscript failed to reveal such a drastic drop in ethanol content of DGS across this time period (Figure 2), but concentrations of certain components have changed in the past 14 years. The significant changes include decreases in fat content that have paralleled the increase in CP content. Starch content decreased gradually following an abrupt drop from 2000 to 2002 whereas NDF has increased gradually. The NEg content of DDG,
calculated from equations based on compositional analysis and these composition changes across time, equates to a decrease in NEg of 1.8 Mcal/cwt for each 1% decrease in fat content of DGS.

Despite the limited chronological change in mean fat content among samples of DDGS assayed at analytical labs, variability in fat content has become quite large. Dairyland (2015) reported that from 2011 to 2013, fat content averaged 9.3% with a range of 5.8 to 12.7% with modes at about 9 and 12% fat (Dairyland Labs, 2015). Similarly, DDGS samples for 2013 from DairyOne (2015) had a mean fat content of 10.7% with a range from 7.6 to 13.6%. With fat comprising a substantial portion of the energy in DDGS, these differences in fat content contribute to the variation to the NE value of this by-product. These differences in energy value become of greatest concern when DDGS is included at higher concentrations in diets as a source of energy rather than when fed at lower levels as a source of dietary protein.

Figure 2. Composition changes in composition of distillers dried grains and solubles compiled from raw data from DairyOne (2015) for this presentation.

Starch extraction
Ethanol yield depends on starch or sugar content of the feedstock and its availability for fermentation. NIR procedures to predict the ethanol yield from a scan of the grain indicates that ethanol yield differs by up to 11% among hybrids (Haefele et al., 2004). Some seed suppliers designate which of the available hybrids yield more ethanol for hybrid selection by grain producers, particularly those who market to and have a vested interest in an ethanol plant. Certain ethanol plants have been reported to reject or discount delivered grain with very light test weight (< 52 lb/bu), presumably because its starch content and consequent ethanol yield will be reduced. Regardless of its test weight, corn grain contains between 69 and 73% of its DM as starch. Ideally, all of this starch would be fermented to ethanol. As shown in Figure 2, starch...
content of DDGS has decreased over the years, but some samples of DDGS still contain a substantial amount of unfermented starch based on current data from DairyOne (Figure 2) and Dairyland Labs (2015) [4.4% starch (range of 1.9 to 7.0%) and 3.5% starch (range of 1.2 to 7.0%), respectively]. About 10 years ago, internal studies indicated that rate of ethanol production was greater from waxy (> 98% amylopectin) than typical yellow dent corn grain that contains 15 to 30% straight-chained amylose plus with the remainder being branched amylopectin. More recent studies have detected no difference in ethanol yield between waxy and normal grain, but ethanol yield from high amylose corn grain (70% amylose) was less than 40% the ethanol yield from typical corn grain (Lemuz et al., 2008.) Changes in grinding procedures to avoid large sized particles and alterations in composition of the saccharolytic enzyme cocktails have helped to increase starch availability and increase ethanol yields. Ethanol yield often is reduced or production is retarded when corn grain has a high N content. High N fertility of soil is associated with increased vitreousness of dry grain as measured by its zein content. High zein content and high absolute density of kernels leads to a coarser mean particle size when ground and particle coarseness reduces the accessibility of starch from dry grain for microbial attack either during either ethanol or ruminal fermentation. Heat-tolerant phytases and proteases have been added to the amylase in cocktails used for saccharification of starch in some plants recently (Figure 1) and likely are responsible for the decreases in residual starch in DGS. Lower ethanol yields often are noted with new crop corn, grain that has not sufficiently “cured” prior to use. Being more difficult to grind to a fine particle size, new crop corn likely generates more particles with a large size that will have reduced starch availability for fermentation.

Level of solubles added
When a separate market exits for condensed or dried solubles, less than the 75% of the solubles as specified by AAFCO may be added to generate DDGS or the DDG may be marketed directly. Depending on logistics, the proportion of solubles re-added to wet grains can vary from 50% of that extracted to 150% of that removed. Per unit of DM, spent grains are much richer in NDF and protein than solubles whereas most residual sugars and ash and a substantial portion of the total fat, phosphorus and sulfur is found in the solubles as illustrated in Figure 3.

As a result of the ratio of solubles added to spent grains, fat content of the DDGS can range from under 10 to over 14% of DM simply by adjusting the proportion of solubles re-added. Addition of more than 100% of the solubles can occur with addition of carryover from previous fermentation batches.

Additional factors
With the advent of cellulosic ethanol production and development of active cellulases and hemicellulases, these same enzymes likely will be included in cocktails employed prior to ethanol fermentation of grain. Currently, cellulases are included in the saccharolytic enzyme mixtures at some ethanol plants. If these enzymes remain active and degrade some of the cellulose, the amounts of ruminally digested NDF present in by-products marketed for ruminant livestock will be reduced although the lower NDF content of the DGS may make it preferable for feeding non-ruminants. Being already gathered at a single location, wet grains could be used directly for cellulosic ethanol production. Potential alternative uses of DGS also include fermentation to yield methane as a biofuel for generating electricity or direct combustion of by-
Figure 3. Impact of ratio of solubles to wet grains on composition of DDGS.

In Brazil the residue from ethanol production from sugarcane known as bagasse was widely available as a very low quality, low protein forage for livestock until recently. Currently, almost all bagasse is combusted at ethanol plants in Brazil. Why? It is simpler and more economical for an ethanol plant to generate electricity (either to sell or replace internal usage) from burning the bagasse than to market this by-product to livestock feeders. Alternative uses for specific ethanol by-products (e.g., as a component of kitty litter) also may increase competition for and decrease the supply of DGS as a feed ingredient for livestock. Additional potential modifications of DGS have been outlined by Rausch and Belyea, 2006).

Production responses to full fat distillers grains plus solubles

In a very thorough board-invited review by Klopfenstein et al. (2008), feeding values obtained by substitution of full fat WDGS and DDGS for grain (typically dry rolled or high moisture grain) were summarized and dietary concentrations to maximize rate of gain and feed conversion efficiency were outlined. In those studies, full-fat DGS was being fed so optimal dietary concentrations could be determined directly.

Quantifying the performance response to dietary inclusion of reduced fat WDGS or DDGS becomes more complex than with full-fat DGS because both the concentration of fat in the by-product and dietary concentration of the by-product can and do change. The poster by Alex Hohertz presented at this meeting outlines a statistical approach to examine the impact of
concentration of fat on ME and NEg value of the by-product based on information available from feeding trials. Through subdividing responses into those by-products with either low, medium, and high fat concentrations, statistical analysis indicates that for each 1% decrease in concentration of fat in DGS DM decreases NEg by 2 Mcal/cwt. This is only slightly greater than the 1.8 Mcal/cwt suggested in the time-based changes proposed from analysis of DGS by DairyOne and close to the estimate derived by Pritchard et al. (2012) from a steer feeding trial. Further study of that latter trial appears worthwhile.

In their trial, finishing yearling steers were fed diets based on a corn-soy diet or this diet with the grain (half dry rolled; half high moisture corn) partially replaced with wet distillers grains or wet distillers grains plus solubles at 40% of diet DM (Figure 4).

![Figure 4. Impact of fat contribution of WDGS to NEg value of diet.](image)

Close examination of responses in feed efficiency (gain to feed ratio) relative to this change in NE (or ME) as shown in Figure 5 reveals that the response in performance (gain to feed ratio) far exceeds that expected from the increase ME content of the diet alone. Of the gain:feed response, only 58% could be ascribed to the altered ME content of the diet while the remaining 42% appears to be associated with an increased intake of net energy and a consequent increase in ADG for steers fed the higher fat DDG.
Figure 5. Performance responses to added fat in WDGS.

Relative importance of NEg versus NEg intake

In 2008, Vasconcelos and Galyean published a paper entitled “Do dietary net energy values calculated from performance data offer increased sensitivity for detecting treatment differences?” They concluded that standard performance variables should adequately explain treatment responses and that performance-calculated net energy values for a diet add little useful information to interpretation of results. Certainly, under most circumstances, increasing diet NEg of a feedlot diet results in a decrease in dry matter intake so NEg intake and rate of gain remain unchanged. Examples matching this concept include responses to more extensive grain processing and addition of fat or roughage to the diet. Yet, when one considers protein supplementation of low-quality, low-protein forages, performance usually is increased both from an increase in the NEg of the diet and from an increased intake of dry matter and NEg. Likewise, estrogenic implants usually increase energy intake and gain to feed ratio without altering NE content of the diet. Consequently, subdividing dietary net energy changes from intake responses appears useful and potentially important for differentiating between these two responses and could help interpret why production responses are seen with a given alteration in the diet, a feed additive, or an implant. Indeed, economic return from a pen of cattle generally is related more directly to gain to feed ratio than to rate of gain or even to RFI. Reanalysis of the 9 trials outlined by Klopfenstein (Figure 6) revealed that increasing the level of substitution of DGS for dry rolled or high moisture corn in the diet increased, ADG, a reflection of NEg intake, but then reached a plateau. However, gain to feed ratio continued to increase because NE content of the DDG exceeded that of the grain it replaced. Although NEg values are useful to
evaluate the relative cost of NE from various dietary ingredients when formulating least-cost
diets, least cost performance also requires an appraisal of effects on intake as well so NE intake
can be appraised.

**Figure 6.** Influence of dietary concentration of DGS on ADG, an index of NEg intake above
maintenance, and gain to feed ratio based on trials summarized by Klopfenstein et al., 2008.

**Factors influencing NEg and NEg intake of diets containing DGS**

Precisely which component(s) inherent to DGS may be involved or responsible for alterations in
available energy content (NEg) and to NEg intake by feedlot cattle remain uncertain.
Considering that replacing grain in a diet with DGS increases the dietary supply of protein, fat,
and NDF while reducing the supply of dietary starch implies that one or more of these factors
probably is involved.

**Responses to the drying process**

For transport and storage, much of the marketed DGS is dried. Drying adds cost to the product
so ethanol plants that market DGS without drying have an economic advantage. Energy
availability for feedlot cattle per unit of DM is greater for wet than dry DGS (Klopfenstein et al.,
2008). For non-ruminants, excessive heat can complexes between amino acids with reducing
sugars decreasing the supply of essential amino acids; color of the dried product often has been
used as an index of protein damage. Heat drying WDGS, as with fermented crops, also drives
off volatiles that could provide energy for ruminants or ruminal microbes giving the wet DGS an
advantage. For some feeds, high temperature drying will denature proteins and increase ruminal
escape of protein; this in turn would decrease the ammonia supply for ruminal microbes and
could depress digestion unless the supply of ruminal ammonia is sufficient or recycling of N to
the rumen is substantial. Even for finishing steers, an insufficient supply of ruminally degraded
N (a negative urea fermentation potential) recently has been shown to performance via reduced
diet digestibility (May et al., 2014). Finally, clumping of DGS may occur during drying. Fine
grinding of DGS with coarse particles has been demonstrated to increase availability of energy
from DGS for growing pigs (Liu et al., 2012). Likewise, nutrients and energy in coarse particles
of DGS may have reduced availability for digestion by microbial or intestinal enzymes of
ruminants.

Responses to protein or N supply
The primary concern related to protein adequacy for maximum productivity of growing cattle or
lactating cows is the postruminal supply of and balance among essential amino acids. However,
as mentioned above, a deficiency of ruminal ammonia also will reduce productivity through
depressing microbial activity and reducing digestibility. Certain peptides or amino acids
delivered to the small intestine (e.g., arginine) also may enhance DMI specifically, perhaps
through hormone alterations.

Ammonia, derived from ruminally degraded protein, also serves as a ruminal buffer helping to
maintain ruminal pH above 6, a point below which ruminal cellulose digestion is depressed.
Surprisingly, ruminal pH generally is not increased by substituting DGS for dietary grains,
previously due to the acidic properties of DGS. Whether digestion of NDF is depressed as
much by the acids present in DGS as by ruminal lactate and VFA needs further study. Also, the
NDF of corn grain differs from that of most forages, being less than 40% cellulose and nearly
60% hemicellulose. Again, whether the digestion depression associated with reduced pH is as
great for hemicellulose as for cellulose deserves further research attention.

When protein intakes are elevated, more urea must be synthesized and excreted. This in turn can
have consequences on both energetics and metabolism. First, urea contains energy and secondly,
energy is required for synthesis of urea. However, the gross (oxidizable or combustible) energy
available for mammal metabolism also is greater for proteins than carbohydrates due to its lower
ratio of oxygen to carbon and hydrogen. This increased gross energy for protein will partially if
not completely compensate for the additional energy involved with urea excretion if not its
synthesis. In addition, excretion of urea requires dilution. The quantity of water consumed and
of urine excreted by ruminants fed high protein diets increases as intake of protein and possibly
of salt is increased. Increased water intake in turn usually is associated with an increased
ruminal dilution rate that increases efficiency of microbial growth and tends to shift site of
digestion downstream from the rumen. This may be desired for lipid and intestinally digested
carbohydrate but undesirable for the NDF in a diet.

Finally, nearly half of the protein in typical corn grain consists of the various zeins.
Consequently, about 15% of the dry weight of DGS should be zeins. Loerch et al. (1983)
indicated that ruminal degradation of a protein source was enhanced when that same protein
source was included in the diet, presumably reflecting an adaptation of ruminal microbes to the
source of substrate. Though not yet checked with DGS, one might speculate that ruminal
microbes, starved for reducible carbon, would adapt to degrade this large quantity of zein. If
zein degradation is increased when DGS is included in the diet, one would expect an increase in
the extent to which zein-embedded starch within dietary grains became available for ruminal or intestinal digestion by ruminants. This in turn could explain the observation that beneficial effects of DGS often are greater when fed together with diets where extent of total tract starch digestion is incomplete (dry rolled; drier high moisture corn or earlage) than when fed with diets where total tract starch digestion is virtually complete (well flaked corn grain).

**Responses to fat**
Addition of corn oil to a diet at a level equal to that found in DGS, due to high ruminal availability of poly-unsaturated fatty acids, often reduces NDF digestion and dry matter intake. More saturated fats including tallow have less adverse effects on ruminal microbes, particularly protozoa. Nevertheless, high concentrate feedlot diets usually are supplemented with fat if cost per calorie is low due to an increased energy density of the diet and increases in quality grade.

Compared with synthesis from carbohydrate, dietary fatty acids that can be deposited directly at various depot sites or in milk entails less heat production. Hence, supplemental fat is particularly useful to reduce heat stress during summer. Although many feeding trials are conducted during summer months, it seems unfortunate that season of feeding trials and heat stress conditions often are not identified within reports of feeding trial results.

Fats also appears beneficial for reducing the incidence of ruminal acidosis, either through direct effects on ruminal microbes or indirectly through substituting for a portion of the carbohydrate and thereby reducing the ruminal lactate load and fluctuations in lactate production. Dietary fat also can alter the extent to which estrogen and other lipid-soluble hormones are degraded by the liver. This in turn could alter concentrations of intake-regulating hormones.

Digestibility of fat decreases as concentration of dietary fat increases (Plascencia et al., 2003). Consequently, ceilings of 6 or 8% dietary fat often are employed in diet formulation programs. With 40% full-fat DGS and 40% corn grain diets, dietary fat concentrations may exceed 6%. The decrease in fat digestibility appears associated primarily with a decrease in intestinal digestibility of palmitic and stearic acids. Because the concentrations of these two fatty acids in corn oil is low, enhanced ruminal escape of biohydrogenation through rapid passage or encapsulation within resistant particles should reduce conversion of dietary unsaturated fats to stearic acid and thereby enhance fat digestibility. With lactating cows, abomasally infused phospholipids (e.g., lecithin) have increased availability of triglyceride suggesting that emulsifying agents may prove useful to increase digestibility of fat (Grummer et al., 1987). To increase extractability of fat from thin stillage, many ethanol plants currently add specific chemicals (demulsifiers, flocculants, sorbitol polyols). These compounds subsequently may retain activity and increase digestibility of fat in the small intestine of ruminants fed their reduced-fat distillers grains. Supplementation of full-fat DGS with rumen escape phospholipids or emulsifying agents might avoid the reductions in energy value noted when high amounts of such DDGS are fed.

**Responses to a reduced starch load**
Through displacing starch-rich carbohydrates, DGS should reduce the potential for ruminal acidosis associated with lactic acid. In addition, the propionate load should be reduced. High rates of propionate absorption or direct infusion of propionate can depress DMI (Oba and Allen,
2003). The degree to which a decreased propionate supply or the hepatic oxidation theory of intake regulation (Allen and Bradford, 2009) might be responsible for the increased energy intake of DGS-supplemented diets is unclear.

Responses to dietary NDF
With high forage diets, ruminal fill with large NDF particles can limit intake, but with high-concentrate feedlot diets NDF digestibility generally is low so ruminal fill never limits DMI. Furthermore, with DGS, NDF particle size is small so ruminal outflow is not limited by particle size. Nevertheless, small fiber particles aid in mixing of ruminal contents to help to avoid ruminal wall damage, papilla clumping, and parakeratosis and, as mentioned previously, avoid ruminal acidosis with associated rumen wall damage and release of endotoxins. That acidosis and rumen wall damage can have persistent effects on absorption and possibly intake has been demonstrated (Krehbiel et al., 1995). Improved rumen health from higher NDF diets was reviewed by Thonney and Hogue (2006).

Figure 7. Intake responses by steers fed a high grain diet or this diet diluted with ethanol by-products.

Adaptation to high concentrate diets often involves bouts of acidosis as calves learn to adjust their DMI based on chemostatic rather than bulk fill factors. Circumventing this adaptation period though continually including DGS with its NDF in the diet should help maintain improved rumen health and function. In contrast, calves fed a control high-grain diet would be more likely to experience acidosis. Consequently, avoiding adaptation to high concentrate diets may help to maintain and sustain higher intakes of DM and NE later in a feeding period. In the trial by Pritchard et al. (2012) as shown in Figure 7, feed intake of the higher grain diet tended to
be depressed during diet adaptation for steers fed the control relative to the diets containing more
though some recovery in DMI was noted later. Carryover effects from adaptation to a high
concentrate diet could be one additional benefit from including DGS in a diet that might be
tested by evaluating the feeding value of DGS only after all cattle were adapted to a high
concentrate diet. If effects of adaptation persist throughout a finishing period, rotating cattle
among treatments in a crossover or switchback design would be expected to yield results that
differ from that of feeding DGS continuously.

Literature Cited

Nutrition Conference, pp. 138-147.
dried grains with solubles from dry grain ethanol processing. Bioresource Tech. 94:293-298.
Dairyland Laboratories. 2015. Feed and forage summaries.
https://www.dairylandlabs.net/resources/feed-and-forage/summaries
forage/feed-composition-library/interactive-feed-composition-library/
Erickson, G. E., T. J. Klopfenstein, D. C. Adams, and R. J. Rasby. 2005 General overview of
feeding corn milling co-products to beef cattle. In: Corn Processing Co-Products Manual,
University of Nebraska, Lincoln, NE, USA.
abomasal infusion of choline, inositol, and soy lecithin. J. Dairy Sci. 70:2518–2524
hybrids for fuel ethanol production. Proc. ASTA Annual Corn and Sorghum Research
ruminal acidosis on volatile fatty acid absorption and plasma activities of pancreatic enzymes
in lambs. J. Anim. Sci. 73:3111-3121
86:355-360.
with solubles particle size on nutrient digestibility, DE and ME content and flowability in
and energy level on in situ nitrogen disappearance of various protein sources. J. Anim. Sci.
56:206-216.
May, D., J. F. Calderon, V. M Gonzalez, M. Montano, A. Plascencia, J. S.-Chavira, N.
Torretera, and R. A Zinn. 2014. Influence of ruminal degradable intake protein restriction on
characteristics of digestion and growth performance of feedlot cattle during the late finishing

Nebraska Corn Board. 2010. Feeding corn milling co-products to feedlot cattle. www.NebraskaCorn.org or beef.unl.edu


University of Nebraska, 2005. Corn Processing Co-Products Manual, University of Nebraska, Lincoln, NE.

Limit Feeding Production Cows in An Intensively Managed System

Karla H. Jenkins¹, Jason Warner², Rick Rasby², and Terry Klopfenstein²
¹ University of Nebraska Panhandle Research and Extension Center, Scottsbluff, NE
²Department of Animal Science, University of Nebraska, Lincoln

Introduction

The available forage supply for maintaining beef cow herds continues to be threatened by several factors. At times, high commodity prices encourage the conversion of pasture land into crop ground. Cities and towns continue to sprawl out into rural areas creating subdivisions where historically cattle grazed, while drought, fires, hail, and insects continue to periodically deplete forage supplies. When forage supplies cannot be located or are not affordably priced; cattle producers must either sell their cattle or feed the cattle in confinement.

Feeding beef cows in confinement is not a new concept. However, limit feeding them (less than 2% of body weight on a DM basis) an energy dense diet, with the intent of keeping the cows in the production cycle, rather than finishing them out, needs to be thoroughly evaluated. Keeping cows in confinement 12 months out of the year may not be the most economical scenario, but an intensive management system involving partial confinement when pastures need deferment or forage is not available, may keep at least a core group of cows from being marketed, or provide a means of maintaining a cowherd where pastures is simply limited. Producers will need to know how and what to feed the cows while in confinement to make it feasible. Crop residues, poor quality hays such as those from the conservation reserve program (CRP), by-products of various industries, and commodities rejected from other markets, tend to be the most economical ingredients to include in confinement diets.

Nutrient Requirements of the Cow

When producers decide to limit feed cows in confinement there are three concepts that become key to successful feeding. The first concept to understand is the cow’s nutrient requirements. The cow’s nutrient requirements vary with age, size, and stage of production (NRC 1996). Two and three year old cows still have requirements for growth as well as gestation and/or lactation and should be fed separately from mature cows in a limit feeding situation to allow them to consume the feed needed to meet their requirements. More frequent sorting may be necessary when cows are limit fed to prevent very aggressive cows from over-consuming and timid cows from becoming too thin. When lactation starts, the cow’s nutrient needs increase and peak at about 8 weeks of lactation (Figure 1). Producers need to either increase the energy density of the diet or increase the pounds of dry matter fed when lactation starts.

Nutrient Content of the Feedstuffs

Another important consideration is the nutrient content of the commodities used in the limit fed ration. Most producers are familiar with feeding low to medium quality forages to mid-gestation cows. They typically supplement with a protein source to improve forage digestion and the cows are allowed ad libitum access to the forage. The protein allows the cow to adequately digest the
forage and if the forage is not restricted, the cow can usually meet her energy requirements. Limit feeding cows while maintaining body condition requires a mindset shift for producers. While the protein needs of the cow do need to be met, the first limiting nutrient, especially for the lactating cow, is energy. Typically, producers are always encouraged to send feed samples to a commercial laboratory for testing. The TDN value listed on commercial laboratory results is not from an analysis but is actually calculated from acid detergent fiber (ADF). In the case of forages, this is fairly similar to the digestibility and is an acceptable measure of forage energy. However, due to the oil content of some by-products, and the interaction of by-products in residue based diets, the University of Nebraska recommends using TDN values for by-products based on animal performance in feeding trials (Table 1). Estimating too much energy for a commodity can result in poorer than expected cattle performance, while underestimating the energy value of a commodity would cause overfeeding, resulting in an increased expense for the confinement period.

Feed Intake of the Nursing Calf

The third important consideration is the feed intake of the calf. Nursing calves can be seen nibbling at forage within the first three weeks of life. By the time they are three months old, research indicates they are eating about 1% of BW in forage (Hollingsworth-Jenkins, et al. 1995). A 300 lb. calf would eat 3 lb. of DM in addition to nursing the cow. If calves are not weaned and in their own pen at this time, additional feed should be added to the bunk for them, or a creep feeding or creep grazing area should be established that cows cannot access. Early weaning does not save feed energy but may be a good management practice in the confinement feeding situation. Research conducted at the University of Nebraska indicated that when nursing pairs were fed the same pounds of TDN as their weaned calf and dry cow counterparts, cow and calf performance was similar at the 205 d weaning date (Tables 2,3, and 4). Table 5 depicts the common diets fed to the pairs and their weaned calf and dry cow counterparts. While not resulting in an advantage in feed energy savings, early weaning can be advantageous in other ways. Early weaning would allow the calves to be placed in a separate pen from the cows. Producers would then have the flexibility of feeding the calves a growing or a finishing diet, or even allowing them to graze forages if available. The cows then, without the demands of lactation, could be placed on a lower energy diet.

Management Considerations for Young Calves in Confinement

A common misconception producers often have is that calves nursing cows do not need to drink very much water. In reality, they do need water, and especially so, when the temperatures are warm. A dairy calf study (Quigley, 2001) determined that calves less than 60 d old, consuming 0.8 gal/d of milk replacer, still consumed 0.66 gal/d of free choice water. These researchers also determined the relationship between temperature and free choice water intake was exponential rather than linear. At temperatures above 85° F, nursing calves may drink close to 1 gal/d of free choice water. Free choice water intake also promotes rumen development. Calves that begin eating early tend to thrive and gain weight better than those that don’t. Young calves need to be able to reach the water tank and have access to sufficient water. In the UNL confinement feeding trial, calves as young as a couple of days drink water during July calving. Tanks need to be banked high enough that calves can reach the edge and water flow needs to be unrestricted.
enough that the tank can refill quickly after cows drink. The size of the tank needs to be big enough that on extremely hot days calves can access the water without cows pushing them away. In the research trial it was necessary to put small tubs of water out of reach of the cows but accessible to the calves. Feed access is also an issue as calves begin eating at a fairly young age. In the UNL confinement study, creep feeders were placed at the back of the feedlot pen to allow calves access to alfalfa pellets prior to 90 days of age. Although consumption was low (0.37% BW), it probably served to initiate some rumen function. Calves begin eating at the bunk with cows at an early age and therefore would need to be able to access the feed bunk as well.

Health Considerations for Calves in Confinement

As cattle in an intensively managed system have increased animal to animal contact, there are greater opportunities for pathogen transmission as compared to pasture systems. Neonatal calf diarrhea (scours) is the disease most likely to affect newborn calves during the first few weeks of life. Typically, the average dose-load of pathogen exposure is likely to increase throughout a calving season as calves that are infected initially serve as multipliers and are the foremost source of exposure to young susceptible calves. Consequently, calves born later during the calving season can receive greater dose-loads of pathogens and may also become more infective to other calves. The three primary strategies for preventing outbreaks of calf scours include: 1) removal of pathogens from the herd; 2) improve calf immunity against pathogens; and 3) adapt the production system to minimize opportunities for pathogen exposure and transmission. In the confinement cow study at the University of Nebraska, all pens were cleaned before calving. Then, pairs were grouped by calf age to prevent calves with more than a two week age difference from residing in the same pen.

Pneumonia (bovine respiratory disease or BRD) is also a prevalent source of calf losses early in life. Maternal immunity against infectious agents decreases with time, because by 90 to 120 days of age, a calf will retain less than 2% of the antibodies it initially absorbed from colostrum. The calf’s immune system, although functional, is undeveloped in calves that are 90 to 120 days of age. Therefore, they may have increased susceptibility to respiratory disease. Management practices that provide opportunities for infection, such as weaning or commingling, may have a reduced influence on health if done before or after calves are 3 to 4 months of age. Developing sound vaccination protocols against respiratory disease in young (≤ 5 months) calves is important, and future research in this area is essential. Because of the increased opportunity for pathogen transmission, the likelihood of diseases such as scours, respiratory disease, and others occurring is greater for intensive than pasture systems. The importance of newborn calves nursing and receiving adequate colostrum immediately following birth cannot be overemphasized.

In the UNL system, the cow vaccination protocol consisted of two annual vaccinations. Cows were vaccinated with a killed virus product approximately 1 month prior to the start of calving to protect calves against scours. Pathogens vaccinated against included: bovine rotavirus, bovine coronavirus, E. Coli, and clostridium perfringes type C. At the same time, cows received a topical pour-on for the control of external parasites and either a pour-on or injectable solution against internal parasites. After calving, approximately 1 month prior to the start of the breeding season, cows were vaccinated with a modified live virus product to protect against persistently
infected calves and to prevent abortion. Pathogen strains included in this vaccine were: IBR, BVD types 1 & 2, PI3, BRSV, and multiple leptospirosis strains. At weaning, cows again received a topical pour-on for external parasites.

Calves were vaccinated initially at birth for blackleg, malignant edema, black disease, enterotoxemia, and haemophilus somnus. At birth, navels were sprayed with iodine and bull calves were band castrated. At approximately 90 days of age, calves again received the same vaccination that was given at birth and a modified live virus product to guard against IBR, BVD 1 & 2, PI3, and BRSV. After weaning at approximately 205 days of age, calves remained in the feedlot for growing and finishing, and received additional respiratory and clostridial vaccinations at that time. In both years of the study, at one location or the other, after weaning, some calves were treated for BRD. It is interesting to note that all calves treated responded well and no calves died from respiratory disease after weaning. Various factors contributed to the outbreaks such as weather, stress, and exposure to newly received cattle. These data suggest vaccination protocols for calves in intensively managed systems may need to be more aggressive than those for calves from extensive pasture systems.

**Reproduction in Confinement**

Cows can be successfully bred in confinement consuming a high energy limit-fed diet (Table 3). The overall conception rate of moderate BCS cows is higher if they are on an increasing plane of nutrition just prior and during the breeding season. This can be done by increasing the DM fed, or increasing the energy density of the diet. Additionally, confinement improves the ease with which synchronization and artificial insemination protocols can be implemented (http://beef.unl.edu/web/cattleproduction/breedingcowsinconfinement). When bulls are confined with cows allow an additional 2 feet of bunk space for every bull and another 15-18 lb of TDN per bull/d depending on the condition of the bulls during breeding.

**Defining Confinement Feeding**

Feeding in confinement does not necessarily have to be done in a feedlot setting. Although, the advantages of the feedlot often include feed trucks with scales and mixers, concrete bunks, good fences, and access to commodities not always available to ranchers. However, feeding cows in confinement can be achieved by setting up temporary feed bunks or feeding under a hot fence on harvested crop ground, pivot corners, a winter feed ground, or even, as a last resort, a sacrifice pasture. It is important to keep in mind that cattle limit fed a diet on a pasture will continue to consume the forage in the pasture and overgrazing can result if this is the option that has to be implemented. Regardless of location, cows will need a minimum of 2 ft. of bunk or feeding space and calves will need 1.5 ft.

**Limit Fed Diet Options for Confined Cows or Pairs**

Numerous commodities are acceptable in cow diets and their inclusion will depend on nutrient content, availability, and price. There is a wide variety of commodities, by-products, and commodities rejected for human consumption available across the United States. As a result, many diets have been formulated for producers. Some diets include ingredients unique to an
area, while other ingredients are available in limited quantities in some areas and therefore cannot be included at very high levels. Purchase price and trucking costs also impact commodity inclusion. The following example diets were formulated by UNL extension specialists for research trials or Nebraska producers (Table 6). These diets have been used to maintain body condition on cows and can be adapted for other regions with the help of a nutritionist or extension personnel. Handling characteristics should be considered as well when determining what ingredients to use. Research has indicated a diet containing 80% ground cornstalks and 20% wet distillers grains (DM basis) will result in some sorting. Ground wheat straw or low quality hay may not result in the same degree of sorting. Corn wet distillers grains often results in less sorting than dry distillers. Unfortunately, many producers do not have access to the wet product. Mixing some water with the diet can reduce sorting or including silage, beet pulp, or some other wet commodity can add enough moisture to reduce sorting. Rumensin can be added up to 200 mg/cow to improve efficiency and limestone should be added at 0.3 lb/cow to enhance the Ca:P ratio.

Limit Feeding Cows in Feedlots-Paradigm Shifts for Employees

Most cattle residing in a feedlot are there to be finished out and are fed to maximize gain. Employees in a feedlot may find it difficult to see a cow in a BCS 5 and not feel like the animal is too thin. Additionally, limit fed cattle will consume all the offered feed within an hour or two. This can be a hard concept to accept for employees who are trained to feed cattle so that feed is available all day. Determining the commodities to use in cow diets can be an adjustment for feedlot nutritionists as well. Good quality forages with rapid passage rates are not as suitable for limit fed rations as lower quality forages. Therefore, communicating goals and explaining management strategies to nutritionists and employees will likely be time well spent.

Conclusion

Limit feeding an energy dense diet to cows or pairs in confinement for a segment of the production cycle can be a viable alternative to herd liquidation. Producers choosing to limit feed cows or pairs in confinement must consider the nutrient needs of the cow, changes in nutrient requirements as production phase changes, nutrient content of available feeds, availability and associated costs of available feeds, as well as the increasing feed demands of the growing calf. Using available feedlot pen space to maintain production cows will require communication on management, feed pricing, and commodity choice, as well as goals and desired outcomes.
Literature Cited


---

**Figure 1.** Energy requirement for gestating and lactating cows calving June 15, early weaned calves weaned at 90 days (EW) and normal weaned (NW) at a traditional 205 d weaning
Table 1. Total Digestible Nutrients of common by-products and commodities in forage based diets determined from feeding trials

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>TDN (% dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn distillers grains, wet, dry, modified</td>
<td>108</td>
</tr>
<tr>
<td>Corn condensed solubles</td>
<td>108</td>
</tr>
<tr>
<td>Sugar beet pulp</td>
<td>90</td>
</tr>
<tr>
<td>Soyhulls</td>
<td>70</td>
</tr>
<tr>
<td>Synergy</td>
<td>105</td>
</tr>
<tr>
<td>Corn gluten feed</td>
<td>100</td>
</tr>
<tr>
<td>Midds</td>
<td>75</td>
</tr>
<tr>
<td>Corn</td>
<td>83</td>
</tr>
<tr>
<td>Wheat straw/cornstalks</td>
<td>43</td>
</tr>
<tr>
<td>Meadow Hay</td>
<td>57</td>
</tr>
</tbody>
</table>

1 Feeding trials from Blasi et al., 1998; Ham et al., 1993; Klopfenstein and Owens, 1988; Loy et al., 2003; Nuttelman et al., 2009; Oliveros et al., 1987.

Table 2. Daily DMI by weaning treatment and year

<table>
<thead>
<tr>
<th>Item</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EW¹</td>
<td>NW²</td>
</tr>
<tr>
<td>Cow</td>
<td>15.0</td>
<td>--</td>
</tr>
<tr>
<td>Calf</td>
<td>8.5</td>
<td>--</td>
</tr>
<tr>
<td>Cow-calf</td>
<td>--</td>
<td>22.8</td>
</tr>
<tr>
<td>Total</td>
<td>23.5</td>
<td>22.8</td>
</tr>
</tbody>
</table>

¹EW = early-weaned at 91 d of age.
²NW = normal-weaned at 203 d of age.
<table>
<thead>
<tr>
<th>Item</th>
<th>ARDC</th>
<th>PREC</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EW^4</td>
<td>NW^5</td>
<td>SEM</td>
</tr>
<tr>
<td>Cow BW, lb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>1201</td>
<td>1180</td>
<td>1227</td>
</tr>
<tr>
<td>January</td>
<td>1206</td>
<td>1166</td>
<td>1302</td>
</tr>
<tr>
<td>Cow BW change, lb</td>
<td>5</td>
<td>-14</td>
<td>74</td>
</tr>
<tr>
<td>Cow BCS^6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>5.5</td>
<td>5.5</td>
<td>5.2</td>
</tr>
<tr>
<td>January</td>
<td>5.4</td>
<td>5.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Cow BCS change^6</td>
<td>-0.1</td>
<td>-0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Pregnancy, %</td>
<td>89.9</td>
<td>85.4</td>
<td>92.5</td>
</tr>
</tbody>
</table>

^1Fixed effect of calf age at weaning.
^2Fixed effect of location.
^3Calf age at weaning x location interaction.
^4EW = early-weaned at 91 d of age.
^5NW = normal-weaned at 203 d of age.
^6BCS on a 1 (emaciated) to 9 (obese) scale.
Table 4. Performance of calves by location and weaning treatment

<table>
<thead>
<tr>
<th>Item</th>
<th>ARDC</th>
<th>PREC</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EW&lt;sup&gt;4&lt;/sup&gt;</td>
<td>NW&lt;sup&gt;5&lt;/sup&gt;</td>
<td>EW&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calf BW&lt;sup&gt;6&lt;/sup&gt;, lb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>280</td>
<td>277</td>
<td>288</td>
</tr>
<tr>
<td>January</td>
<td>475&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>510&lt;sup&gt;a&lt;/sup&gt;</td>
<td>499&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calf ADG, lb</td>
<td>1.73&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>2.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.86&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1Fixed effect of calf age at weaning.
2Fixed effect of location.
3Calf age at weaning x location interaction.
4EW = early-weaned at 91 d of age.
5NW = normal-weaned at 203 d of age.
6Actual weights.
7<sup>a</sup>Within a row, least squares means without common superscripts differ at \( P \leq 0.05 \).
Table 5. Ingredient and nutrient composition of diets fed to all cows and calves from October to January by location and year

<table>
<thead>
<tr>
<th>Ingredient, %</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARDC</td>
<td>PREC</td>
</tr>
<tr>
<td>Corn silage</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>MDGS</td>
<td>56.5</td>
<td>--</td>
</tr>
<tr>
<td>WDGS</td>
<td>--</td>
<td>58.0</td>
</tr>
<tr>
<td>Cornstalks</td>
<td>40.0</td>
<td>--</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>--</td>
<td>40.0</td>
</tr>
<tr>
<td>Supplement²</td>
<td>3.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Calculated Composition**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>19.0</td>
<td>18.8</td>
</tr>
<tr>
<td>TDN, %</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.75</td>
<td>0.77</td>
</tr>
<tr>
<td>P, %</td>
<td>0.50</td>
<td>0.49</td>
</tr>
</tbody>
</table>

¹All values presented on a DM basis.
²Supplements contained limestone, trace minerals, vitamins and formulated to provide 200 mg/cow daily monensin sodium.

Table 6. Example Diets of by-products and residues for gestating, lactating, and lactating cows with 60 day old calves

<table>
<thead>
<tr>
<th>Diet (DM ratio)</th>
<th>Ingredients</th>
<th>Late Gestation Cow</th>
<th>Lactating Cow</th>
<th>Cow with 60 d old calf</th>
</tr>
</thead>
<tbody>
<tr>
<td>57:43</td>
<td>Distillers grains:straw</td>
<td>15.0</td>
<td>18.0</td>
<td>20.0</td>
</tr>
<tr>
<td>30:70</td>
<td>Distillers grains:straw</td>
<td>19.2</td>
<td>23.0</td>
<td>25.6</td>
</tr>
<tr>
<td>40:20:40</td>
<td>Distillers grains:straw:silage</td>
<td>15.4</td>
<td>18.5</td>
<td>20.6</td>
</tr>
<tr>
<td>20:35:45</td>
<td>Distillers grains:straw:beet pulp</td>
<td>14.6</td>
<td>17.5</td>
<td>19.4</td>
</tr>
</tbody>
</table>

Dry matter intake, lb
Managing Cows in Confinement - Theory into Practice

Roberto E. Eizmendi, M.V. M.Agr.
General Manager Cactus Feeders Cow-Calf Division

The United States cattle industry is facing one of the smallest beef cattle populations since the 1950’s; we have lost 35 million head of cattle in 39 years up to January 2014. The main reasons for this decline are the alternative uses of land that generate larger incomes compared to the average low return per cow, the drought condition we have experienced during the last years, and an aging cattleman population.

This process has produced a reduction on the availability of feeder cattle and an increase on its value, making the economics of cattle feeding more complicated. As a result, there are several feeding facilities closed or running with low numbers. One of the opportunities for those facilities is the implementation of a dry lot cow-calf operation.

In 2011 our company made the decision to explore the feasibility of developing a year-round confined cow-calf operation. We were in the middle of the 2010 – 2013 drought and cow calf producers were reducing their herds size due to lack of forage. We bought 1200 bred cows from sale barns around New Mexico and Texas.

Our initial idea was to hold a breeding herd on each one of our yards as part of their normal operation. So, we sent the 1200 bred cows to one of our yards for calving. After the first calving season in that yard, we realized that management and facility needs for a confined cow-calf operation were different than ones of a finishing yard. On April 2012, the decision was made to convert one of our Kansas yards into a dry lot cow-calf operation; we moved the 1200 cows to Syracuse Feedyard and started modifying the facilities to accommodate the cow needs.

Syracuse Cow Calf Operation

Goals
a) Produce weaned calves with strong immune system, and the genetic potential to perform above average at our yards and at the packing plant.
b) Develop production protocols to be applied on several production units.
c) Find an option for empty or sub utilized feeding facilities.
d) Test several feeding options to add flexibility to the system.
e) Improve the genetic composition of the initial herd by buying high quality replacement heifers and through a genetic program with ABS.

Size
Syracuse Feedyard was a 40,000 head feedyard before converting it into a cow-calf facility. Cows need more square footage than a feeder; as a result, the total capacity of this yard is of 8,500 breeding cows with all the bulls and replacement heifers necessary to keep the herd size stable.
Nutrition
Feed cost represents 80% of the total cost of production in a dry lot operation; in order to keep this cost as efficient as possible we have implemented a limited feeding program. Limit feeding allows us to cover the nutritional needs of breeding females, growing replacement heifers and bulls on their different physiological stages while managing their Body Condition Score (BCS) and reducing total feed consumption.

To maintain our feeding program as simple as possible, we are using one ration for all the cattle groups, varying the amount delivered by head according to the nutritional requirements of each group. The ingredients used in our ration are readily available in the southwest Kansas area - Corn, Corn stalks, Silage, Wet distiller grains.

The flexibility to utilize different types of ingredients available in our area allows us to maintain feed cost as efficient as possible. In order to have that flexibility, we are using a vertical mixer system that mixes efficiently either high roughage or low roughage diets and ingredients with different degrees of processing.

As I stated before, feed cost is the major cost in this production system. Ionophore (monensin) technology allows us to improve the nutrient utilization of the ration reducing the amount of feed needed to meet the requirements of our cattle. Therefore, monensin is included in our ration formulation with the exception of the ration we use to synchronize the estrus of replacement heifers.

The nutrient requirements of a cow-calf herd vary according to the reproductive stage of the herd. To accommodate this variation we modify the feeding level of each pen following a defined program. The different stages are:
- Pre-calving
- Calving to Weaning
- Mid-Gestation
- Growing replacement heifers
- Breeding replacement heifers
- Mid-Gestation First Calf Heifers

As we move from Pre-calving phase to Calving-Weaning phase we increase the feed level based on the percentage of the pen population that have calved, keeping a close look at the BCS of the individuals in the pen.

We have observed during the Mid-Gestation phase that even when the ration level is calculated to maintain BCS, the cows tend to improve their BCS. We believe that maintenance requirements are lower when the cows are kept in confinement, reducing their energy needs to exercise, collect water and feed. Right now we are working with Dr. Lallman graduate student Corbit Bayliff, from Oklahoma State University, to evaluate that reduction on nutrient requirements.

Bunk space is a critical factor on a limit feeding system, every group of cattle should be assigned the right bunk space on each production stage. Free and comfortable access to the feed bunk at
time of feeding for all the individuals in a pen, independently of their social dominance in the
group, is extremely important to keep BCS of the pen even. When this principle is not achieved
we start having individuals gaining BCS and others losing it, this forces us to sort the pens to
regain BCS on the less dominant individuals.

Cows in the Mid-Gestation stage can be assigned less bunk space than cows in the Calving to
Weaning stage, allowing an increase of total carrying capacity when running more than one
breeding season.

Calves start eating out of the feed bunks as early as 2 to 3 weeks of age; therefore, access to the
feed bunk should be addressed, at the same time, measures should be taken to avoid calves
crawling in the feed bunks.

Reproduction
No cow calf operation would be successful without clear reproductive goals and programs in
place. Reproductive success is the corner stone of a cow calf operation. Under grazing conditions
weather affects forage quality and availability during the year, affecting the nutrient balance of
the breeding age females adding volatility to herd reproductive outcome.

On a confined system, this variability disappears since nutrient availability is managed by us. By
taking out nutrient risk, we can set specific reproductive targets to be accomplished:
- Breeding season: 60 day
- Pregnancy rate: 94%
- 75% of females bred in the first 30 days of breeding.
- Productive cow life: 8 years
- Age at first calving: 24 months

Calf survivability is greatly affected by weather conditions at time of calving; pen surface offers
no protection against cold or hot conditions even when wind breaks, shades and bedding are in
place. One way to minimize this problem is to schedule calving seasons on the milder weather
parts of the year. At Syracuse Feedyard we have adopted three breeding seasons, two of them to
produce calves born in May-June and September-October and a third one to produce bred
replacement heifers to supply the strong market demand for bred heifers to grow the national
herd.

One of the greatest advantages of a confined cow-calf operation over an extensive pasture system
is the capability of managing large number of females in a short period of time with reduced
labor, reduced animal energy cost and low stress. This makes the implementation of a general
Fixed Time Artificial Insemination program (FTAI) simpler than on an extensive pasture system,
reducing the total bull population and investment, and allowing a faster genetic progress on the
herd.

Dr. Cliff Lamb from University of Florida and ABS have helped us to develop our
synchronization and breeding program. Dr. Lamb introduced us to an Estrus Synchronization
Planner that the Beef Reproduction Task Force has developed. This planner can be downloaded
for free from Iowa State University or University of Nebraska web sites. It is a simple and powerful tool to compare, budget and plan different synchronization alternatives.

Our reproductive program starts with a synchronization process that allows us to FTAI all the reproductive females at Syracuse feed yard. Replacement heifers have a different program than mature cows. The replacement heifer program is a Melengestrol Acetate (MGA) + Prostaglandin F2 Alpha (PGF) system, based on feeding MGA for 14 days, a withdraw period of 19 days, a shot of PGF, and then FTAI 72 hours after the PGF shot, with an injection of Gonadotropin Releasing Hormone (GnRH).

MGA is not labeled for use on mature cows for estrus synchronization; hence, we need to use a different program for our mature cow herds. The program elected is the 7 day Co-Synch + CIDR. This program is based on the application of a CIDR and an injection of GnRH at the same time, CIDR removal after 7 days and one shot of PGF at CIDR removal, FTAI 60 to 66 hours after the PGF injection with another shot of GnRH at the FTAI time.

Both systems are effective, but the MGA program has a lower cost per head and is simpler to apply on a dry lot situation. Every time we need to run cows or heifers through our processing facilities we increase the risk of an injury, stress on the cattle and the cost of operation. Unfortunately, MGA is not labeled for synchronization of mature cows and we cannot use it in that group.

One day after FTAI, we introduce clean up bulls for a period of 60 days at a ratio of one bull every 50 females or a 2% bull to cow ratio. Bull activity is closely monitored to detect social dominance issues and injuries.

Bulls are an important part of our reproductive success; we perform a Breeding Soundness Test (BST) and Trichomoniasis Test 45 days before the start of the breeding season. Our goal is to start the breeding season with our bulls in a BCS 5 or 6, so they can endure the effort of the breeding season.

Pregnancy determination is performed 45 days after withdrawing the bulls from the herds. Based on pregnancy age, herds are classified on Early Calving/AI groups and Middle to Late Calving/Bull bred groups to better manage the calving process. Any female open at the time of pregnancy determination is either sold to a packing plant (mature cows) or sent to one of our yards for feeding (replacement heifers). Pregnancy levels on mature cows range from 93% to 95% of exposed females and 92% to 94% of exposed replacement heifers.

BCS is an important indicator of the future reproductive performance of cows and heifers. Our goal on mature cow herds is to reach the calving season with an average BCS of 6; this allows our mature females to reach the breeding season with a BCS of 5 or above. On replacement heifer herds BCS should be 6 at the beginning of the breeding season.

One management practice available to improve reproductive performance is temporary weaning for at least 48 hours from the moment of the PGF injection until after FTAI. The lack of stimulus from the calf suckling activity on the dam’s udder allows the release of GnRH and
Luteinizing Hormone (LH), inducing ovulation and increasing pregnancy rates. One of the drawbacks of this technique is that the calves may lose performance if they are not used to eat from a feed bunk; this problem is solved in a confined operation since the calves start eating at an early age and they don’t lose production during the temporary weaning process.

Special attention should be paid to fencing when this technique is applied, temporary weaning is performed at the same time as the synchronization process and large numbers of females move around increasing the excitement of the weaned dams and pressure on fences. Several pens will be weaned at the same time, if fences fall down and pens mix, the process of returning the temporary weaned calves to their mothers would be impossible, forcing to early wean pens with no previous planning.

Another weaning technique is early weaning, taking the calves away from their mothers at early age is a powerful tool that reduces the total nutritional requirements of the dam and also has the same hormonal effect as the temporary weaning on the onset of estrus.

Once again, a confined cow-calf operation makes early weaning easier than an extensive grazing system since the calves already know how to eat from a feed bunk, making the transition easier on them. A study from University of Nebraska (UNL) (Klopfenstein et al. 2015) shows that the total production and feed consumed on two different treatments (early weaning vs. traditional weaning) didn’t differ when the same ration was supplied to both treatments. We have seen the same results, but, on this coming calving season we will use a different ration on the early weaned calves, formulated to better fit the nutrient requirements of the calves, in order to improve daily gain and feed efficiency with the goal of reducing the total cost per lb weaned.

Health Program
As we increase production intensity we face new challenges on the herd’s health, having a strong vaccination program helps prevent or reduce the incidence of infectious outbreaks.

Passive immunity transfer at birth through colostrum intake is a must to ensure a good start of the new born calf. Our vaccination program is directed to prevent reproductive diseases and to produce high quality colostrum with high concentration of antibodies to be transferred to the new born.

Replacement heifers are vaccinated with two doses of IBR, BVD, Pi3, BRSV, Leptospirosis, Vibrio and clostridium vaccines before their first breeding season. Mature cows receive an annual revaccination of the same vaccines and both groups receive a calf scours vaccine 45 days before calving.

Calves receive two doses of IBR, BVD, Pi3, BRSV and clostridium vaccines before weaning, with the first dose around 60 to 90 days of age.

BVD Persistently Infected (PI) individuals are continuously shedding BVD virus to the environment. In order to become PI a fetus has to be infected with the BVD virus before three month of pregnancy, as a result the immune system of the future calf doesn’t recognize the BVD virus as a threat and allows the virus to replicate. Identifying and eliminating any PI individual in
the herd is necessary to stop the spreading of BVD infection. Every purchased replacement heifer or new bull entering the herd is PI tested, as well as any raised replacement heifer before entering the breeding herd.

Internal de-wormers and pour on products are used to control internal parasites and lice population.

**Facilities**

Feedyard facilities provide the base to run a dry lot cow-calf operation, but, they have to be modified in order to be ready for this kind of production system.

Fences have to be modified to ensure that calves cannot move away from their home pen, as well as, feed bunk rails and cables to keep calves from crawling on the feed bunks, but at the same time, letting the calves access feed at early age.

Calves start drinking water as soon as two weeks of age, most of the water tanks are taller than a calf that young, therefore, measures has to be taken to assure access to the water. Normal measures are raising water level up to the upper edge of the tank and raising the ground with dirt around the tank.

Hot or cold weather effect on calves is magnified in the pens; we have measured ground temperatures above 140 degrees in the summer. In order to mitigate these effects, special structures should be built to provide shade areas where only the calves have access. Also, wind breaks and bedding will mitigate the effect of cold weather conditions.

As calves grow, their feed consumption increases and competition with their dams for feed bunk space increases too. Dedicating a feed bunk area just for calves is an effective way to address this problem. Creep feed type fences are built on a section of the feed bunk area letting us feed the calves independently from their dams.

Feedyard processing facilities have been designed to handle cattle from 400 lbs to 1350 lbs, handling 60 day old calves is a totally different challenge. Special working alleys, sorting fences and chutes have to be in place to handle pairs efficiently.

Calving difficulties are not more frequent than in an extensive system, but they will occur. This is other situation that the feedyard has not been designed for. Therefore, special facilities have to be in place to handle dystocias in an efficient way. Calving chutes and pairing pens must be built.

Weaning puts pressure on the fencing system of the feedyard, dams and calves will try to reunite in any possible way, cows jumping over low fences, breaking gates, calves crawling under fences or into feed bunks. Therefore, special attention should be paid to fence height, gate lock system, fence netting and bunk cables.
Personnel
Staffing a confined cow-calf operation requires finding people with a set of different skills. On one side you need the organization, routine and pace of a feedyard crew and on the other side you need the compassion, observation skills, flexibility and extra dedication of a cow-calf ranch hand. On a finishing feedyard operation, we set the schedule for the animals on feed, we can do the same at a cow-calf confined operation, but, there are several months of the year were the schedule is dictated by the cows. Calving, breeding, weaning are some of the activities where the schedule is dictated by the physiology of the cows and calves, not by us.

The number of employees per cow is lower than on an extensive cow calf operation, but, at the same time we need better prepared personnel that could handle the pressure and higher technology of an intensive system.

Challenges
As we grew our operation we found several questions and challenges:
- Total Mixed Ration or feeding concentrates separate from roughage
- Feed cost
- Limit feeding
- Protein supplied at different physiological stages
- Vaccination program
- Optimum weaning age
- Bunk space per head
- Sq footage per head
- Wind break system
- Shade system
- New born protocols
- Synchronization systems
- Handling of light weight calves

Most of these questions and challenges have been resolved, but, calf survivability during the first ten days of age is still a challenge we are working on. Neonatal calf diarrhea is the main cause of death during that period. Most of the available information on calf survivability comes from semi confinement systems where the calving occurs outside the yard, on grazing conditions, returning the cows to the yard when the calves are 60 days or older.

We calve in the yard, with high cattle concentration and little protection against weather conditions. We are still working on finding the most effective new born protocol to reduce calf morbidity and mortality at early age.

Future
This is an exciting time to be involved in the beef cattle business. Actual and new technologies, coming from inside of our industry and from other industries, are going to let us manage cattle on a totally different way in the near future. Individual identification systems (ID), genomic information, sexed semen, new synchronization protocols among other technologies will allow
us to increase the productivity of our herd and tailor our end product (weaned calf, culled cow, bred replacement heifer, culled heifer) to our customer needs.

More research is necessary on cow nutritional requirements when they are in confined environments. Calf survivability is another area of this system that requires more investigation and development of better protocols.

Summary

- Running cows in a year round confined system is a feasible alternative to traditional extensive cow calf production.
- Empty or sub utilized feeding facilities may be adapted for this production system.
- Young cattlemen may enter the cow-calf business with a lower capital need.
- Total control of nutrient supply allows setting specific reproductive goals.
- The nutrient requirements of a confined cow seem to be lower than of a grazing cow.
- Limit feeding works with no problem and reduces the total feed cost.
- Feeding level should change as the physiological stage of the cows change.
- Bunk space allocation is crucial to limit feeding success.
- FTAI can be applied on a large scale.
- Early and temporary weaning are useful techniques.
- Vaccination programs should be in place to prevent reproductive problems and to produce high quality colostrum for passive immunity transfer.
- Facilities have to be modified to handle pairs and young calves and to provide protection against weather conditions.
- Finding, retaining and training the right personnel must be a priority.
- Reducing calf morbidity and mortality during the first ten to fifteen days of age is an ongoing challenge.
- Actual and new technologies will allow us to reduce our production cost and at the same time add value to our end products.

Literature cited

Did I just do research or was it simply a feedlot show and tell?

R.H. Pritchard
Department of Animal Science, South Dakota State University

Introduction

If a producer decides to use an alternative vaccine or a competing company supplement on a pen of cattle to “see how it works” we might call that a Comparison. If university personnel get involved with a producer that has paired 2 pens of cattle and they feed one pen with, and one pen without a GMO, we might call that a Demonstration. If an academic has 20 steers that are being fed in an automated individual intake system and tallies the data in Proc Mixed we would call that research.

If the Comparison example was upscaled to a larger feedlot and included an entire alley of pens is it now research? If the Demonstration example used 2 sets of paired pens do we elevate that to the new administrative term of Applied Research? If the 20 steers fed in the intake system were used to test the effects of 4 ionophores on DMI and carcass Quality Grade is that really research?

Basically we have 3 overarching principles for qualifying the contrasting of independent variables as research. First, we expect the treatments to be randomly assigned to the experimental units. Second, we expect there to be multiple experimental units on each treatment. Third, we expect (often simply assume) that the experimental units will be managed similarly and without bias. These 3 principles are important, but there are nuances to applying definitions to random application, experimental unit, and bias that distinguish a work as quality research.

When a graduate student finally gets their first SAS job to run they oftentimes perceive the Output to be evidence that they have properly executed the appropriate statistical analysis for their research. We teach them that having an Output and a proper AOV are not necessarily synonymous. At the end of a cattle feeding exercise we still have most of the cattle. We have data that may include BW, feed records, and carcass traits and we execute a properly structured AOV. At this point we still have merely the equivalent of the SAS Output. There remains a question as to whether these data and the interpretation constitute meaningful research.

Quality of Research

We all have a vested interest in finding meaningful advances for the cattle industry. Over the years I have designed research with a focus on replication to drive sensitivity. After all, sensitivity noted as $P < 0.05$ is needed for talking points and journal publications. In our discipline there is much less discussion about reproducibility of results. Rather than being concerned about the lack of reproducibility we shift the focus and begin to seek out other factors that may be involved in the outcomes. That is an understandable behavior because those “other factors” become the subject of new research projects. To a degree the lack of reproducibility of research results is actually feeding the research machine. It is a form of job security. Wolfe (1991) addressed this possibility with his 4th Law of Thermodynamics that “the emotion in scientific discussion increases proportionally to the softness of the data being discussed”.

80
MacLeod et al (2014) estimated that 85% of research resources are wasted. Wasted did not mean inefficient or misappropriated funds. Wasted meant the resources were used to generate research publications that were not reproducible, presumably because they were fraught with Type I and Type II errors. How is it that we get away with publishing all these errors? Nuzzo (2014) suggests we go down this road because of a mislead faith in the $P$ value. Nuzzo (2014) points out that $P < 0.01$ has an 11% probability of not representing a real difference (depending upon the underlying probability that there is a true effect). A $P < 0.05$ actually has a 29% probability of not being real. The math behind this is over my head, but I’ve seen this happen often enough in my own data to appreciate the point that they make.

Ioannidis (2005) charged that many of our research findings are nothing more than accurate measures of the prevailing biases in the discipline. He also provided 6 corollaries regarding whether research findings might be true:

1) The smaller the studies conducted in a scientific field, the less likely the research findings are to be true.
2) The smaller the effect sizes in a scientific field, the less likely the research findings are to be true.
3) The greater the number and the lesser the selection of tested relationships in a scientific field, the less likely the research findings are to be true.
4) The greater the flexibility in designs, definitions, outcomes, and analytical modes in a scientific field, the less likely the research findings are to be true.
5) The greater the financial and other interests and prejudices in a scientific field, the less likely the research findings are to be true.
6) The hotter the scientific field (with more scientific teams involved), the less likely the research findings are to be true.

If one contemplates these corollaries in the context of our perpetual arguments that we have about grain processing, roughage levels, trace minerals, fetal programming, you can see where Ioannidis was going with this essay.

**Approach to Cattle Feeding Research**

Where do we look for guidance on doing reproducible research? The closest source I could find for guidance on generating reproducible results was the lab. Analytical Chemistry is based upon methodologies and procedures that emphasize the ability to generate reproducible results. It is an interesting exercise to pose the challenge “Do the expectations for cattle feeding studies match the expectations for lab assays?”.

There is a litany of comparisons that could be made between successful lab assays and a successful cattle feeding study. Some of the comparisons seem quite obvious once you think about them. Others may be more of a stretch of the imagination, but nonetheless worth consideration.

**Lab Rule # 1**

For any lab assay we must first verify or validate our assay capability. For our cattle studies, that means the facility has proven that it can measure an expected response. If I want to estimate the
NEg value for a feed, I need first to validate that I can measure the difference between two feeds with known NEg values such as Whole Shelled Corn (NEg=68) and High Moisture Corn (NE=71). In doing so, it is important to be cognizant of Ioannidis (2005) charge of accurately measuring the prevailing bias in the discipline. If 3 research sites that have never done this validation step were to conduct studies to determine NEg values for WSC to DRC based diets what will happen? The point the cited statisticians were making in the Quality of Research section was that these 3 studies would likely find differences (i.e. $P<0.05$) in some of the many variables they measured in the course of the studies and, those findings would likely not be consistent across the 3 studies. Sound familiar?

**Rule #2**

Lab assays include reruns. Sometimes reruns are necessary for only selected samples; sometimes we ask a grad student to repeat a complete run. When reruns are necessary the bad data are destroyed. Cattle feeding studies are probably no different. The assay goes wrong sometimes and the study needs to be dumped. Finding a $P<0.05$ is not our proof that the assay worked. Unfortunately the cost of cattle feeding studies, the time and resources needed for a rerun, the demand for publications, and marketing needs mean that Rule #2 is seldom applied. So seldom is it applied, I am not familiar with any standards for deeming a rerun to be in order for animal data in a cattle feeding study. Don’t expect this to change any time soon.

**Pipetting – Bunk Management**

Both represent the allocation of the unknown to the assay vessel. Pipetting takes practice. So does making proper feed calls and accurate feed deliveries. I’m not sure of what laboratory action is analogous to a self-feeder.

**Chemicals – Diet Ingredients**

Lab assays specify the quality of chemicals to use and are sensitive to changes. The commodities are our chemicals. Specifications matter and they will vary. The variation, whether it be particle size, test weight, DM, CP, ash, EE, starch, or NDF must be understood and it is important to recognize whether they are nominal or critical to the test. We should be careful that these are insightful determinations and not based upon ruminant nutrition cliché.

**Reagents – Mixed Diets**

Reagents must be properly prepared including specific chemicals, sequencing of ingredients, mixing time… (or you buy them from Sigma). They must be fresh and stable. The same issues apply to mixing diets. There is an effective way to make the reagent or diet preparation. If the chemicals change, there is a strong likelihood that the preparation process changes. Never have I had a reviewer ask for verification of this.

**Homogeneity of Samples**

There are aspects of homogeneity of the samples inputted into the test as well as the samples collected during the test. Samples can include Diets or Ingredients. The plasma sample used in the blood glucose assay is homogenous. We take more care to get a homogenous sample from the rumen, and even more steps to get a representative commodity sample from a feed bay. In terms of the input side of a feed test, imagine the differences that exist in cattle feeding studies evaluating WDGS if loads are received daily, or weekly, or all at once and bagged-stored. Those
three WDGS studies are actually not making the same evaluation. It would be bad form to run a standard curve using reagents from Sigma and then to run the unknown samples using reagents from Fisher. Pooling data from these 3 studies may be effectively doing just that.

The populations in our pens are another concern on homogeneity of samples. Does the research facility definition of “uniform” refer to origin, BW, age, breed, or genotype? The degree of variation among animals in a pen is rarely characterized when pen is treated as the experimental unit. Our current state of the science is that the variation within pen can be quite large as long as we use enough cattle and enough pens to make manageable the variation among pens within a treatment. Pen head counts and allotment strategies can be manipulated to control the variation among pens. These steps increase sensitivity, but won’t necessarily contribute to reproducibility of results. Very limited numbers of very uniform cattle, as might occur with individual feeding studies, can be extremely sensitive and at the same time significantly biased. Some types of data generated from testing within a very specific population can be extrapolated to the greater feeder cattle population while other types of data would not suitable for this extrapolation.

We recognize that genotype, or some other mechanism, can have a major impact on the response variable of interest. Good research requires that these factors be balanced across our treatments. Unfortunately we are often blind to these considerations, leading us to invariably do allotments primarily on the basis of BW. Under these circumstances if the numbers of cattle per pen or per treatment are quite small, randomness is not always our friend. As an example for perspective, the allotment based upon BW may be appropriate for studying the impact of a nutriceutical on growth efficiency but may include allocation bias (due to imbalances of genotype) if carcass marbling is the dependent variable.

**Instrument Bias – Pens and Scales.**

Not all wells of the block digester heat the same and not all shelves in the oven dry the same. In the feeding facility all pens are not equally impacted by environment and management. Consequently, random assignment of treatment to pens will impose bias. We don’t use a 1 ml pipette to pipet 10uL samples. In our feeding studies what is the acceptable window for error on dry matter delivered per head in a pen? A commercial 250 head pen fed an 80% DM diet, using scales with 20 lb breaks and no wind have a precision of 0.03lb DM/head. With 3 deliveries per day the total error could be 0.10 lb DM/head. It is unclear whether this is the correct increment, but it is a reasonable benchmark in that it mimics commercial precision. With wind it could jump to 0.14 lb/hd. Equivalent precision for a 4 head pen fed once daily would require scales with 1 lb increments. Feeding the 4 head pen twice daily would require scales with 0.5 lb increments to have comparable error rates to the 200 head pen. The feed allocation weighing conditions would have a dramatically greater impact on precision in the low population pens.

**Standard Curve – Control**

A standard curve is necessary for each assay run even though an assay has been validated in the lab. Feeding studies cannot afford the pens and cattle to run standard curves, but they do need a known variable Control. This can be part of the treatments. In a factorial arrangement of treatments for comparison of flaked milo or flaked corn fed with or without WDGS, the milo vs corn main effect contrast can serve as the Control. If the known responses are not evident in the results, then the assay did not work and any potential WDGS effects observed become moot. To
study anabolic agents, a no anabolic treatment contrasted against a positive control known anabolic confirms the assay for evaluating the unknown anabolic.

**Quality Control – Nothing**
The lab may expect duplicate dry matter determinations to agree within 1.25%, PUN triplicates to agree within 5%, and duplicate runs of ADF of finishing diets to agree within 10%. What level of repeatability for feed/gain or HCW is expected for the pens within a treatment for a cattle feeding experiment? Nothing. The expression “enzyme in excess” may be the best analogy for ad libitum access to feed. The units of activity of the enzyme are easily characterized. Ad libitum access to feed could only be when bunks are never slick. Since most feeding involves clean or slick bunk management (which certainly seems appropriate to me), what is the slick days pattern that confirms intake was not limited? Nothing. How many times can intakes crash for a given pen before data for that pen are no longer valid? Nothing. What percent change in DMI constitutes an intake crash? Nothing. Blinding to treatment is frequently impossible because the crew can see the difference between whole and flaked corn. Data integrity and verification is a matter of each to his own unless you are involved in a clinical study.

**Pen Size**

The first obvious problem with trying to compare pen size is that pen size is confounded with industry and academic sources of data. An obvious source of confounding is pen size and feed caller experience. An inexperienced feed caller could impact research outcomes. Since universities teach, then universities probably have more data from inexperienced feed callers. Universities are coincidentally predominately small pen facilities. It is not valid to connect these points and conclude that small pens are generally inferior to large pens for cattle research. If one looks to award the 6 corollaries associated with false research outcomes to either group it might look like the information in Table 1.

**Table 1.** Corollaries about probabilities that research findings are false.$^1$

<table>
<thead>
<tr>
<th>Corollary</th>
<th>Risk Factor</th>
<th>Industry</th>
<th>Academic</th>
<th>Individual Intakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small samples</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Small effect sizes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Extra comparisons</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Protocol exceptions</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Financial interest</td>
<td>✓</td>
<td>Growing</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>What’s sexy today</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

$^1✓$ indicates a susceptible category.

Dilution is the solution to pollution error. Large pens by virtue of the numbers of animals involved gain precision in the estimate of pen mean BW and the amount of feed delivered and will have a smaller $S_e$ when pen is the experimental unit. This is independent of how homogenous or heterogeneous the feeder cattle population is in the studies. These characteristics increase the sensitivity of the large pen study and this can cause the perception that large pens are better. However this sensitivity probably comes with a cost of lower reproducibility. The broader sampling of the population in the large pen studies may attenuate false outcomes to some
degree, but will not eliminate them. Conversely, by virtue of requiring fewer cattle, small pens can impose tighter specification for research targeting a specific animal type (age, breed, BW, flesh); smaller pens are oftentimes better able to capture individual data (except DMI) that can produce important insights.

There is a multitude of these point-counterpoint issues. In the end it can be distilled down to there being a need for the large pen, small pen, and individual intake models. Each model has particular strengths for specific types of research. Each model also has critical weaknesses that make them unsuitable for some types of research. To this end it would be best if we would learn how to use these models in an integrated strategy of research rather than debating which model is better (Wolfe’s 4th Law of Thermodynamics).

The following outline is an example of respecting the limitations described in the 6 Corollaries of Ioannidis (2004) and capitalizing on the strengths of each of our research models in a sequential fashion to “determine whether magic oil A will improve Quality Grade and Heath in feeder cattle”.

**Individual Intake Model**
Treatments: Control- 0 ppm Magic Oil A; Target- Expected dosage of Magic Oil A; and High- and dosage in excess.
Purpose: Primary - proof of concept. Secondary - observing for ancillary effects and unintended consequences.
Test variables: gene expression and/or regulation in adipocytes and immune system where daily individual dosage is known.
Off limits variables: Conclusions about “A” impact on growth rate, growth efficiency, IMF, and health.

**Small Pen Model**
Treatments: Dosages (4 or 5) that range from 0 ppm to some level greater than Expected.
Purpose: Primary - to confirm that no adverse effects are evident. Secondary - test for favorable outcomes of targeted response variables.
Test variables: Dose titration against ADG, DMI, F/G and marbling. Appropriateness of testing for a Categorical shift in YG and QG are questionable, being dependent on the number of cattle involved.
Off limits: Health. At best, health information is only anecdotal.

**Large Pen Model**
Treatment: Control and Targeted Dosage
Purpose: Primary - Morbidity and Mortality, Quality Grade distribution. Secondary – growth rates and efficiencies.
Off limits: Prescribing definitive changes in conclusions regarding optimal dosage, and DMI, ADG, or F/G responses because of the high risk of false positive findings.
What is and is not Research?

Hopefully this overview has provided some new insights or perspectives for answering the original questions about what differentiates Comparisons, Demonstrations, and Research. As long as the comparison includes 2 observations per treatment, and we try to be fair, the comparison meets the most liberal constraints of research. Further conditions or constraints go to the integrity and value of the research. The most stringent standard for defining quality research is reproducibility. Since our Experiment Stations and our scientific journals frown upon duplication of research, the test of reproducibility will have to come from industry. This could be in the form of formal collaborations, or as independent work. In either case it is very important to recognize the strengths and weaknesses of our data and our science.

It is by design that this essay has avoided addressing details regarding the application of methods. This simply wasn’t the forum for a very important subject. I will take time to strongly advocate for greater communications and transparency regarding our methodologies. We inherently default to an assumption that we are all using similar or equivalent methodologies in the logistics and mathematics of our research. We should probably be more cautious about making those assumptions because they may not be true. Once we get past the assumption phase we need to approach divergent methods as a two-way test. The two-way test offers protection against error based on assuming our methods are always the better methods. Good science is full of useful surprises.

Literature Cited

Experimental Design and Statistical Considerations for Feedlot Studies

Michael A. Ballou¹, Michael L. Galyean, and Matthew D. Sellers
College of Agricultural Sciences and Natural Resources
Texas Tech University, Lubbock

Why Do We Need Statistics?

In a broad sense, data are collected because we hope to use it to draw conclusions about hypotheses and relationships, and to help us establish best practices for using new products and management techniques. Sources of data include historical records, surveys, controlled experiments, observations, or other databanks (e.g., published literature). These data can either be numerical (e.g., average daily gain or feed:gain) or categorical (e.g., healthy vs. diseased or quality grades). Data sets, particularly those derived from commercial settings, often include hundreds to tens of thousands of observations, and statistical analysis is a tool to help us draw meaningful conclusions and better understand the population from which the data were sampled. Very often, large amounts of data are reduced down to 2 important measures: (1) central tendency; and (2) dispersion. Typically measurements are taken with the intention of comparing different groups (treatments) to test whether there is some difference. In addition, the relationship or association between variables is often of interest (e.g., the relationship between weaning weight and average daily gain during finishing). Therefore, statistics gives us a tool to capture the important points about a large amount of data without sacrificing critical information, thereby allowing conclusions to be made.

Sampling is an important concept in statistics. It is time- and cost- prohibitive to collect data on an entire population, so a sample is usually taken from the population of interest, and inferences are made about the population. An inference is the process of using logic to reach a conclusion (e.g., we make a conclusion about the larger population based on the characteristics of our sample). Therefore, statistics are used to help make inferences. More often than not, statistical methods in animal science are based on null hypothesis testing. The null hypothesis essentially states that there is no difference between or among measurements. Examples include no difference: between 2 or more treatment means; between an observed value and a hypothesized value for a population parameter; between the slope of a regression equation and zero (or some other specific value); or between (or among) the distribution of observations in discrete categories. In null hypothesis testing, competing hypotheses, the null and alternative hypotheses (i.e., there are differences), are formulated. Data are collected from a sample of the population of interest, and the likelihood of observing particular outcomes relative to the null hypothesis is mathematically derived. If the likelihood of the data being observed given that the null hypothesis is true is very small, the investigator might choose to reject the null hypothesis (i.e., is there enough evidence in my sample that the null hypothesis is highly unlikely?). Rejection of the null hypothesis does not “prove” that the alternative hypothesis is true (or not true if we fail to reject the null hypothesis); statisticians live in the world of probability, not proof.

¹Contact information: Goddard Building, Suite 108, MS 42123, Lubbock, Texas 79409; P: 806.834.6513, F: 806.742.2836, Email: michael.ballou@ttu.edu
Similar to the judicial system, 2 types of errors can be made with inferential statistics. These are referred to as Type-1 ($\alpha$) and Type-2 ($\beta$) errors (Figure 1). Two conclusions can be made in a statistical test: reject the null hypothesis or fail to reject the null hypothesis (like the judicial system, not guilty or guilty; note that there is no innocent verdict). If at the population level the null hypothesis is true and we fail to reject it, we made the right conclusion; however, if the null hypothesis is false and we fail to reject it, we committed a Type 2 error. A Type 1 error is made when we reject the null hypothesis, when in fact at the population level, it is true. By their very nature, null hypothesis testing and the judicial system must allow one type of error to be “more acceptable” than the other. In most experiments conducted by animal scientists, the scientist is more willing to accept a Type 2 error (i.e., it is more acceptable) than a Type 1 error. Similarly, the US judicial system favors the release of a guilty person over incarcerating an innocent one (i.e., innocent until proven guilty). Type 1 error rate, referred to as the alpha ($\alpha$) level, is normally set at 5%, whereas the Type 2 error rate is commonly set at 20%. The Power of a statistical test is defined as: 1 – Type 2 error rate, where the Type 2 error rate is $\beta$). Thus, in the case of a $\beta = 20\%$ the Power would be 80%. In plain English, this means, “If a difference truly exists in the population, there is an 80% probability this study will find that difference.”

Finally, it is important to note that there is a possibility of an error in every statistical test performed, and that the error of multiple tests is compounded. A tightrope walker provides a good analogy of this compounding effect. If there is a 5% chance of falling every time someone walks across the tightrope, would the person that walks the rope once or the person that walks it 10 times have the greater chance of falling? Similarly, if we measure enough variables or perform enough statistical tests, we will find something that is “different”, regardless of whether it truly is different. Controlling for these “family-wise error rates” takes into account the compounding of error in multiple statistical tests and makes an adjustment for a reasonable error for the group or ‘family’ of tests. There are many different adjustments that can be imposed, with a few of the more popular including the adjustments devised by Tukey, Bonferonni, and Duncan. These adjustments generally work by making each individual statistical test more conservative against making a Type-1 error, so that the overall error rate of the multiple tests is still reasonable.

**Sampling and Parameter Estimation**

**Measurement**

For any type of experiment, the person conducting it (the investigator) needs to consider a variety of issues long before the experiment is actually conducted. Of particular importance are questions about the type of measurements that will be made, the tools of measurement, and the precision of the measurements. In studies with feedlot cattle, these questions are especially noteworthy, as there is a temptation to think “This isn’t rocket science – we are just feeding cattle.” The reality is that to obtain the highest quality of the experimental results, investigators will produce far better outcomes if they treat what they are doing like rocket science. Thus, ensuring that tools for measurement (feed mill scales, feed truck scales, animal scales) are properly calibrated and regularly validated is essential to achieving good results. Giving consideration to measurement error also is important. For example, if the scale and load cells on a feed delivery system have a 5-lb readability, the error is 5% on a 100-lb delivery. Investing in “finer” load cells or increasing the number of animals in the pen to increase the feed delivered
and thereby decrease the error would be good choices. Similarly, regularly evaluating the quality and composition of dietary ingredients, as well as the consistency of processes used to mix and deliver feed or measure animal weights is critical. Quality of feed mixing should be tested regularly, with consideration for mixing efficiency across the range of batch sizes that might be encountered in an experiment. Similarly, checks on the accuracy and precision of feed delivery systems need to be considered. If slope at the point of delivery varies among pens, mobile systems (e.g., PTO-based feed mixers) should be tested for accuracy of delivery across the range of slopes. Likewise, mixer clean-out and the possibility of cross-contamination need to be considered. Indeed, there are so many sources of measurement error, many of which are unique to a particular experimental feedlot, that the investigator should think through these potential errors and test them in practical settings before an experiment is conducted. Unless such issues are considered, the risk is that bias could be introduced that would lead to the wrong conclusion (i.e., Type 1 or Type 2 errors).

**Sampling**

There are many things to consider regarding the sample that is taken from the larger population of inference. It should be representative of the larger population, should not be biased in any way, and the act of sampling should not change anything about the population. When the dependent variable is a subjective measurement, the investigator should not know the identity of the treatments (i.e., they should be “blind” to treatment) to prevent bias. The simplest way to sample is to collect a random sample, which means that every unit within the population has an equal opportunity of being selected.

The concept of experimental unit is related to sampling. The experimental unit is often defined as either the smallest unit to which the treatment is applied or the unit on which the measurement is taken. In most feedlot studies, individual animals are often assigned to pens to which the treatment is applied. Thus, the experimental unit is often considered the pen, and the animals within the pen are referred to as sampling units.

When the objective of an experiment is to test the null hypothesis that no difference exists among various treatments, the experimental units are generally arranged in a design that allows for the desired treatment comparisons. A completely randomized experimental design (CRD) is an example of a design in which the experimental units are applied to different treatments randomly, so that each experimental unit has an equal opportunity of being assigned to any of the treatment groups in the study.

Blocking is common in many experimental designs and refers to the arrangement of experimental units into groups that are similar to one another. The decision to block is based on information that the blocking variable could influence the primary outcome variables in the study (e.g., initial body weight influences average daily gain or feed:gain ratio [F:G]). The goals of including a blocking factor are to control for a possible confounding factor and to decrease the residual variation in the data. Very often blocking is combined with completely randomizing, which results in randomized block design (RBD) experiments. In most feedlot studies, the blocking factors are not of any inferential interest (e.g., no conclusions will be made regarding the blocks), but they are included in the statistical model because they explain some nuisance
variation, which ultimately will improve the accuracy of our population estimates and potentially increase the power of the experiment. This will be discussed in more detail below.

**Estimation**

Estimation is calculating a statistic, often the mean or standard deviation, which is an approximation for the corresponding parameter from the population from which the sample was drawn. Point estimates and confidence intervals are common types of estimation. A point estimate is a single value, whereas a confidence interval takes into account the level of certainty of that point estimate. With random sampling and consideration for issues of measurement bias noted previously, the sample mean is an unbiased estimator of the population mean. Let’s suppose there are a 1,000 heifers on a ranch and we want to know some aspect about the population. Rather than measuring the body weight of all the cattle, a sample of 10 animals could be used to estimate of the mean body weight of the entire population. Knowing that the mean body weight is 700 lb gives us an idea about of the population of heifers. If another random sample of 10 animals is drawn from the same ranch, is it likely that these 10 heifers would have the same mean body weight as the first 10 sampled? Although this might be possible, most of us would not consider it likely. The reason the 2 means will likely not be identical is because of random variation in the sample. The important point about sample-to-sample variation is that we can use this random variation to construct a confidence interval or to test the null hypothesis. We can obtain an estimate of this random variation in our sample mean, called the standard error of the mean (SEM), from the standard deviation (SD) of our sample and the sample size as follows:

\[ SEM = \frac{SD}{\sqrt{n}} \]

You can see from the equation how both the SD of the sample, and the sample size influence the SEM. The 2 ways to decrease the SEM, and thereby decrease the width of a confidence interval or increase the power for testing the null hypothesis, are to decrease the SD of the sample, which reflects the sampled population or increase the sample size. Why does increasing sample size decrease the SEM? If samples were repeatedly drawn of n = 10 or n = 50 from our population of 1,000 heifers, which sample would have a greater likelihood of being a more accurate estimate of the population? **Figure 2** shows the sampling distribution for 1,000 independent samples of size n = 10 or n = 50. Notice that the means of both sampling distributions are the essentially the same, which is equal to the mean of the 1,000 heifers that make up the larger population that these data were sampled from = 695.6 lbs. But notice how the distribution is wider for samples of n = 10, which is reflected in the larger SD of 18.13 vs. 8.45 lb with samples of n = 50. The SD of the sampling distribution is equal to the SEM. Notice the mean variances of each sample, denoted \( \sigma^2_{\text{Within}} \), are similar for both sample sizes with an average of 3,491 lb. The SD of the sample can be estimated as the square root of the variance, which is 59 lb; therefore, we can estimate the SEM for both sampling distributions as: 59/3.2 = 18.4 and 59/7.1 = 8.3 for n = 10 and n = 50, respectively. Notice how close this is to the estimate we received for the SD of each sampling distribution in **Figure 2**. The confidence interval takes the SEM and multiplies it by a reliability coefficient, which essentially is how many SD +/- away from the mean encompasses 95% of the area under the curve for a 95% confidence interval. The reliability coefficient for a 95% confidence interval is approximately 2, and it is a relatively straightforward calculation mean ± (SEM x 2), which can be confirmed from the confidence intervals of both figures. The reliability coefficient for a 99% confidence interval will be greater because it reflects the number
of SD +/- away from the mean that encompasses 99% of the possible values that the sample mean could be based on.

Statistical Significance
The SEM or residual variation is central to null hypothesis statistical testing because it gives us an idea of how confident we can be in our estimate. Using our example from above with a sample size of \( n = 10 \), what is the likelihood that we would get a sample mean less than or equal to 650 lb? We can actually calculate the exact probability, which is how the \( P \)-value of a statistical test is calculated, but just looking at Figure 2, we can see that it would be very unlikely. Therefore, if we are testing the null hypothesis that \( \mu = 696 \) lb, and a sample mean of 650 lb is observed, the appropriate statistical conclusion would be \textbf{Reject} the null hypothesis. This is because if the true population mean is 696 lb (i.e., null hypothesis is true) it would be very unlikely to get a sample mean of 650 lb. Similarly, the probability of getting a sample mean of 675 lb with a sample size of \( n = 50 \) is unlikely, so we would \textbf{Reject} the null hypothesis with this sample. In contrast, the appropriate statistical conclusion for the same sample mean of 675 lb, but from a sample size of \( n = 10 \) would be \textbf{Fail to Reject} the null hypothesis. This is because the likelihood of observing a sample mean equal to 675 lb given a sample size of \( n = 10 \) is not sufficiently large to protect against a Type 1 error. Therefore, although the magnitude of the difference (known as the \textit{effect size}) between the hypothesized value of the population mean and the observed sample mean are identical (i.e. \( 696 - 675 = 21 \) lb), for these 2 scenarios, we come to different statistical conclusions. This reiterates that statistical significance is based on the likelihood of observing a sample mean given that the null hypothesis is true, and it does not give any information regarding the effect size of the difference (i.e., how large is the difference). In plain English, “Statistical significance examines whether the observed difference was a result of random chance, and if the difference was not likely caused by random chance, the treatments are statistically different, regardless of the biological size of the difference.”

Experimental Design Considerations

Influence of Pen Size
Although pen is almost always the experimental unit in feedlot studies, such studies are conducted with a variety of pen sizes (i.e., number of cattle per pen). Common sense would suggest that as the number of cattle per pen increases the variation between pens should decrease. This is similar to the example of how a sample size of \( n = 50 \) yielded a more accurate estimate and resulted in a lower SEM than a sample size of \( n = 10 \). \textbf{Figure 3} depicts the sampling distributions for F:G for pen sizes of \( n = 4, 20, 100, \) and \( 200 \). One thousand samples were taken for each pen scenario from a single population of cattle with a mean F:G of 5.29. Notice the mean of the sampling distribution is the same for all pen sizes, which is equal to the population mean from which the samples were drawn. This reiterates the fact that the sample mean is an unbiased estimator of the population mean. In addition, the average within pen variation (\( \sigma^2_{\text{Within}} \)) is similar across the different pen sizes. The major difference is evident in the between-pen variation (\( \sigma^2_{\text{Between}} \)). Clearly, as the number of animals per pen increases, the between-pen variation decreases. The result is decreased random pen-to-pen variation, which is generally the random variation used in the statistical tests of hypotheses in feedlot studies in which the experimental design is a CRD. The effect of animal numbers within pen is also observed in the decreased SEM and size of the 95% confidence interval of the sampling distribution.
It should be noted that these comparisons are based on the assumption that the variation in F:G of individual animals does not change as we increase the number per pen. This is not an easy assumption to test, and one might argue that increasing the number of animals per pen could alter competition for space at the feed bunk or modify social interactions in such a way that individual variation in F:G actually increases as number of animals increase in the pen. If that is true, the differences noted in between-pen variation in Figure 3 would be decreased, but still likely less with increasing pen size.

When cattle are assigned to pens and treatments in an experiment, there are unrecognized traits, such as genetic merit, source of cattle, or previous health status, that might influence their response in the study (e.g., cattle with previous incidence of respiratory disease are known to have decreased performance in the feedlot). The variation in assignment of cattle with these traits to pens also increases the pen-to-pen variation, and this effect will be greater in smaller pens. Table 1 shows the sampling distribution for the allotment of cattle with an unrecognized trait to a pen size of 4, 20, 100, or 200. The proportion of cattle in the population with the unrecognized trait is 0.35. As pen size gets larger, the SEM and consequently the CV and the 95% CI, become smaller because there is less pen-to-pen variation. For example, consider a pen size of 4 vs. 100. The 95% CI for the pen size of 4 is [0, 81.8%], indicating the range in cattle in the pen that would have the unrecognized trait that could influence the dependent variable. In contrast, the 95% CI for the pen size of 100 is [25.7, 44.3], suggesting that the effect of the unrecognized trait on the performance variable of interest would likely be less with larger pen size.

Therefore, one result of increasing the number of animals per pen is that fewer pen replicates are required to observe a fixed difference in the effect size between any 2 treatments applied to the cattle in a study; this reflects the decreased pen-to-pen variation with increasing pen size. Figure 4 shows the relationship between the number of pens per treatment and the mean $P$-value from 500 individual $t$-tests for each combination of cattle per pen and the number of pens per treatment. The samples for the 2 treatments were drawn from 2 separate populations with a known effect size of 3% in F:G, a 9% coefficient of variation for individual cattle within each population, and a fixed $\beta = 0.20$. These data reiterate that the same level of protection against making a Type 1 error can be achieved for a similar effect size, regardless of pen size; however, it is going to require more pen replicates for pens with fewer animals. Whatever pen size is chosen, it is important to determine the number of pens required to detect a biological effect size when designing a study. One needs an estimate of the effect size, SD of the dependent variable among experimental units, and the probability of performing Type 1 and Type 2 errors to determine the appropriate sample size. As the effect size difference becomes smaller or the SD of the samples increases, the number of pens required per treatment will increase, given a fixed probability of protection from Type 1 and 2 errors.

Although less pen replicates are required per treatment with larger pens, the total number of cattle in a study will most likely be greater in larger pens. For example, approximately 30 pens per treatment are required for a pen size of 4 or a total of 120 cattle per treatment, whereas 3 pens per treatment are required for a pen size of 100 or a total of 300 cattle per treatment for the example described in Figure 4. Therefore, smaller pens of cattle may be preferred when the total number of cattle or the available facilities in a study warrants limitation. Some research scenarios that favor smaller pens might include: (1) evaluation of a new product (e.g., preliminary data
before larger-scale testing); (2) evaluation of a treatment with potential adverse outcomes; (3) analysis of dependent variables that are either labor intensive or expensive to measure; and (4) experiments when interactions among treatments (beyond a simple 2 x 2 factorial arrangement) might be of interest.

An argument for studies with larger pen sizes is that they reflect the “real world” situation better than smaller pens. There could be some truth to this because animal-to-animal interactions in smaller pens are potentially different than in larger pens. Moreover, it is conceivable that management of these larger pens is more similar to that observed in a commercial feedlot; however, this is likely only the case if the experiment was designed to manage these cattle like a commercial pen of cattle. Very often data are collected in experiments, small or large pens alike, which would not be collected on a commercial group of cattle. The cattle are often handled or manipulated to collect those data in a way that does not reflect conditions of a commercial pen of cattle. Thus, the statement that larger pen studies closely reflect the “real world” situation is likely an over generalization. Further, “real world” for one feedlot is not the same as in others. It also is noteworthy that treatment responses (effect sizes) measured in small and large pens that have reported in the literature are often very similar. A recent example of this is illustrated by the effect size between a Control vs. a β-agonist-treated group of cattle in small- or large-pen studies. In the small pen study (5 animals per pen) reported by Vasconcelos et al. (2008), feeding zilpaterol hydrochloride for 20 d yielded and effect size for hot carcass weight of 37.9 lb. In the Elam et al. (2009) report, which involved cattle fed in pens ranges from approximately 70 to 100 animals per pen in “commercial” settings, the effect size for hot carcass weight was 30 lb. Certainly, there is no loss of ability to detect comparable effect sizes in smaller pens, and the ability to detect significant differences was similar with adequate replication (28 pens per treatment) in the smaller-pen vs. the larger-pen study (6 to 7 pens per treatment over 4 locations). There is considerable random variation in every study, regardless of whether cattle are in small or large pens. The goal of the investigator should be to minimize that random variation, so that estimates of population parameters are more accurate and meaningful conclusions can be drawn from the data.

There are clear benefits of large-pen studies when measuring data collected on either a binomial or ordinal scale. Data collected on a binomial scale have either a “Yes” or “No” type of outcome and include events such as: live/dead; treated/untreated; pregnant/open; and diseased/healthy. Ordinal data consist of numerical scores, and in feedlot studies, include variables such as quality or yield grades. In addition, large pens of cattle are favorable when one desires to represent or consider a subpopulation of cattle with a very low frequency of occurrence. The benefit of using large pens to evaluate these variables or scenarios occurs primarily because, as noted previously, more total cattle are commonly included in these studies.

The sampling distributions for a binomial variable such as (Choice or better) for pens sizes of 4, 20, 80, 100, 200, and 400 are shown in Table 2. All data were sampled from a hypothetical population with a Choice or better proportion of 0.60. Notice that the mean of all the sampling distributions approximates the true population mean of 0.60. As the pen size gets larger, the SD of the sampling distribution, the SEM, and consequently the coefficient of variation decreases. Therefore, as pen size gets larger, each individual pen is a more accurate estimate of the true population mean. If conducting a small pen study (e.g., 4 cattle per pen), the SEM in the
Statistical analysis will be less than the 0.243 shown in Table 2 because it will account for the total number of pens that went into that estimate. The SEM shown in Table 2 estimates the variability in any sample of a single pen for that particular pen size. Nonetheless, the SEM used in the statistical test and reported will be closer to the observed SD of pen data, which will be close to the SEM reported in Table 2 divided by the square root of the number of pens. The more pens used in the estimate, the more accurate or confident one would be in that estimate, so the SEM would decrease. Therefore, the actual SEM for 20 pens of 4 cattle per pen will be closer to 0.054, which is approximately the SEM for the binomial sampling distribution shown for pen size equal to 80. This is not completely surprising because 80 cattle went into that estimate of the proportion of cattle that graded Choice or better (e.g., 4 cattle per pen x 20 pens). We analyzed a hypothetical data set with 4 cattle per pen and 20 pens per treatment using Proc Glimmix in SAS. The data set had treatment means for the proportion of cattle grading Choice or better of 0.625 and 0.563 for Treatments 1 and 2, respectively. The pooled between-pen SD was 0.290. The pooled SEM from the Glimmix analysis was 0.055, and the 95% CI of treatment estimates were [0.511, 0.723] and [0.449, 0.670] for Treatments 1 and 2, respectively, with \( P = 0.426 \). The limitations of using small pens for binomial or ordinal data can be overcome by increasing the number of pen replicates and consequently the total number of cattle per treatment. Nonetheless, it should be noted that studies designed primarily with performance metrics as the outcome variable in small pens are typically going to be underpowered to detect biologically/economically significant treatment differences in binomial or ordinal data. The results in Table 2 indicate that with approximately a total of 400 cattle per treatment, the SEM for Choice or greater is 0.025 given the estimate was 0.60. The 95% CI is [0.552, 0.648], which means with 400 cattle per treatment, an effect size of +/- 0.05 in Choice or greater would be statistically significant.

**Influence of Blocking**

As discussed previously, cattle in feedlot studies, particularly smaller-pen studies, are blocked into groups that are similar to one another with regards to some variable, and then treatments are assigned randomly within each block. The variable that is used to create the blocks is usually based on information that it might influence the primary outcome variable(s) in the study. The first goal of blocking is to control for a possible confounding factor (i.e., ensure that different values of the blocking variable are equally represented in all treatments in the study). The second goal is to decrease the unexplained or residual variation in the data. Variation among experimental units, pen-to-pen, is the residual variation in many feedlot data sets (i.e., the model does not explain why pens given the same treatment are different from each other). The residual variation in a statistical model is what is used to determine whether a treatment differs more than would be expected from random chance alone. As residual variation decreases, the power of the statistical test increases, given a fixed effect size, sample size, and risk of a Type 1 error. Remember how increasing the number of cattle per pen influenced the sampling distribution in Figure 3? As the number of cattle per pen increased, the SEM decreased. The SEM in that case was the measure of pen-to-pen or residual variation that was used in the test of the null hypothesis.

In experimental designs where cattle are blocked, the block can be included as a random effect in the statistical model. This type of statistical model is called a mixed model because it includes both fixed (e.g., treatment) and random effects. The fixed effects in the model are those that are
controlled in the experiment and where all levels of inferences are represented in the study. The random effects differ from fixed effects in that they are included in the model to explain some of the random variation, but they do not represent all possible levels, and typically the scope of the experiment is not to make any inferences regarding different levels of the random effect. If you are fully confused by all the statistical jargon, let’s consider an example to show how blocking (by initial body weight in this case) can influence the residual variation in F:G and how the response depends on pen size.

An empirical population of 285 steers with individual average daily gains during the finishing period was sampled (by re-sampling with replacement) and either: (1) completely randomized to 1 of 2 theoretical treatments (CRD); or (2) blocked by initial body weight and then randomly assigned to 1 of the 2 theoretical treatments (RCB). The theoretical treatments were a Control and a “Treated” group that resulted in a 3% improvement in F:G. Dry matter intake was predicted for each animal from initial body weight according to McMeniman et al. (2010), and an individual F:G value was estimated. Cattle assigned to the Treated group had their DMI decreased so that they had a 3% improvement in F:G. The between-cattle coefficient of variation in the F:G was 9% for both treatments. Data were simulated for 4 different pen sizes (n = 4, 20, 100, and 200), and the number of pens per treatment varied from 2 to 50. Data were analyzed as either: (1) a CRD that included the fixed effect of treatment, such that the residual variation described the pen-to-pen variation; or (2) a mixed model for the RCB with the fixed effect of treatment and the random effect of block, such that the residual variance excluded the variance associated with block. Data from the simulations (150 iterations per combination of pen size and number of pens per treatment) are reported as the residual variance and are shown in Figure 5. Each plot is for a different pen size with residual variation on the y-axis and the number of pens per treatment on the x-axis. As discussed previously, notice how the residual variation decreases as the number of cattle per pen increase for the CRD and is equal to the $\sigma^2_{\text{Between}}$ reported for each pen size in Figure 3. In addition, the residual variation for each pen size does not change as number of pens per treatment increases in the CRD, whereas the residual variation increases as the number of pens per treatment increase for each pen size in the RCB. This result makes sense because more pens per treatment in the RCB results in more blocks, which creates greater pen-to-pen variation (i.e., more pens with lighter vs. heavier cattle compared with pens that have the same distribution of lighter and heavier cattle in the CRD). These results suggest that blocking is beneficial only for small pens (4 cattle per pen in this example) and only up to a certain number of pen replicates, which in this example was approximately 15 pens per treatment. Furthermore, there seemed to be no benefit to blocking by initial body weight in larger pens. As noted in previous discussions of pen size effects with the CRD, these simulations reflect an assumption that individual variation in F:G does not change with increasing pen size. Further, blocking by initial body weight may reduce pen-to-pen variation more when the decision to slaughter cattle is based on a desired maturity rather than a fixed number of days on feed because lighter blocks of cattle can stay on feed longer than the heavier blocks.

**Implications**

Statistics are a very useful for allowing us to make sense out of large amounts of data by compressing results to a few numbers that can be used to draw meaningful conclusions. Because sampling the entire population is not feasible, a sample is often taken and inferences are made to
the larger population based on the characteristics of the sample. Statistics are necessary to examine whether there is reasonable evidence from our sample to reject the null hypothesis that there is no difference at the population level. Inferential statistics are based on probabilities, and experiments should be designed to limit the probabilities of making either Type 1 or Type 2 errors. Feedlot studies can be conducted in either small or large pens, and there are unique benefits and challenges to both pen sizes. Larger pen sizes decrease the pen-to-pen variation, which results in fewer pen replicates needed in a study to detect a given difference compared with small pens. Nonetheless, in most instances the total numbers of cattle in the study are typically substantially greater for larger-pen studies. In situations where the number of cattle in a study needs be limited for logistical or reasons related to the nature of the treatments and ancillary measurements being taken, smaller pens may be more effective than larger ones. As a result of the greater number of cattle in larger pen studies, these types of studies are favored when evaluating binomial or ordinal data such as carcass quality, and many small-pen studies are statistically underpowered to make meaningful conclusions on carcass yield and quality grades. Blocking, especially in smaller pens, decreases the residual pen-to-pen variation and can increase the power of statistical tests. There seems to be little benefit to blocking in larger pens, and in fact, blocking in large-pen studies could increase the residual pen-to-pen variation compared with a completely randomized design.

**Literature Cited**


Figure 1. An explanation of the 2 types of errors that can be made in classical null hypothesis statistical testing, as well as the US judicial system.

<table>
<thead>
<tr>
<th>CONCLUSION</th>
<th>Null hypothesis = True or Innocent</th>
<th>Alternative hypothesis = True or Guilty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail to reject Null hypothesis or Innocent</td>
<td>Correct</td>
<td>Type 2</td>
</tr>
<tr>
<td>Reject Null hypothesis or Guilty</td>
<td>Type 1</td>
<td>Correct</td>
</tr>
</tbody>
</table>

Figure 2. Comparison of the sampling distribution of the mean from a sample size of n = 10 versus a sample size of n = 50. The sampling distribution for each was constructed from 1,000 independent samples from a single population with a mean of 695.6 lb and variance of 3,502 lb.
Figure 3. Comparison of the sampling distribution of pen means in feed:gain from pen sizes of n = 4, 20, 100, and 200 cattle per pen. The sampling distribution for each was constructed from 1,000 independent samples from a single population of cattle with a mean of 5.29 and variance of 0.202.
Figure 4. Relationship between the number of pens required to reach statistical significance for a fixed effect size difference between 2 hypothetical treatments. Samples for each treatment were drawn from 2 populations that had a 3% effect size difference in feed:gain with a 9% coefficient of variation for between cattle within each population. Data are reported as the mean for 500 separate t-tests.
Figure 5. Influence of blocking by initial body weight vs. a completely randomized design on the residual variance in feed:gain of a statistical test. Data were simulated for pen sizes of 4, 20, 100, and 200, and the number of pens per treatment were analyzed from n = 2 to n = 50 for each pen size. Each data point represents 150 iterations. The CRD was analyzed with the fixed effect of treatment, and the RCB was analyzed as a mixed model with the fixed effect of treatment and random effect of block. The population that was sampled had a treatment difference of 3% in feed:gain and a 9% coefficient of variation among individual observations for both treatments.
Table 1. Binomial sampling distributions for sample sizes of 4, 20, 100, and 200. The population mean had an unrecognized trait success rate of 0.35.

<table>
<thead>
<tr>
<th>Pen size</th>
<th>Population mean</th>
<th>Mean</th>
<th>SEM</th>
<th>CV</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.35</td>
<td>0.348</td>
<td>0.240</td>
<td>69.1</td>
<td>[0, 81.8]</td>
</tr>
<tr>
<td>20</td>
<td>0.35</td>
<td>0.350</td>
<td>0.107</td>
<td>30.6</td>
<td>[14.0, 55.9]</td>
</tr>
<tr>
<td>100</td>
<td>0.35</td>
<td>0.350</td>
<td>0.048</td>
<td>13.6</td>
<td>[25.7, 44.3]</td>
</tr>
<tr>
<td>200</td>
<td>0.35</td>
<td>0.350</td>
<td>0.033</td>
<td>9.5</td>
<td>[28.5, 41.5]</td>
</tr>
</tbody>
</table>

Table 2. Binomial sampling distributions for sample sizes of 4, 20, 80, 100, 200, and 400. The population mean had a Choice or greater success rate of 0.6.

<table>
<thead>
<tr>
<th>Pen size</th>
<th>Population mean</th>
<th>Mean</th>
<th>SEM</th>
<th>CV</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.6</td>
<td>0.599</td>
<td>0.243</td>
<td>40.6</td>
<td>[0.123, 1.000]</td>
</tr>
<tr>
<td>20</td>
<td>0.6</td>
<td>0.600</td>
<td>0.109</td>
<td>18.2</td>
<td>[0.386, 0.814]</td>
</tr>
<tr>
<td>80</td>
<td>0.6</td>
<td>0.599</td>
<td>0.055</td>
<td>9.1</td>
<td>[0.492, 0.707]</td>
</tr>
<tr>
<td>100</td>
<td>0.6</td>
<td>0.601</td>
<td>0.050</td>
<td>8.2</td>
<td>[0.504, 0.698]</td>
</tr>
<tr>
<td>200</td>
<td>0.6</td>
<td>0.600</td>
<td>0.034</td>
<td>5.7</td>
<td>[0.532, 0.668]</td>
</tr>
<tr>
<td>400</td>
<td>0.6</td>
<td>0.600</td>
<td>0.025</td>
<td>4.1</td>
<td>[0.552, 0.648]</td>
</tr>
</tbody>
</table>

**Graduate Student Research Poster Presentations**

**Effects of monensin and dietary energy intake on maintenance requirements in beef cows**  
C. J. Boardman, T. A. Wickersham, L. A. Trubenbach and J. E. Sawyer, Texas A&M University, College Station

Raising beef cattle using intensified practices appears to be an option for cow-calf systems to improve production efficiency. Limit-feeding a diet including an ionophore to cows during mid-gestation in an intensified system could reduce maintenance energy requirements. Two projects were conducted to determine the effects of monensin and level of intake on digestibility and performance. Both projects were designed as 2 × 2 factorials that fed one diet at either 120% (H) or 80% (L) of NRC requirements with one of two levels of monensin inclusion 0 or 200 mg•hd^{-1}•d^{-1}. Sixteen ruminally cannulated steers were used in an intake and digestion trial, followed by a 56 d performance trial consisting of 39 mature gestating cows. Monensin did not significantly affect any measure of digestibility (P > 0.15), but steers fed L had greater (P < 0.01) DM digestibility (74.3 vs 69.1%), OM (76.9 vs 71.4%), ADF (58.8 vs 52.5%) and GE (75.3 vs 70.2%) than H. Passage rate was less for L than H (1.69 vs 2.37% • h^{-1}; P < 0.01) and 200 than 0 (1.90 vs 2.16% • h^{-1}; P < 0.03). Interactions, intake × time (P < 0.05) and monensin × time (P < 0.01), for acetate:propionate resulted from a decrease 2 h after feeding followed by a gradual increase. At all time points 200 had lower acetate:propionate. An intake × time interaction (P = 0.01) for rumen pH resulted from a decreased pH after feeding through hour 9, followed by a return to baseline. No differences were detected at 0, 2 and 16 h after feeding, but L had a higher pH at hours 4, 6, 9 and 12 (P < 0.05). Rumen pH was higher for 200 than H (6.48 vs 6.33; P < 0.05) at all sample times. Cows gained more BW when fed at H versus L (P < 0.01) with no effect of monensin (P = 0.97). Retained energy was greater for H than L (16.57 vs -2.48 kcal•d^{-1}•MBW^{-1}; P < 0.01) although heat production was also greater (110.57 vs 94.76 kcal•d^{-1}•MBW^{-1}; P < 0.01). Monensin had no effect on either RE (P = 0.94) or HE (P = 0.53). Maintenance requirements can be decreased by feeding less ME. Although monensin decreased passage rate and decreased the acetate:propionate ratio, additional research is needed to understand the full effects of monensin on limit-fed diets to gestating cows over a longer period.

**Carcass gain, efficiency, deposition changes, and profitability in steers at extended days on feed**  
R. G. Bondurant¹, J. C. MacDonald¹, G. E. Erickson¹, K. Brooks², R. N. Funston³, and K. Bruns³, ¹Department of Animal Sciences and ²Department of Agricultural Economics, University of Nebraska, Lincoln, ³West Central Research and Extension Center, University of Nebraska, North Platte

Recent increases in base carcass price of fed cattle have increased average days on feed (DOF). Cattle which are fed longer have increased risk for discounts for overweight carcasses and increased yield grade (YG) while also having increased chance for receiving premiums for higher quality grade (QG). Crossbred steers (n = 114, initial BW = 767; SD = 287 lbs) were utilized in an experiment to evaluate the change in carcass composition throughout the feeding period and the economic profit/loss realized by feeding cattle 0, 22 and 44 days longer than the industry average. Steers were assigned randomly to 1 of 3 pens and stepped up on a common finishing ration 24 d prior to the start of the study. On d 1, cattle were weighed and assigned randomly to 3 serial harvest groups within pen, allowing for 38 hd per harvest (1/3 of each pen). Steers were fed (twice daily) a common finishing ration through the GrowSafe system, allowing for calculation of daily individual feed intake. Real time carcass ultrasound measurements
including ribeye area, intra-muscular fat percentage, 12th rib fat thickness, and rump fat thickness were collected on 76 steers (2 pens) at 1, 78, and 134 DOF. Steers were considered to be industry average when the group appeared to be at 0.5" 12th rib fat thickness. The first set of calves was harvested at 142 DOF, while the second and third groups were harvested at 163 and 185 DOF, respectively. Economic assumptions were applied to steers to determine profit/loss per head when feeding to longer DOF. Steer DMI was not different among DOF while live ADG and feed efficiency decreased linearly (P ≤ 0.04) as steers were fed to longer DOF. However, HCW increased linearly (P < 0.01) from 823 to 903 lbs, as steers were fed to 142 and 185 DOF, respectively. Rib-eye area (REA) quadratically increased (P = 0.04) from 13.8 to 14.5 in² (142 and 163 DOF, respectively) and remained constant for 185 DOF at 14.3 in². Marbling score numerically increased from 475 to 506 (142 and 185 DOF, respectively) but was not significantly different. Calculated YG and 12th rib fat thickness increased linearly (P < 0.01) as DOF increased for steers. The percentage of steers with overweight carcasses (≥ 1050) increased for 185 DOF (2.63%) compared to 142 and 163 DOF which had no overweight carcasses. The number of steers grading choice or better was similar across DOF, however the 185 d cattle had an increase in steers grading upper 2/3 choice. The percentage of cattle with YG 4 or 5 increased with DOF (5.26, 13.16, and 31.58%, respectively). Although steers fed at 163 and 185 had higher total feedlot costs than 142 DOF ($483.21 and $551.14 vs. $432.09, respectively), profit per head was greater for steers fed for 163 and 185 DOF ($16.96 and $54.11 vs. $2.77, respectively). The increase in profit despite the added total feedlot costs can be attributed to more HCW sold and an increase in QG premiums. When comparing economics at current market conditions, steers can be fed for 44 days longer and increase revenue per head even though HCW and YG discounts increase.

Effects of shade and feeding zilpaterol hydrochloride to finishing steers on performance, carcass quality, mobility, and body temperature  
B.M. Boyd1, S.D. Shackelford2, K.E. Hales2, T.M. Brown-Brandl2, M.L. Bremer1, M.L. Spangler1, and G.E. Erickson1, 1University of Nebraska, Lincoln, 2US Meat Animal Research Center, Clay Center, NE

Crossbred steers (n=480) were utilized to study the effects of shade and feeding zilpaterol hydrochloride (ZH) on performance, carcass quality, mobility, and body temperature (BT). A randomized complete block design with a 2×2 factorial arrangement of treatments was conducted with four replicates per treatment. Factors included housing type (open lot or shaded pens; HT) and the use of ZH during the last 21 days of the finishing period either at 0 or 7.56 g/ton. Cattle were blocked into heavy or light BW and assigned randomly to pens within block. Boluses to record BT were inserted prior to initiation of ZH feeding. Respiration rates were taken daily during the ZH feeding period. Mobility scores were collected at various time points from before ZH feeding through harvest. For carcass and performance data, the model included fixed effects of block, dietary treatment, HT and their interaction. For mobility, respiration, and BT day was included as a repeated measure using either simple (mobility and BT) or autoregressive (respiration) covariance structure. Mobility included a covariate of mobility score prior to treatment. Interactions between ZH and HT were not significant (P>0.26). No differences (P>0.44) were observed for DMI, ADG, or F:G on a live basis due to ZH but cattle fed in open lots tended (P=0.08) to gain more than cattle with shade. Carcasses were 31 pounds heavier with larger LM area (P<0.01) for cattle fed ZH. Respiration rates for cattle fed ZH were greater (P=0.05) with no differences (P=0.88) due to HT. There was no time* treatment interaction (P=0.14) for mobility scores. Time was significant (P<0.01) for mobility scores with
observations taken the morning of harvest at the abattoir being the worst for all cattle. An interaction ($P<0.01$) was observed between ZH and HT for BT. Cattle fed ZH in open pens had lower ($P<0.05$) average and maximum BT than control cattle in open pens. Cattle in shade fed ZH had greater ($P<0.05$) average and maximum BT than cattle fed ZH in open pens. In open pens, cattle fed ZH had lower ($P<0.05$) area under the curve (AUC) BT than the control. In shaded pens average and maximum BT was greater ($P<0.05$) for cattle fed ZH. Feeding ZH increased respiration rate and slightly increased panting score with no effect on BT. Feeding ZH also increased carcass weight with a minor impact on mobility. USDA is an equal opportunity provider and employer.

Modifying different components of distillers grains and the impact on feedlot performance
Z. E. Carlson, C. J. Bittner, D. B. Burken, G. E. Erickson, and J. C. MacDonald, University of Nebraska, Lincoln

The composition of distillers grains has potential to change as corn components are removed for further ethanol production. Crossbred yearling steers (n = 448; initial BW = 811 ± 29 lb) were utilized in a randomized block design to determine the effect of altering distillers grains composition on performance and carcass characteristics. Treatments were: 1) negative control (CON) with 81.5% blend of high-moisture corn and dry-rolled corn; 2) positive control (DDGS) replaced corn at 50% of diet with dried distillers grains plus solubles; 3) non-pelleted corn stover (STV), treated with calcium oxide, contained 18.75% solubles, 12.5% treated corn stover, and 18.75% high-protein distillers grains; 4) pelleted corn stover (PEL-STV) at same DM inclusion as STV; 5) bran (COMP) included 18.75% solubles, 12.5% isolated fiber, and 18.75% high-protein distillers grains; 6) bran medium protein (COMP-MED) contained 24.4% solubles, 16.2% isolated bran, and 9.4% high-protein distillers grains; and 7) bran low protein (COMP-LOW) had 30% solubles and 20% isolated bran (DM basis). Performance and carcass characteristics were analyzed using the PROC MIXED procedures of SAS with pen as the experimental unit. Block was a fixed effect and contrasts were developed to determine effects of exchanging components in distillers grains. Intakes and ADG were greater for DDGS compared to CON ($P < 0.01$), but F:G was similar between CON and DDGS (6.83 vs. 6.80, respectively; $P = 0.75$). However, combining bran, solubles, and protein together in similar proportions to distillers grains reduced F:G by 7.6% ($P < 0.01$) compared to DDGS. Replacing bran with treated corn stover further reduced feed efficiency ($P < 0.01$). No difference between pelleting corn stover or not ($P = 0.60$) was observed for ADG and F:G. Intake decreased with pelleting corn stover ($P < 0.02$) without affecting ADG or F:G ($P \geq 0.37$). There was a quadratic increase in DMI as protein was removed between COMP, COMP-MED, and COMP-LOW ($P < 0.04$) but no impact was observed for ADG or F:G ($P \geq 0.16$). Both HCW and fat thickness were significantly higher for DDGS compared to CON ($P < 0.01$). There was no significant difference in HCW, LM area, and marbling between COMP and PEL-STV ($P \geq 0.79$). However, when treated corn stover replaced bran, fat thickness decreased ($P < 0.02$). Steers fed DDGS had heavier HCW ($P < 0.01$) and increased fat thickness ($P < 0.02$) compared to COMP. As protein decreased between COMP, COMP-MED, and COMP-LOW fat thickness decreased linearly ($P = 0.02$) and LM area tended to increase quadratically ($P = 0.08$). Decreasing proportions of protein did not negatively impact feed efficiency, possibly due to solubles concentration increasing with decreasing protein inclusion. These data suggest that replacing bran normally found in distillers grains with treated corn stover increases intake and reduces feed efficiency, whether pelleted or
not. Diets formulated with isolated ingredients of distillers grains did not mimic performance of distillers grains suggesting some component(s) was missing.

**Impact of feeding distillers grains or isolated components in distillers grains on feedlot performance and carcass traits**

Brianna B Conroy¹, Jacob A Hansen¹, Galen E. Erickson² and Matt K Luebbe¹, ¹University of Nebraska, Scottsbluff, ²University of Nebraska, Lincoln

The ethanol industry is partially removing corn oil to produce de-oiled distillers with solubles. Additional processing changes (i.e. corn oil, fiber, protein) are underway that will change the nutrient composition and potentially the energy value of distillers grains plus solubles in feedlot diets. An experiment was conducted utilizing 264 crossbred steers (BW= 848 ± 53 kg) in a randomized block design to estimate the energy value of individual components. Diets were formulated to equal the fat, fiber, and protein components of a diet consisting of 40% wet distillers grains plus solubles (WDGS; DM basis). Diets included a corn-based control (CON), WDGS (40% of diet DM) replacing corn, or diets with equal proportions of fiber (FIBER; corn bran and de-oiled germ), protein (PROT; corn gluten meal), or fat (FAT; corn germ) with condensed distillers solubles included at 10% (DM basis). These diets have the same proportions of each component relative to the 40% DGS diet. A 10% condensed distiller solubles (CCDS) diet was also included for comparison of the component diets relative to CON. There were a total of six dietary treatments with five pens/treatment. Dry-matter intake was greatest for FAT and PROT, intermediate for fiber, and least for WDGS, CON, and SOL (P = 0.04). Average daily gain was greatest for WDGS, intermediate for FAT, PROT, and FIBER, and least for SOL and CON (P < 0.01). Feed efficiency was greatest for WDGS, intermediate for CON, SOL, PROT, and FIBER, and least for FAT (P < 0.01). Final carcass adjusted BW and HCW were greatest for WDGS, intermediate for CON, FAT, PROT, and FIBER, and least for SOL (P < 0.01). Fat depth was greatest for DGS, intermediate for PRO, FIBER, and SOL, and least for FAT and CON (P = 0.02). Marbling score and LM area were not different among treatments (P ≥ 0.13). Feeding WDGS compared with CON improved feedlot performance and carcass characteristics. It is unclear what component is responsible for improved performance and carcass characteristics when feedlot cattle are fed distillers grains diets compared with a corn-based control diet as no single component fed to steers improved performance as much as WDGS.

**Effects of rotating antibiotic and ionophore feed additives on enteric methane and volatile fatty acid production of steers consuming a high forage diet**

W. L. Crossland¹, L. O. Tedeschi¹, T. R. Callaway² M. Miller¹, W. B. Smith¹ and M. Cravey³, ¹Texas A&M University, College Station, ²USDA-ARS, College Station, ³Huvepharma Inc., Amarillo, TX

Feed additives such as ionophores and antibiotics have been shown to decrease ruminal methanogenesis, but evidence as a long-term means of mitigation is lacking. In the present study, we proposed a rotation of feed additives as an alternative to reduce methane (CH₄) production and to increase animal responses. Rumen-cannulated steers (n = 12) were fed a basal high forage diet at 2% of BW (DM) for 13 weeks in a Calan gate facility for individual DMI measurement. Steers were randomly assigned to 1 of 6 treatments 1) control (C) containing the basal forage diet and no additive, 2) bambermycin (B) = C + 20 mg B/hd/day, 3) monensin (M) = C + 200 mg M/hd/day, 4) B7M= rotating B and M treatments weekly, 5) B14M = rotating B and M treatments every 14 days, and 6) B21M= rotating B and M treatments every 21 days. Performance data and rumen fluid were collected weekly for in vitro analysis (n = 13) and results
were interpreted on organic matter intake (OMI) basis. Treatments did not affect ADG or feed efficiency. Potential activity of CH₄ (PAM) was greatest for M-fed steers and least for B21M-fed steers (0.219 vs 0.172 mM/kg OMI, respectively; P < 0.05). Additionally, PAM of the B21M-fed steers was most consistent of all treatments. Total VFA concentration differed (P < 0.05), being greatest for M- and B14M-fed steers (3.46 and 3.47 mM/Kg OMI) and lowest for the B7M treatment (2.87 mM/Kg OMI), but were not different from other treatments. PAM differed over time for all treatments decreasing toward week 6 then increasing toward week 12. Week also affected total VFA peaking at week 3 followed by a significant depression in week 4 (4.02 vs 2.86 mM/Kg OMI; P < 0.05). There is evidence to suggest that weekly rotation of B and M feed additives may not provide additional benefit at either the ruminal or environmental level when compared to continuous feeding of single feed additives. However, a 21-day rotation may combine desirable animal performance, decreased CH₄ emissions, and provide a novel practical approach for industry feeding protocol.

**Effect of condensed tannin extract supplementation on beef cattle performance and nitrogen balance II: Finishing phase**

P. J. Ebert¹, A. L. Shreck², J. S. Jennings³, N. A. Cole², and E. A. Bailey¹, ¹West Texas A&M University, Canyon, ²USDA-Agricultural Research Service, Bushland, TX, ³Texas A&M AgriLife Research, Amarillo

Nitrogen emissions from concentrated animal feeding operations are of increasing concern to regulatory agencies. As such, we evaluated the effect of top-dressing a finishing diet (14.4% CP) for beef cattle with a commercially-available condensed tannin extract (CT) at three levels (0, 0.5, and 1.0 % of diet, DM basis). British-cross steers (n = 27; initial BW=350 ± 32 kg) were fed individually via a Calan gate system for 126 d. Diet digestibility and N balance were estimated approximately 30 d after the experiment began (EARLY) and 30 d before the animals were harvested (LATE), using TiO₂ as a marker of fecal output and creatinine:BW ratio as a marker for urine output, respectively. Ruminal CH₄ and metabolic CO₂ fluxes were measured using a GreenFeed unit (C-Lock Inc., Rapid City, SD) for two, 20-d sampling periods, that coincided with fecal and urine sampling. Urine energy loss was estimated from urine N excretion, assuming all excreted N was urea. Heat production was estimated from the Brouwer (1965) equation. Oxygen production was estimated from CO₂ production assuming a respiratory quotient of 1.05. Inclusion of CT in the diet did not affect (P ≥ 0.21) ADG or DMI over the entire finishing period. Hot carcass weight was not different (P = 0.83) among treatments, but fat thickness and LM area tended to decrease (P ≤ 0.08) when CT was included in the diet. Organic matter intake tended (P = 0.10) to increase when CT was fed during EARLY. Apparent total tract starch digestibility during EARLY was lesser (P = 0.03) for 1% CT than either 0 or 0.5% CT. Intake of OM and starch were similar (P ≥ 0.31) among treatments during LATE; similarly, apparent total tract digestibility of OM and starch were similar (P ≥ 0.31) during LATE. Nitrogen intake did not differ (P ≥ 0.11) among treatments during EARLY and LATE, but fecal N excretion was greater (P = 0.05) for 1.0% CT than 0% CT during EARLY. Urinary N excretion was not different (P ≥ 0.43) among treatments during EARLY and LATE, but urine N:total N excretion decreased when CT was included in the diet during EARLY. Retention of N was not different (P = 0.80) among treatments during EARLY, but tended to decrease (P = 0.07) when CT was included in the diet during LATE. Flux of CO₂ (10,279, 10,537, and 10,478, g/d) and CH₄(144, 154, and 158 g/d) were similar (P ≥ 0.23) among treatments during both sampling periods. Percentage of GE intake lost as CH₄ was not different (P ≥ 0.26) for 0 (3.27%), 0.5 (3.32%) or 1.0 (3.71%) percent CT. Proportion of GE intake lost in urine averaged 1.03, 1.01,
and 0.97% for CT levels of 0, 0.5, and 1.0%, respectively but was not different ($P \geq 0.41$) among treatments. Heat production was similar ($P \geq 0.55$) across treatments during (27.3, 28.0, 27.8 Mcal/d) during both sampling periods and no difference ($P \geq 0.39$) was observed for heat production lost as a percent of GE intake (47.0%, 45.7%, 50.1%) for 0, 0.5, and 1.0% CT, respectively. Under the conditions of this experiment, supplementation of a finishing diet with condensed tannins had minor effects on performance, nutrient digestibility, and energetic losses of beef steers fed a finishing diet, but did alter the site of N excretion.

Effect of high stress and low stress cattle handling on selected blood chemistry parameters in finishing steers. D.A. Frese¹, C.D. Reinhardt¹, J.P. Hutcheson³, S.J. Bartle⁴, D.N. Rethorst⁴, B.E. Deppenbusch⁵, M.E. Corrigan³, and D.U. Thomson¹, ¹College of Veterinary Medicine, Kansas State University, Manhattan,² College of Agriculture, Kansas State University, Manhattan,³ Merck Animal Health Amarillo, ⁴Beef Cattle Institute, Kansas State University, Manhattan, ⁵Innovative Livestock Services, Inc., Great Bend, KS

Angus cross steers (n = 40; 1,239 ± 97 lb.) were used to examine the effect of handling on blood chemistry and physiology of steers near market weight. Steers were stratified by backfat thickness and randomly assigned to treatment groups: Low stress handling (LSH) and high stress handling (HSH). Cattle were then randomly assigned to one of 5 blocks containing 4 steers from LSH and HSH treatments. Steers in the LSH treatment were walked a course of ~ 1 mile. Steers in HSH were forced to run the 1mile course. Blood samples were obtained via jugular venipuncture before handling (BASE), and at ~1/2 mile (LAP1) and ~ 1 mile (LAP2), 1 h (1H) and 2 h (2H) after finishing the course. Blood samples were analyzed for plasma lactate (LAC), creatinine kinase (CK), base excess (BE), blood pH (pH), serum cortisol (CORT) concentrations and venous CO2 (PCO2) and O2 (PO2) pressures. Heart rate (HR), respiratory rate (RR) and rectal temperature (TEMP) were measured at the same intervals. Cattle in HSH treatment had greater ($P < 0.05$) LAC than LSH cattle at BASE (4.1 vs. 3.0 mmol/L), LAP1 (16.5 vs. 2.3 mmol/L), LAP2 (22.3 vs. 2.4 mmol/L), 1H (7.2 vs. 2.7 mmol/L), and 2H (4.0 vs. 2.5 mmol/L), respectively. Creatinine kinase and RR were not different ($P > 0.14$) at any sample time. Blood pH in HSH cattle was lower compared to LSH cattle ($P < 0.05$) at LAP1 (7.25 vs. 7.45) and LAP2 (7.19 vs. 7.48) but was not different ($P > 0.13$) at BASE, 1H or 2H. Heart rate and TEMP were increased in HSH cattle compared to LSH ($P > 0.01$) at all sampling times. Serum cortisol was increased ($P < 0.05$) in HSH compared to LSH cattle at LAP1 (87.5 vs. 58.9 nmol/L) LAP2 (144.4 vs. 93.1 nmol/L) and 1H (113.5 vs. 53.1 nmol/L). Although RR was not different between LSH and HSH, PCO2 was decreased in HSH compared to LSH ($P < 0.05$) at LAP2 (30.6 mmHg vs. 39.3 mm Hg) and PO2 was increased at LAP1 (42.7 vs 33.5 mmHg), and LAP2 (51.5 vs. 36.6 mm Hg). Results of this study show that high stress handling can cause physiologic and blood chemistry changes in steers. These changes could be potentially detrimental to cattle, emphasizing the need for low stress handling practices for promotion of welfare in cattle.

Effects of bambermycin or monensin on health and performance of receiving cattle. W. L. Galyen¹, T. Hess², D. S. Hubble², M. S. Gadberry³, E. B. Kegley¹, M. Cravey⁴, J. G. Powell¹, E. A. Buckes¹, L. R. Meyer¹, and P. A. Beck⁵, ¹University of Arkansas, Fayetteville, ²University of Arkansas LFRS, Batesville, ³University of Arkansas Cooperative Extension Service, Little Rock, ⁴Huvepharma, Inc., Amarillo, TX, ⁵University of Arkansas SWREC, Hope

Growing steers and bulls, were received in 3 blocks (Block 1, n = 150, BW = 459 ± 27.3 lb; Block 2, n = 99, BW = 470 ± 36.8 lb; Block 3, n = 149, BW = 483 ± 32.8 lb) to evaluate the
effects of supplying 20 mg bambermycin (Gainpro; Huvepharma, Inc., Sofia Bulgaria) or 0.35 mg/lb BW monensin (Rumensin; Elanco Animal Health, Indianapolis, IN) in receiving supplements (20% CP and 78% TDN) compared with non-medicated supplements (Control) on cattle morbidity, performance, and coccidia infection. Upon receiving, bulls were castrated, and calves were weighed on 2 consecutive days. Calves were then stratified by BW and arrival castrate status and allocated randomly to receiving pens (n = 12-1 acre grass traps in Block 1 and n = 6 grass traps in Blocks 2 and 3). Calves received 2 lb of supplement daily and had ad libitum access to moderate quality hay. Steers were weighed every 14 d. Fecal samples were collected from 6 steers/pen on d 0, 14, and 28 to evaluate coccidia infection. Water in the Gainpro pens was treated from d 14 to d 19 with 10 mg/2.2 lb BW amprolium (Corid; Merial, Duluth GA). Steers remained on treatment for 56 to 84 d for Block 1, 49 d for Block 2 and 42 d for Block 3, depending on availability of wheat forage for subsequent grazing. Data were analyzed as a randomized complete block design using the mixed procedure of SAS (SAS Inst., Cary, NC). Coccii counts were log transformed before analysis and were analyzed as a repeated measure in time. There were no differences (P ≥ 0.36) in morbidity, mortality, or animals identified as chronically morbid. There was no treatment by day interaction (P = 0.12) for cocci oocysts counts. Rumensin decreased (P ≤ 0.03) coccidia oocyst counts compared with Control and Gainpro, which did not differ (P = 0.85). No cattle were observed with or treated for symptoms of coccidiosis (bloody scours and diarrhea). At the end of receiving, BW and ADG for Control (523 ± 11.2 lb/steer and 1.08 ± 0.595 lb/d, respectively) was less than (P ≤ 0.04) Gainpro (536 ± 11.2 lb/steer and 1.32 ± 0.595 lb/d) and Rumensin (245 ± 11.2 lb/steer and 1.50 ± 0.595 lb/d), and BW and ADG of Rumensin tended (P ≤ 0.10) tended to be greater than Gainpro. The results of this experiment indicate both Gainpro and Rumensin increased receiving cattle gain performance compared with Control, and Rumensin also provided greater benefits in reduction of coccidia counts.


Feedlot cattle (n = 80; BW = 668 ± 36 kg) were used to measure the effects of handling at the time of shipping on physiological response, blood parameters, and carcass quality in cattle fed ractopamine hydrochloride during the summer in a commercial feedlot. Eight phenotypically similar steers were selected from 10 pens. Within each pen, cattle were stratified by wt and randomly assigned to 1 of 2 handling treatments: 1) Low-stress handling (LSH) or 2) High-stress handling (HSH). For the LSH treatment, 4 penmates were walked a course of 1,600 meters. Penmates from the HSH treatment were kept at a minimum of a trot over the 1,600 m course. Rectal temperature (RT), heart rate (HR), and respiratory rate (RR) were recorded prior to handling (baseline) and post-handling. Blood samples were collected at baseline, post-handling, and during exsanguination at the abattoir. Steers on the HSH treatment had higher HR than LSH cattle post-handling (100.4 vs. 86.7 beats/min; P = 0.01). There was no difference between treatments on post-handling RR (76.7 vs. 75.7 ± 2.6 breaths/min, P = 0.80) or RT (40.5 vs. 40.3 ± 0.09 ºC, P = 0.17). Blood pH, bicarbonate, and base excess were all decreased post-handling in the HSH cattle (P < 0.0001). Blood lactate was greater in the HSH cattle post-handling (15.1 vs. 5.2 ± 1.93 mmol/L, P = < 0.0001). High-stress handled cattle had greater post-handling levels of plasma epinephrine (2,408 vs. 1,598 ± 232.8 pg/mL, P = 0.02), norepinephrine (3,435 vs. 2,011 pg/mL ± 523.4; P = 0.0004), and cortisol (49.17 vs. ± 41.35 ng/mL; P = 0.01) than LSH cattle.
High-stress handled cattle had greater serum glucose post-handling (260 vs. 102 ± 10.3 mg/dL; \( P < 0.0001 \)) than LSH cattle. There were no significant differences between handling treatments in blood parameters or semimembranosus glycolytic potential at post-exsanguination. No differences in carcass quality were observed between treatments \( (P > 0.05) \). High-stress handling increased HR and stress hormones, while depleting inspired respiratory oxygen resulting in increased anaerobic glycolysis, lactic acid production and metabolic acidosis.

**Comparison of heat stress mitigation techniques and production systems used in feedlot cattle**

*C.L. Haviland, B. C. Bernhard, C.L. Maxwell, B. K. Wilson, D. L. Step, C. R. Krehbiel, and C. J. Richards, Oklahoma State University, Stillwater*

High environmental temperatures coupled with high relative humidity, solar radiation, and slow wind speeds can decrease performance of feedlot animals. In order to prevent susceptibility to hyperthermia and improve overall summertime feedlot performance, management strategies designed to alter the peak and/or pattern of body temperature must be implemented. Common mitigation techniques that are used to decrease the core body temperature of feedlot cattle in these hot environments include providing sprinklers on hot days or shade daily. Wetting heat-stressed feedlot cattle with sprinklers decreases body temperature through evaporative cooling of the animal and its environment. Providing shade benefits heat load through reducing the thermal radiation that is reaching the animal. A strong understanding on how mitigation techniques impact core body temperature of cattle will be beneficial effectively manage heat stress. Rumen temperature of 52 crossbred steers were monitored throughout their feeding period at the Willard Sparks Beef Research Unit in Stillwater, OK. A ten day period with extreme heat conditions was selected to compare shade or no shade in Natural or Conventional production systems. The purpose of the Cattle Comfort Index (CCI) is to create thresholds that utilize multiple environmental variables, incorporated into a continuous index that adjusts temperature for combined effects of relative humidity, wind speed, and radiation. Steers were randomized by weight into Natural or Conventional production system and then assigned to pens with Shade or No Shade in a 2 x 2 factorial design. The Natural system did not receive any growth promoting technologies throughout the feeding period and the Conventional system received an implant at arrival, and monensin and tylan as a component of the daily ration. Average rumen temperatures during three time periods were evaluated. Time periods included 0400-0800 (morning maximum), 0800-1200 (morning minimum), and the 1600-2000 (afternoon maximum). There was a production system by shade interaction \( (P < 0.01) \). Steer with Shade had lower \( (P < 0.01) \) temperatures than steers with No Shade throughout all three time periods. For steers with Shade, Conventional steers had lower temperatures \( (P < 0.01) \) than Natural steers. For steers with No Shade, Natural steers had significantly lower temperatures than Conventional system steers \( (P < 0.01) \). Conventional steers in outside pens had the highest temperatures \( (P < 0.01) \). In a second evaluation, the addition of sprinkling with No Shade was evaluated on days when the Comprehensive Climate Index (CCI) was greater than 41°C. During the period evaluated, sprinkling events occurred on three consecutive days. The first sprinkling event was used to compare Shade to No Shade with a sprinkler event. Sprinkled cattle’s body temperature increased at a greater rate and were higher than the shaded steers \( (P < 0.01) \) for both production systems. The sprinkled Natural steers were coolest at the morning maximum the next day but were not significantly different than the shaded steers. Conventional steers that were shaded were hottest at the afternoon maximum after sprinkling. The steers with Shade had significantly higher temperatures than the sprinkled steers during the morning minimum time period \( (P < 0.01) \).
Shade provides consistent cooling for feedlot steers located in hot environments. Sprinkling events cool cattle temperatures but will not provide a consistent cooling for animals experiencing heat stress. Sprinkling feedlot steers cool their temperatures with a lag from the sprinkler event.

**The effect of delayed corn silage harvest on corn silage yield and finishing performance in yearling steers** F. H. Hilscher\(^1\), D.B. Burken\(^1\), C.J. Bittner\(^1\) and, G. E. Erickson, \(^1\)University of Nebraska, Lincoln

Crossbred yearling steers (n=180; BW = 943 ± 86 lbs) were used in a feedlot finishing trial to evaluate the effects of harvesting drier corn silage and replacing corn with corn silage in diets with 40% modified distillers grains with solubles. Factors were harvested corn silage dry matter (35 or 42%) and inclusion level of corn silage in the finishing diet (15 or 45%). Steers were blocked by BW and assigned randomly within block to pen (n =20; 9 steers/pen). Steers were fed for an average of 108 d before harvest. The day of harvest, HCW were recorded, and performance measures were calculated from HCW adjusted to a common dressing percentage (63%). Marbling score, 12th rib fat thickness, and LM area were recorded after a 48-h chill.

Data were analyzed using the GLIMMIX procedure of SAS as a randomized block design with pen was the experimental unit and block as a fixed effect. There were no interactions between corn silage DM and level of corn silage inclusion (\( P \geq 0.47 \)) for feedlot performance or carcass characteristics, therefore, main effects will be discussed. As level of corn silage in the finishing diet increased from 15 to 45%, ADG decreased (\( P = 0.04 \)), while DMI did not differ (\( P = 0.15 \)) and consequently F:G increased (\( P < 0.01 \)). Carcass adjusted final BW and HCW were lower (\( P \leq 0.04 \)) for steers 45% corn silage compared to 15%. There were no differences (\( P \geq 0.26 \)) in LM area, 12th rib fat, and marbling score as level of corn silage inclusion was increased. As DM of corn silage was increased from 35 to 42% there were no differences (\( P \geq 0.30 \)) in DMI, ADG, or F:G. Additionally, there were no differences (\( P \geq 0.68 \)) in carcass adjusted final BW or HCW as corn silage DM was increased. No differences (\( P \geq 0.27 \)) in 12th rib fat, or marbling scores were found as DM of corn silage was increased. While increasing the level of corn silage from 15 to 45% in place of corn in finishing diets reduces performance, delaying corn harvest in order to increase harvested corn silage tonnage could prove to have an economic incentive to put up drier corn silage.

**Determining energy value of oil-extracted corn distillers grains with solubles in feedlot diets** A. Hohertz\(^1\), C. Zellmer\(^1\), F. Owens\(^2\) and A. DiCostanzo\(^1\), \(^1\)University of Minnesota, St. Paul, \(^2\)Dupont Pioneer Nutrition, Johnston, IA

A dataset derived from 14 manuscripts containing 75 means for treatments comparing control diets with diets containing various concentrations of low-, reduced-, or full-fat wet, modified wet or dry distillers grains with solubles (DGS) in finishing beef cattle experiments was subject to a meta-analysis to determine the impact of oil extraction in DGS on performance and energy value. In all instances DGS substituted grain or grain and protein supplement source at a given percentage of diet DM without regard to impact on caloric, lipid, protein or dry matter concentrations of dietary treatments. Treatment diets were grouped as low and reduced-fat or full-fat DGS. Using a mixed model approach, independent variables, co-product type (RF or FF) or control, were evaluated through analysis of variance on performance variables: DMI, ADG, feed-to-gain (FTG) analyzed as gain-to-feed, final BW, and observed ME. At increasing DGS inclusion, FF DGS affected a greater (\( P < 0.05 \)) decrease in DMI than RF DGS. Feeding DGS at moderate or high inclusion regardless of type resulted in greater (\( P < 0.05 \)) feed conversion.
efficiency. At high inclusion, feeding FF DGS led to greater \( (P < 0.05) \) feed conversion efficiency than feeding RF DGS. Feeding FF DGS at moderate or high inclusion or RF DGS at moderate inclusion resulted in greater \( (P < 0.05) \) observed ME concentration. Estimated ME values for grain and DGS were similar to previously reported NRC values. Similarly, value of fat contribution to dietary ME \( (0.06 \text{ Mcal/percentage unit EE}) \) from DGS was similar to values observed when adding fat to diets reported by other researchers. Effect of DGS ether extract reflected an impact of 0.09 Mcal observed ME/1% change in DGS ether extract content. At an average of 6.73% ether extract concentration for DGS modeled in this analysis \( (3.04 \text{ Mcal ME/kg DM}) \), the expected ME concentration of full-fat DGS \( (12\% \text{ ether extract}) \) would be 3.35 Mcal ME/kg DM. Equivalent NE\(_g\) concentrations for DGS containing 12\%, 7.75\% or 4.5\% ether extract, corresponding to average concentrations for full-, reduced- and low-fat DGS, would be 73.3, 65.5 and 59.2 Mcal NE\(_g\)/cwt DM, respectively. Results of this meta-analysis demonstrated that reducing oil content of corn distillers grains with solubles reduced energy value of the DGS, thus corrections to energy content of currently available DGS are required.

**Effect of growth implant regimen on health, performance, and immunity of high risk, newly received stocker cattle**

H. D. Hughes\(^1\), P. A. Beck\(^2\), D. S. Hubbell\(^3\), M. S. Gadberry\(^4\), E. B. Kegley\(^2\), J. G. Powell\(^2\), F. L. Prouty\(^5\), and J. T. Richeson\(^1\), \(^1\)West Texas A&M University, Canyon, \(^2\)University of Arkansas, Fayetteville, \(^3\)University of Arkansas, Batesville, \(^4\)University of Arkansas, Little Rock, \(^5\)Zoetis, Louisburg, KS

Cattle experiencing stress-induced physiologic and metabolic alteration are commonly received at a stocker or feedlot facility, following stressful events during the marketing process. The objective of this study was to determine the effects of growth implant timing \( (d\ 0,\ 14,\ or\ 28) \) on health, performance and immunity in newly received beef calves utilized in a 120 d receiving/grazing stocker system. We hypothesized that efficacy of an exogenous growth promoting implant containing 200 mg progesterone and 20 mg estradiol benzoate is reduced when administered on-arrival when calves are typically experiencing a greater degree of physiological stress. Male beef cattle \( (n=203; 447 \pm 5.94 \text{ lb}) \) were received at the UA Livestock and Forestry Research Station near Batesville, AR, and assigned to treatments consisting of: 1) negative control \( (\text{no growth implant}) \), 2) growth implant administered on-arrival \( (d\ 0) \), 3) growth implant administered on \( d\ 14 \), and 4) growth implant administered on \( d\ 28 \). Calves were stratified by \( d\ -1 \) BW and castrate status, then assigned randomly to pen \( (2\ \text{blocks, 8 pens/block; 12 to 17 calves/pen}) \). There were no differences \( (P \geq 0.16) \) in steer BW or ADG during the receiving period; however, overall ADG was greater \( (P \leq 0.01) \) for implanted treatments, regardless of timing. During the first 21 d of the grazing period \( (d\ 42\ to\ 63) \) steers that were implanted later in the receiving period \( (d\ 14\ and\ 28) \) gained weight faster \( (P \leq 0.01) \) than control. At the end of the grazing period \( (d\ 91\ to\ 120) \) steers implanted on \( d\ 28 \) gained more rapidly \( (P \leq 0.01) \) than steers that were not implanted or were implanted on \( d\ 0\) or 14 \( (P \geq 0.12) \), indicating that the growth response from implants administered early in the receiving period had decreased at this time, whereas implants administered later \( (d\ 28) \) in the receiving period remained active. A sharp decrease in NEFA occurred subsequent to \( d\ 0 \) \( (\text{day effect; } P < 0.001) \), but was not affected \( (P = 0.47) \) by the timing of growth implantation. Blood urea N concentrations increased transiently \( (\text{day effect; } P < 0.001) \); however, no treatment effect was observed \( (P = 0.72) \). Respiratory vaccine response, as indicated by BVDV antibody titer concentration, was not impacted by treatment \( (P = 1.00) \), nor was clinical BRD morbidity \( (P = 0.52) \). Therefore, under
conditions of this study, the time of growth implant administration did not affect overall growth implant efficacy, health, or vaccine response in beef stocker calves.

Effects of *Saccharomyces cerevisiae boulardii* supplementation during the receiving period on growth efficiency, and behavioral and health responses in newly weaned beef heifers

M.L. Jenks¹, G.E. Carstens¹, A.G. Cupples¹, J.E. Sawyer¹, W.E. Pinchak², K.S. Barling³ and E. Chevaux³, ¹Texas A&M University, College Station, ²Texas A&M AgriLife Research, Vernon, ³Lallemand Animal Nutrition, Milwaukee, WI

Objectives of this study were to evaluate the effects of live yeast (LY; *Saccharomyces cerevisiae boulardii* strain I-1079; 0.35 x 10⁹ cfu/g ProTernative™) supplementation during the receiving period on growth efficiency, feeding behavior, activity and vaginal temperature in newly weaned beef heifers (N = 72; initial BW of 203 ± 22 kg). Immediately upon weaning, heifers were vaccinated (IBR, BVD, BRSV and PI3; Pyramid 5, Boehringer Ingelheim), and ship stressed (800 km) before being returned to the research center. Upon arrival, heifers were randomly allotted to 1 of 4 pens equipped with GrowSafe™ feed bunks, and pens to 1 of 2 treatments (n = 36). Control heifers were fed a receiving diet (ME 2.36 Mcal/kg, CP 16.5%) without LY, while the LY fed heifers were fed the control diet containing LY (5 g/kg diet; Lallemand Animal Nutrition). Heifers were weighed at 7-d intervals during the 56-d study and re-vaccinated on d 28. Daily feed intake and feeding behavior data was collected starting on d 5 of the study, and a bimodal distribution model fit to non-feeding interval data to compute individual-animal meal traits (frequency, duration, size, eating rate). During the first 14 d of the study, temperature sensors (iButton™) were placed intra-vaginally (CIDR) to record temperature, and HOBO™ devices attached (left hind leg) to measure physical activity (n = 18). Five heifers were removed from the study; 3 due to failure to eat from GrowSafe bunks and 2 due to lameness. LY treatment did not affect morbidity rate (10.4%), vaginal temperature (39.2 ± 0.2 °C), or frequency (16.6 ± 2.2 events/d) and duration (46 ± 5 min/event) of standing bouts. Compared to control heifers, ADG tended (P = 0.09) to be greater for LY heifers during the first 28 d (0.62 vs 0.43 ± 0.08 kg/d), but not over the entire 56-d study. LY treatment did not affect DMI, but DMI increased as the study progressed from 2.05 (first 14 d) to 2.91 ± 0.22% of BW during the 56-d study. Furthermore, LY treatment did not affect time to bunk, frequency or duration of bunk visit events. However, the LY heifers consumed more (P < 0.05) meals (16.8 vs 14.6 vs. ± 1.1 events/d) that were shorter (P = 0.08) in length (12.8 vs 14.9 ± 1.2 min/event) and smaller (P < 0.05) in size (0.48 vs 0.55 ± 0.04 kg/event) and at a slower (P < 0.05) meal-eating rate (4.61 vs 5.54 ± 0.39 g DM/min) compared to control heifers. Moreover, heterogeneity of DMI (SD = 0.59 vs 0.92 kg/d) and RFI (SD = 0.48 vs 0.73 kg/d) were lower (P < 0.05) in LY than control heifers. While the LY treatment did not affect growth efficiency or health status, supplementation with *Saccharomyces cerevisiae boulardii* may have favorably affected meal patterns of newly weaned beef heifers.

Evaluation of a feed additive mixture of direct fed microbials, prebiotics, and enzymes on *in vitro* true digestibility of feeds

H. Larson, N.M. Kenney-Rambo and A. DiCostanzo, University of Minnesota, St. Paul

Two *in vitro* experiments were conducted to determine effects of feeding a proprietary formula containing direct fed microbials, prebiotics, and enzymes (FORMULA) for 21 d (ADAPTED) and/or incubating with or without FORMULA inclusion (ADDITIVE) on *in vitro* true digestibility (IVTD) of forage (Experiment 1) and concentrate (Experiment 2) samples.
cannulated lactating Holstein cows underwent a 21-d adaptation period consisting of daily intra-cannula dosing of either 2 g of FORMULA in a dried distillers grains (DDG) carrier (ADAPT) or 2 g of DDG (NADAPT). Feed samples (n=8) representing mature (MGH) and late-bud (LBGH) grass hay, and fresh range grass (FRG; Experiment 1) or corn silage (CS), dry rolled corn (DRC) and DDG (Experiment 2) were incubated in ANKOM F57 filter bags for 48 h in each of four incubator jars in two replicate incubations (ANKOM DAISYII) within experiment. Proportion of non-NDF (100 – NDF) fraction remaining in bags after 48 h represented IVTD. Rumen fluid from either ADAPT or NADAPT was mixed with buffer at a 1:4 ratio, and filter bags containing 0.5-g samples were suspended in each incubator. While preparing incubations, FORMULA (ADD) or DDG (NADD) was added at 0.04 g/incubator. Therefore, all possible combinations of rumen fluid source and additive inclusion were represented for a 2 X 2 split plot factorial (ADAPTED X ADDITIVE) experiment where ADDITIVE effect was nested within ADAPTED. Incubating forage samples in ADAPT led to greater (P < 0.05) IVTD in MGH (34.0 vs 37.2%) and FRG (56.0 vs 59.0%) but not (P > 0.05) in LBGH (64.6 vs 64.9%). Adding FORMULA the day of incubation of forage samples resulted in greater (P < 0.05) IVTD (52.0 vs 53.3%). When concentrate samples were incubated in ADAPT, IVTD was greater (P < 0.05) regardless of concentrate sample (84.3 vs 87.8%). In vitro evaluation of effects of long-term ruminal adaptation to FORMULA on digestibility demonstrated potential to improve digestibility of forages and concentrates in vivo. Specific situations for which digestibility improvements may not occur need to be determined in additional studies. Future in vitro studies must be conducted using rumen fluid of cattle adapted to FORMULA for at least 21 d.


Feedlot consulting veterinarians (n = 23) representing over 15.6 million feeder cattle in the United States and Canada were invited to participate in a beef cattle health and well-being recommendation survey. The objective of the study was to survey consulting feedlot veterinarians on recommended practices for cattle health and well-being. The current survey tool was built on a previous survey (Terrell et al., 2011), and was reviewed by Kansas State University and industry veterinarians before distribution. Veterinarians were directed to an online survey to answer 78 questions on feeder cattle husbandry, health, and preventative medicine recommendations. Response rate was 100%. The consulting veterinarians visited feedyards in their practice an average of 1.7 times per month. Ninety-six percent of veterinarians were involved in training pen riders. All veterinarians were familiar with the Beef Quality Assurance (BQA) Feedlot Assessment Tool, and 95% used BQA concepts in employee training. Participants recommended one pen rider per 3,464 high-risk calves, and one per 6,405 low-risk calves. All veterinarians recommended an IBR vaccine for both high-risk and low-risk cattle. Banding was the most commonly recommended method of castration in cattle over 500 pounds. Ancillary therapy for BRD was recommended by half of the participants, and Vitamin C was the product most commonly recommended for such therapy. Cattle health risk was considered the most important factor for predicting morbidity. This survey provides valuable information on the current recommendations of feedlot consulting veterinarians in the United States and Canada, and offers benchmarking data for veterinarians in the industry.
Ionophore and non-ionophore growth promoters on no roughage finishing diet

Barbara J M Lemos¹, Flavio G F Castro¹, Bruno P C Mendonça², Carlos E Dambros¹, Dheividy B Fernandes², Antenor L Braga Netto², Victor R M Couto¹, Juliano J R Fernandes¹,
¹Universidade Federal de Goiás, Goiânia, Brazil, ²AgroCria, Brazil

The effects of growth promoters monensin, virginiamycin and flavomycin isolated and in combination on dry matter intake, growth performance and carcass characteristics of Nelore bulls fed a no roughage finishing diet were evaluated. Ninety eight Nelore bulls (392 ± 47 kg BW; 4 or 5 bulls per pen) were fed once daily ad libitum for 101 days a TMR diet (85% whole corn + 15% pelleted concentrate; TMR composition: 88% DM, 12% CP, 14% NDF, 72% TDN). Bulls were adapted over 18 days by decreasing the sugar cane bagasse inclusion from 25 to 0% of diet DM. The experimental design was a randomized complete block (4 blocks by initial BW) and the pens were the experimental units (n = 20). Treatments within pellets were MON = monensin 30 ppm; VGM = virginiamycin 25 ppm; M+V = monensin 20 ppm + virginiamycin 25 ppm; FLV = flavomycin 40 ppm; M+F = monensin 20 ppm + flavomycin 20 ppm. No treatment effects (P > 0.05) were observed in this study. The responses on intake and growth observed for MON, VGM, M+V, FLV and M+F were, respectively: DMI = 8.4, 9.0, 8.8, 9.3 and 9.1 kg/d (SEM = 0.39, P = 0.578); ADG = 1.465, 1.466, 1.444, 1.504 and 1.463 kg/d (SEM = 0.04, P = 0.902); G:F = 0.18, 0.17, 0.17, 0.16 and 0.16 (SEM = 0.01, P = 0.799). Numerically, the feed efficiency expressed as G:F was higher for MON diet compared to diets with virginiamycin and flavomycin (5.6 and 11.1%, respectively). The responses on carcass characteristics observed for MON, VGM, M+V, FLV and M+F were, respectively: HCW = 309, 306, 309, 309 and 304 kg (SEM = 2.62, P = 0.455); DP = 57.4, 57.3, 57.6, 56.9 and 56.2% (SEM = 0.45, P = 0.267); Fat thickness = 3.2, 3.4, 2.9, 3.4 and 3.5 mm (SEM = 0.18, P = 0.158). In conclusion, there was evidence that ionophore and non-ionophores growth promoters, monensin, virginiamycin and flavomycin, isolated and in combination, consistently maintain similar responses on dry matter intake, growth performance and carcass characteristics of finishing bulls fed no roughage finishing diet.

Adapted from abstract in proceedings of Joint of Annual Meeting ASAS – ADSA 2014

Influence of wet distillers grains produced from a novel cellulosic ethanol process utilizing corn kernel fiber on performance of feedlot cattle

E. L. Lundy, D. D. Loy, and S. L. Hansen,
Iowa State University, Ames

Changes in ethanol production influence the nutrient profile of the distillers grains (DG) produced. One recent example of this is a secondary fermentation process involving cellulosic enzymes, yeast, and heat which partially converts corn kernel fiber into cellulosic ethanol, resulting in a novel wet DG product (C-WDG). The objective of this study was to evaluate the impact of feeding C-WDG or traditional wet DG (T-WDG) on finishing cattle growth and carcass characteristics. Crossbred steers (n = 168; 928 ± 52.7 lb, SD) were stratified by source, blocked by weight to pens of 6 steers, and assigned to 1 of 4 dietary treatments fed for 94 days. Diets included a corn-based control with 13% T-WDG (CON), 30% T-WDG (TRAD), 30% C-WDG (CEL), or 18% C-WDG plus 12% condensed corn distillers solubles (CEL+CCDS). Co-products replaced corn on a DM basis. Data were analyzed in SAS as a randomized complete block design with pen as the experimental unit (n = 7/treatment). Three comparisons were made: 1) CON vs. TRAD, 2) TRAD vs. CEL, and 3) CEL vs. CEL+CCDS. Data presented are LSMEANS ± pooled SEM. Steers fed TRAD had greater (P ≤ 0.01) ADG (3.86 ± 0.091 lb), F:G (6.51 ± 0.165), and HCW (811 ± 15.7 lb), and tended (P = 0.07) to have larger ribeye areas.
(REA) compared to steers fed CON (ADG 3.51 lb; F:G 6.74; and HCW 802 lb). Steers fed CEL had decreased F:G ($P = 0.01; 6.51$) due to increased DMI ($P = 0.02; 24.0 \pm 0.53$ lb) compared to TRAD-fed steers (23.2 lb). No differences ($P \geq 0.16$) in ADG, HCW, or REA were observed among steers fed CEL or TRAD. Steers fed CEL had leaner carcasses ($P \leq 0.04; \text{YG} 2.8 \pm 0.08$) compared to TRAD-fed steers (YG 3.1). Steers fed CEL+CCDS had lesser ($P \leq 0.04$) DMI (22.0 lb) and ADG (3.48 lb) than CEL-fed steers (ADG 3.71 lb), while F:G did not differ ($P = 0.56$). Subsequently, steers fed CEL+CCDS tended ($P = 0.07$) to have lesser HCW (800 lb) compared to CEL-fed steers (811 lb), likely because of the greater S contributed by the CCDS. Dietary NEg calculations based on cattle performance confirmed a 7% increase ($P < 0.01$) in TRAD compared to CORN, a 5% decrease ($P < 0.01$) in CEL compared to TRAD, and a 3% increase ($P = 0.01$) in CEL+CCDS compared to CEL. Results from this study reiterate that T-WDG are superior to corn in energy content and establish that C-WDG produced from conversion of corn kernel fiber into cellulosic ethanol maintains growth performance of cattle when replacing corn in feedlot diets.


Effect of inclusion of post-extraction algal residue on nutrient utilization, carcass performance, and beef flavor in finishing steers  J.C. Morrill, J.E. Sawyer, J.R. Baber, S.B. Smith, R.K. Miller, and T.A. Wickersham, Texas A&M University, College Station

A three phase experiment was conducted to determine effects of post-extraction algal residue (PEAR) inclusion on nutrient utilization, carcass performance, and beef flavor in finishing steers. In Phase 1, 18 Angus × Hereford steers (BW = 549 ± 38.8 kg) were randomly assigned to one of three treatments: PEAR hand-mixed into the diet at 1.0 kg OM/d (PEAR), 1.0 kg OM/d glucose infused ruminally (GR) or abomasally (GA). Infused steers were fitted with ruminal cannulae, allowing continuous infusion of glucose via anchored infusion lines. Basal diets consisted of dry rolled corn (42.3%), ground milo (18.0%), cottonseed hulls (13.5%), grass hay (10.0%) molasses (6.7%), cottonseed meal (5.4%), vitamin/mineral premix (2.3%), urea (0.9%), and limestone (0.9%). Steers were adapted to housing and basal diet for 5 d; subsequently, treatments were applied for 35 d, until harvest. Intake was measured daily and digestion was determined from d 27 to 31 using fecal grab samples. Forty-eight h post-harvest, carcass measurements and strip steaks were collected from each carcass from GA, GR, and PEAR treatments. Strip steaks were analyzed by an expert trained sensory panel in Phase 2. Seventy-two h post-harvest, beef primals and subcutaneous fat from the chuck and round of each carcass from GR and PEAR treatments were collected for evaluation by a consumer panel in Phase 3. Ground round and ground chuck was analyzed in a 2 × 2 factorial arrangement with two factors for diet: GR and PEAR. Greater DMI was observed for PEAR (13.0 kg/d) than GR (10.3 kg/d; $P < 0.05$); DMI for steers receiving GA (11.2 kg/d) was intermediate and not different from either PEAR or GR ($P \geq 0.14$). Intake of digestible OM was similar among treatments ($P = 0.51$) and averaged 8.8 kg/d. Digestion of NDF was substantially less (55.7%) for PEAR than GA (75.4%) and GR (75.0%; $P < 0.01$). No measurable NDF was added to the diet by inclusion of PEAR; thus, effects on NDF digestion are indirect. Steers fed PEAR had greater marbling scores (520) than GA (463) and GR (452; $P = 0.01$). Accordingly, USDA Quality Grade was greater for PEAR than GA and GR ($P = 0.01; 340, 321, and 317$, respectively). There were no differences in USDA Yield Grade or HCW among treatments ($P \geq 0.66$). Additionally, no off-flavors were detected by trained sensory panel analysis in strip steaks from GA, GR, or PEAR ($P > 0.05$). No
significant differences for overall like, overall flavor like, beef flavor like, or juiciness like were observed in ground beef from PEAR or GR fed steers ($P \geq 0.17$). Diet digestibility was impacted, carcass quality was slightly improved, but beef flavor was not affected by PEAR in the diet of finishing steers.

**Feeding alkaline-treated corn stover to lightweight steers during the backgrounding phase**

*K. Nenn, E. Mousel, G.A. Bridges, S. Bird, and A. DiCostanzo, University of Minnesota, St. Paul*

The objective of this study was to investigate whether alkali-treatment (CaOH$_2$) of corn stover or simply adding water to corn stover improved gains and feed conversion efficiency of cattle during a backgrounding phase. Fifty-one lightweight Angus steers (average BW 434 lb) were randomly allotted individually to a Calan gate feeding system to one of 3 dietary treatments. Treatments consisted of feeding corn stover treated with calcium hydroxide at 6% diluted in water, corn stover treated only with water (target final moisture content of stover for both treatments was 50%), or untreated corn stover as a negative control. Because only one bag was prepared for each corn stover treatment, no statistical analyses could be conducted on feed samples. Yet, concentration of NDF in calcium hydroxide-treated corn stover samples collected over the course of the study were numerically lower than those of either water-treated or untreated corn stover. Cumulative gas production (triplicate samples) of calcium hydroxide-treated corn stover numerically increased faster over time than those of either water-treated or untreated corn stover samples. Corn stover was fed at 30% of the diet dry matter. Legume-grass silage (15%), dry rolled corn (25%), dry distillers grains and solubles (25%) and a vitamin and mineral supplement (5%) on a DM basis made up the balance of the diet. Steers were fed once daily at 0600 h and orts were collected and sampled during this time. A shrunk live weight measurement was taken after a 16-hour stand without feed or water on days 1, 29, and 49.

Statistical differences ($P < 0.05$) were identified using the least square means procedure under MIXED procedure of SAS. Cattle fed water-treated corn stover consumed more ($P < 0.05$) feed DM and had faster rates of gain ($P < 0.05$) than those fed untreated corn stover. Cattle fed calcium hydroxide-treated corn stover had intermediate rates of gain that were similar ($P > 0.05$) to those of cattle fed water-treated or untreated corn stover. In spite of numerical differences in feed conversion efficiency (model $P$-value = 0.08), no statistical differences ($P > 0.05$) were detected amongst corn stover treatments. Although samples collected indicated a reduction in NDF and improvement in digestion due to calcium hydroxide-treatment of corn stover, we failed to demonstrate a statistically significant on feed conversion efficiency. Conversely, an alternative to alkali treatments, albeit when forage supply is not limiting, may be simple water addition as cattle fed water-treated corn stover gained weight more rapidly while consuming more DM.

**Effects of vaccination program on antibody response, health, and performance of receiving calves**  

*E.R. Oosthuysen$^1$, M.E. Hubbert$^2$, J.R. Graves$^1$, A.K. Ashley$^1$, and C.A. Löest$^1$, $^1$New Mexico State University, Las Cruces, $^2$Clayton Livestock Research Center, New Mexico State University, Clayton*

The ability of calves to illicit an immune response to vaccine is compromised during period of high stress (weaning, transportation, and comingling) due to the deleterious effect of stress on antibody development. Immune response to vaccines can also be decreased by the presence of high maternally derived antibodies (MDA), and this decrease is reported to be less pronounced when using alternative intranasal vaccines. This study evaluated the effects of an alternative...
intranasal-based vaccination program compared with a traditional subcutaneous injection-based vaccination program on calf health, performance, and antibody response to ovalbumin inoculation. Crossbred South Texas heifers (n = 227, initial weight = 409 ± 3.4 lb) were blocked by 2 truckloads and assigned to 24 pens and 3 treatments in a randomized complete block design. Treatment were no vaccination program (CON), an intranasal-based vaccination program (NASAL), and a traditional injection-based vaccination program (SQ). At initial processing (day 0), NASAL calves received an intranasal bacterial (M. haemolytica and P. multocida) and modified live virus (IBR and PI3) vaccine. Calves assigned to SQ received an injectable modified live virus (IBR, BVD type 1 and 2, PI3, BRSV, M. haemolytica, and P. multocida) and a clostridial vaccine at initial processing. On day 14, both NASAL and SQ calves received the same injectable vaccines used for SQ calves at initial processing. All calves were inoculated with an ovalbumin vaccine on day 0 and 14, and blood samples were collected on day 0, 14, and 28 for ovalbumin-specific IgG analysis as indication of immunocompetence. Calf weights were obtained on day 0, 28, and 56. Morbidity was assessed daily and recorded throughout the 56-day experiment. Calf weight, dry matter intake, morbidity, and mortality were not different (P ≥ 0.24) among the vaccination programs. During the first 28 days, SQ calves had greater (P = 0.02) ADG than CON, with NASAL being intermediate and not different to SQ or CON (1.05, 1.31, and 1.56 ± 0.11 lb/day for CON, NASAL, and SQ). Improved performance for vaccinated calves during the first 28 days may suggest that calves were able to respond to vaccines during the high stress receiving periods. Both SQ and NASAL calves had lower (P < 0.01) feed to gain ratio than CON (7.46, 5.67, and 4.65 ± 0.54 lb/lb for CON, NASAL, and SQ) during the first 28 days. From day 28 to 56, SQ and NASAL calves had lower (P < 0.01) ADG than CON calves (2.92, 2.49, and 2.48 ± 0.20 lb/day for CON, NASAL, and SQ), and had greater (P < 0.01) feed to gain ratio than CON calves (4.80, 5.44 and 5.56 ± 0.50 lb/lb for CON, NASAL, and SQ). For the 56-day experiment, ADG and feed to gain ratio was not different (P ≥ 0.33) among vaccination programs. Treatments did not affect (P ≥ 0.27) ovalbumin-specific-IgG responses in calves. In conclusion, the route of administration and number of antigens in vaccines did not affect health, performance, and immune response of newly received feedlot heifers.

An evaluation of biofuel coproducts in feedlot diets: cattle growth performance, carcass characteristics, apparent nutrient digestibility, and water use assessment of feedstock sources

T. L. Opheim1, P. R. B. Campanili1, B. J. M. Lemo1, L. A. Ovinge1, J. O. Baggerman1, K. C. McCuistion2, J. Dwyer3, M. L. Galyean1, J. O. Sarturi1, and S. J. Trojan1, 1Texas Tech University, Lubbock, 2 Texas A&M University-Kingsville, Kingsville, 3Texas Tech University, Lubbock

Crossbred steers (British x Continental; n = 192; initial BW 391 ± 28 kg) were used to evaluate the effects of feeding ethanol coproducts on feedlot growth performance, carcass characteristics, apparent nutrient digestibility, and the relationship between crop yield, water input, and animal performance. Steers were blocked by initial BW and assigned randomly to 1 of 6 dietary treatments within block. Treatments were replicated in 8 pens with 4 steers/pen and included: 1) control, steam-flaked corn-based diet (CTL); 2) corn dried distillers grains with solubles (DGS; DRY-C); 3) de-oiled corn dried DGS (DRY-CLF); 4) blended 50/50 dry corn/sorghum DGS (DRY C/S); 5) sorghum dried DGS (DRY-S); and 6) sorghum wet DGS (WET-S). The inclusion rate of DGS was 25% (DM basis); DGS diets were isonitrogenous, whereas CTL was formulated for 13.5% CP. All diets were balanced for fat. Overall ADG (1.64 kg), and DMI (10 kg/d) did not differ (P ≥ 0.14) among treatments. Means for G:F were identical (0.153) for...
DRY-C and DRY-CLF, which were similar to CTL, DRY C/S, and WET-S ($P \geq 0.30$). Gain efficiency was decreased 9.6% with DRY-S vs. CTL (0.142 vs. 0.157, respectively, $P < 0.01$), and was 7.2% les for DRY-S vs. DRY-C or DRY-CLF ($P < 0.05$), but tended ($P = 0.06$) to be 5.6% greater for WET-S vs. DRY-S. Diet did not affect HCW (400 kg) or dressing percent (62.4%; $P \geq 0.10$); however, yield grade tended ($P = 0.09$) to be less for DRY-CLF and DRY-S vs. other treatments. Digestibilities of DM and OM did not differ among CTL, DRY-C, DRY-CLF, and WET-S ($P \geq 0.30$), and were least for DRY-S vs. other treatments ($P < 0.01$). Digestibilities of DM and OM were greater for DRY-C/S vs. DRY-S ($P < 0.01$), and similar for DRY-C/S, and DRY-C ($P \geq 0.20$). Digestibility of NDF was greater ($P < 0.01$) for WET-S vs. other treatments, and least for DRY-S vs. other treatments ($P < 0.01$), but not different among DRY-C, DRY-CLF, and DRY-C/S ($P \geq 0.40$). Starch digestibility was the greatest, and not different among CTL, DRY-C, DRY-CLF, and DRY-C/S ($P \geq 0.40$). Analysis of total crop water use for corn vs. grain sorghum relative to G:F for DRY-C, DRY-S, and WET-S diets revealed a greater coefficient for steer gain relative to grain yield as a function of water input at 280 mm of water for grain sorghum vs. corn. At a moderately high (25% dietary DM) inclusion, blending C/S or feeding WET-S resulted in similar cattle performance to CTL and corn-based coproducts.

Behavioral evaluation when using wet corn gluten feed or wet distillers grains plus solubles to adapt cattle to finishing diets  

L. Ovinge¹, J.O. Sarturi¹, G. E. Erickson², and T. J. Klopfenstein³, ¹Texas Tech University, Lubbock, ²University of Nebraska, Lincoln

Behavioral responses to adaptation diets using Sweet Bran (Cargill) or wet distillers grains plus solubles (WDGS) were evaluated. Six ruminally cannulated steers (300 ± 22 kg) at 11 months of age were assigned randomly using a CRD experiment to one of two adaptation strategies including either Sweet Bran or WDGS. Steers were fed a series of six diets: four adaptation steps, a finishing, and a finishing blend diet. The first step included 87.5% DM of either Sweet Bran or WDGS, with 0% dry rolled corn (DRC), and was reduced to 35% of the finishing diet over a period of 4 steps (7 days each), and increasing the level of DRC to 52.5%. Diets also included 7.5% alfalfa hay and 5% supplement. Blend diet (50:50) contained WDGS and Sweet Bran (17.5% of each, DM basis). Behavioral status (24 h) was recorded by video cameras strategically located on top of individual pens. Behavior was evaluated every 5 min during d-4 of each period, and it was noted whether the steers were resting or ruminating, as well as standing up or lying down, eating, or drinking. Data were analyzed using the GLIMMIX procedures of SAS, and blend diet was used as a covariate. Steers fed Sweet Bran strategy spent more time ($P < 0.10$) ruminating while lying down than WDGS in steps 1 and 4 (223 vs. 93; 289 vs. 77 min/d, respectively); and ruminating overall in step 4 (321 vs. 65 min/d, and tended ($P \leq 0.15$) for similar pattern for total rumination in steps 1, 2, and 4 (259 vs. 105; 323 vs. 129; for Sweet Bran and WDGS strategies, respectively). Steers fed Sweet Bran strategy also spent more time ($P < 0.10$) ruminating per percentage unit of NDF in step 4 (11.38 vs. 2.29 min-d/%NDF, respectively), as well as tended ($P \leq 0.15$) to spend more time chewing (ruminating plus eating activities) than WDGS strategy in step 4 (418 vs. 227 min/d). Steers fed WDGS strategy had greater ($P < 0.10$) time resting while standing up in steps 2 and 3 (267 vs. 174; 283 vs. 211 min/d; respectively). Overall, the Sweet Bran adaptation strategy shows a more desirable rumination pattern during adaptation to DRC-based finishing diets in feedlot steers than strategy using WDGS.

In the first year of a multiple-year experiment, feedlot performance and carcass traits were evaluated for 39 fall-born Angus, Angus x Hereford steers from two cow/calf production systems. Production systems were 1) intensive, semi-confined production system utilizing native range (spring and fall), dry-lot feeding with limited winter wheat pasture grazing (winter), and limited cover crop grazing (summer); 2) extensive, season-long continuous grazing on native range with protein supplementation during winter, representative of traditional cow/calf management in the region. Initial BW upon entering the feedlot was greater for steers produced in the intensive (IS) system than for steers in the extensive (ES) system ($P < 0.05$) at 370 and 334 kg hd$^{-1}$ respectively. Analysis of Variance was conducted using the GLM procedure in SAS software. Back fat thickness was included as a covariate in analysis of performance and carcass traits. Results presented are least squares means calculated by SAS. Steers produced in the IS had 18% greater ($P < 0.05$) ADG and a 15% improvement ($P < 0.05$) in gain per unit of feed (G:F). Steers produced in IS had a 5% greater ($P < 0.05$) live finished weight, 3.2% greater ($P < 0.05$) hot carcass weight, and 6% lower kidney, pelvic, and heart (KPH) fat ($P < 0.05$), than ES steers. There was no difference in marbling ($P > 1.0$) but there was a trend for ribeye area to be greater in IS steers than in ES ($P = 0.14$). Yield grade was 13% lower ($P < 0.05$) in IS Steers than in ES steers at 3.2 and 3.6 respectively. Postnatal grazing management system had a dramatic impact on summer feedlot entry weight, feedlot performance and carcass characteristics in a fall-calving system. Improved winter nutrient status when cows limit grazed and calves grazed wheat pasture ad libitum resulted in greater summer weaning weight followed by increased weight gain and feed conversion during the finishing phase.

Evaluation of glycerol inclusion in receiving diets of feeder calves  E. M. Rife, A. R. Taylor, and R. H. Pritchard, South Dakota State University, Brookings

Glycerol (GLYC), a by-product of the biodiesel industry, has an energy value similar to corn. Consistent with previous studies, we observed a linear decrease in DMI ($P<0.01$) as glycerol replaced dry rolled corn in finishing diets. In contrast, we observed a linear increase in DMI ($P<0.01$) as GLYC replaced corn silage in backgrounding diets. Reduced DMI associated with high-concentrate diets was apparently not an anti-nutritional characteristic of GLYC, since the absolute GLYC intake (lb/d) was higher for steers backgrounded on corn silage. In finishing steers, plasma glucose (GLS) concentrations tended to decrease linearly ($P=0.10$) in response to increasing dietary GLYC. Plasma GLYC concentrations responded quadratically ($P<0.01$) with 15% GLYC diets resulting in plasma GLYC concentrations lower than Control steers. These observed changes in blood GLS and GLYC concentrations in finishing cattle may indicate the effectiveness of GLYC inclusion in high starch diets is limited due to the abundance of glucogenic compounds relative to demand. Collectively, these data suggested that dietary GLYC might expedite re-establishment of normal GLS status and energy balance in newly weaned calves introduced into the feedlot. Steer calves (n=216; 633 ± 58 lb) were weaned and shipped 360 miles to the Ruminant Nutrition Center. Calves were allowed to rest overnight before processing. The processing BW was used to allot steers to 1 of 4 dietary treatments (6 pen replicates • diet$^{-1}$; 9 steers • pen$^{-1}$). Dietary treatments consisted of 0, 8, 16, and 24% GLYC replacing corn in sorghum silage-based diets of similar nutrient composition (12.5% CP; 48

123
Mcal/cwt NE\textsubscript{G}). Steers were individually weighed prior to the morning feed delivery on d 1, 11, 22, and 53 post-arrival. Feed records were summarized for each of these interim periods. Blood samples were collected via jugular venipuncture from 3 sentinel steers per pen on d 6, 20, and 48 post-arrival to quantify circulating concentrations of NEFA, GLYC, GLS, and urea nitrogen (PUN). Treatment and pen replicate were included in the model as independent sources of variation to evaluate the response of GLYC on steer performance using pen as the experimental unit. Treatment, pen replicate, and time were included in the model as independent sources of variation to evaluate the response of GLYC and time (repeated measures) on blood metabolites using individual steer as the experimental unit. Feed deliveries were managed to accommodate naive calves during the initial 17 d of the receiving phase. Increasing levels of dietary GLYC did not affect DMI. Body weight change increased linearly during the 1 to 11 d interim period with increasing dietary GLYC inclusion (\(P<0.01\)). Steers fed lower levels of GLYC exhibited a linear, compensatory change in BW during the 12 to 22 d interim period (\(P<0.01\)). There were no differences in steer performance throughout the remainder of the 53 d receiving period. Plasma NEFA (\(P<0.01\)), GLYC (\(P=0.02\)), and GLS concentrations (\(P=0.04\)) decreased linearly while PUN concentrations increased linearly (\(P<0.01\)) as GLYC increased in the diet. A treatment × time interaction was detected for GLS concentrations (\(P=0.04\)) with elevated GLS levels in Control steers compared to glycerol fed steers on d 48. In conclusion, dietary GLYC hastens re-establishment of normal GLS status and has no adverse impact on acceptability of feed to incoming naive calves. Future studies should address the potential for these responses to improve feedlot receiving period health of calves.

**Effect of injectable trace mineral administration on health, performance and vaccine response of newly received beef cattle**  
S. L. Roberts\textsuperscript{1}, N. D. May\textsuperscript{1}, C. L. Brauer\textsuperscript{2}, W. W. Gentry\textsuperscript{2}, C. P. Weiss\textsuperscript{2}, J. S. Jennings\textsuperscript{2}, and J. T. Richeson\textsuperscript{1}, \textsuperscript{1}West Texas A&M University, Canyon, \textsuperscript{2}Texas A&M AgriLife Research, Amarillo

Previous research has established that trace minerals are necessary for optimal animal health and performance. The objective of this study was to evaluate the impact of an injectable trace mineral supplement containing copper, zinc, selenium, and manganese (Multimin 90) on vaccine response, growth performance and morbidity of beef calves upon entry into a feedlot. A total of 128 crossbred bull (n=40) and steer (n=88) calves were utilized. Cattle were stratified by initial BW (607±7 lb) and gender, then assigned randomly to treatment pens (n=8/treatment). Treatment protocols were: 1) negative control (Control), or 2) Multimin 90 (Multimin) administered at 1 mL/100 lb BW subcutaneously on d 0. Cattle were also administered a pentavalent modified-live respiratory vaccine, anthelmintic, and metaphylaxis with tilmicosin phosphate on d 0. Individual BW data and blood were collected on d 0, 14, 28, and 42. Harvested serum was used to determine bovine viral diarrhea virus (BVDV) type 1a antibody titer as a proxy for vaccine response. Health was monitored daily by trained personnel blinded to treatment pen assignment. Calves were pulled when assigned a clinical illness score of \(\geq 2\), and considered morbid and administered antimicrobial treatment if rectal temperature was \(\geq 103.5^\circ\text{F}\) or if lung auscultation score was \(\geq 3\) on a 1 to 5 scale. Overall DMI was not different (\(P=0.82\)) between Control and Multimin. Also, no difference in overall ADG (\(P=0.21\)) was detected between Control (3.00 lb/d) and Multimin (2.77 lb/d) steers. The overall morbidity rate observed for this study was low (14%). There was no statistical difference (\(P=0.71\)) in morbidity between treatments, which averaged 15.6 and 12.5%, for Control and Multimin, respectively. There was a treatment x d effect (\(P=0.09\)) for BVDV-specific antibody titer. On d 14, the Multimin group had
a greater ($P=0.02$) BVDV antibody titer than the Control group. Multimin administration numerically decreased ($P=0.53$) the total antimicrobial treatment cost by $1.52/\text{head}$. This data suggests that while administration of an injectable trace mineral did not improve performance or morbidity rate when disease incidence was low, the BVDV-specific antibody response to a respiratory vaccine developed faster for Multimin 90 treated animals.

**Effect of corn silage bacterial inoculation on feedlot performance with or without the addition of yeast product**  
C. A. Row, C. J. Bittner, J. L. Harding, D. B. Burken, J. C. MacDonald, T. J. Klopfenstein, A.A. Aguilar, R. Schmidt, G. E. Erickson, University of Nebraska, Lincoln

A finishing study using 320 yearling steers (initial BW = 417 kg ± 22.7) evaluated the effect of using a silage inoculant or not on performance and carcass characteristics. Treatments were designed as a $2 \times 2 \times 2$ factorial arrangement with factors being no inoculant (CON) or use of inoculant (Buchneri spp.; B500) at silage harvest, silage fed at 15 or 40% of diet DM, and presence (LEV) or absence (noLEV) of Levucell SC yeast product fed at 14.2 g/d. Performance data were analyzed with pen as the experimental unit, with 5 pens/treatment. There was very little numeric differences in DM, CP, pH, or organic acids between the CON and B500; however, no statistical analysis was performed due to only one silage bunker per treatment. There was a three-way interaction for final live BW, HCW, ADG, and G:F ($P < 0.05$). Greater inclusion of silage in the diet increased DMI ($P < 0.01$). At 15% silage inclusion, the B500 LEV treatment had the lowest ADG, which was similar to both CON treatments ($P = 0.55$) and less than the B500 noLEV treatment, ($P \leq 0.05$). At 40% silage inclusion, the CON LEV and B500 noLEV treatments had the numerically least ADG, but all treatments were similar ($P \geq 0.06$), with CON LEV tending to have the lowest ADG. At 15% silage inclusion, the B500 LEV treatment had the lowest G:F ($P = 0.04$), all other treatments were similar ($P \geq 0.16$). At 40% silage inclusion, all treatments had similar G:F ($P \geq 0.07$). Feeding corn silage at 40% inclusion instead of 15% inclusion increased DMI and decreased G:F. When including silage at 15%, using B500 inoculant, the addition of LEV did not improve performance of finishing steers. When not using an inoculant the addition of LEV did improve performance of finishing steers. When including silage at 40%, using B500 inoculant, the addition of LEV did improve performance of finishing steers. However, when not using an inoculant, the addition of LEV did not improve performance of finishing steers.

**Influence of feed efficiency ranking on diet digestibility and performance of beef steers**  
J. R. Russell$^1$, N. O. Minton$^2$, W. J. Sexten$^2$, M. S. Kerley$^2$ and S. L. Hansen$^1$, $^1$ Iowa State University, Ames, $^2$ University of Missouri, Columbia

The study objective was to determine effects of growing phase (GP) diet, GP feed efficiency (FE), and finishing phase (FP) diet on diet digestibility and FP feed efficiency. Two groups, totaling 373 steers, were fed at the University of Missouri (70-d GP), shipped to Iowa State University (ISU) for finishing, and fed in GrowSafe bunks during both phases. During GP, steers received whole shell corn (GCorn) or roughage-based (GRough) diets. Within each group, the 12 greatest and 12 least feed efficient steers from each GP diet ($n = 96$ total; 1074 ± 116 lb) were selected. At ISU, steers were fed 10 g titanium dioxide (TiO$_2$) daily in receiving diets similar to GP diets for 14-d, followed by 2-d fecal collection to determine diet DM digestibility during GP (GDMdig). For FP, steers were transitioned to corn (FCorn) or byproduct-based diets (FByp). Optaflexx was fed for 28-d prior to harvest and the TiO$_2$ protocol was repeated immediately before Optaflexx introduction to determine FP diet digestibility (FDMdig). The 96 steers were
ranked by growing phase G:F and categorized as the 24 greatest (HFE) or 24 least (LFE) feed efficient steers from each GP diet. Data were analyzed using PROC MIXED of SAS with group as a random effect. The HFE steers tended to have greater GDMdig than LFE (69.1% vs 65.5%; \( P = 0.13 \)), but FDMdig did not differ due to FE (\( P = 0.9 \)). A positive correlation between GDMdig and FDMdig was noted for steers fed similar diets during both feeding phases, for GCorn-FCorn steers (\( r = 0.49, P = 0.02 \)) and for GRough-FByp steers (\( r = 0.68, P < 0.01 \)). Despite greater finishing G:F in HFE versus LFE steers (\( P = 0.04 \)), there was a negative correlation for G:F between phases in GRough-FCorn steers (\( r = -0.57, P < 0.01 \)). In this study, digestibility was positively correlated between feeding phases when steers were grown and finished on similar diets. Feed efficiency was negatively correlated between phases when steers were roughage-grown and corn-finished, reinforcing the idea that cattle should be FE tested using diets similar to the production environment of interest.

Adapted from an abstract presented at 2015 Midwest ASAS/ADSA Meetings

Effect of zilpaterol hydrochloride on carcass characteristics of beef steers fed at maintenance or ad libitum intake

A.N. Schmitz, L.J. Walter, W.T. Nichols, J.P. Hutcheson, and T.E. Lawrence
West Texas A&M University, Canyon, Texas, and Merck Animal Health, Summit, NJ

An experiment was performed to evaluate carcass characteristics of over-finished steers supplemented zilpaterol hydrochloride (ZH) and fed at maintenance (M) or ad libitum (AL) intake level. Fifty-six single-sired steers were blocked (n=28 per block) by implant status and sorted into pairs by weight. Pairs were randomly assigned to a harvest d of 0, 28, or 56 and to a M or AL diet level within d 28 and 56. Supplementation of ZH was randomly applied within a pair for each of M and AL diet levels. Steers were individually weighed on d 0, 1, 27, 28, 55 and 56 following feed and water withdrawal for 9 h. Adjustments for DMI on M diet level were performed accordingly by weighing steers on d 11 and 21 with AL bunk calls adjusted daily depending on feed refusal. Zilpaterol was fed continuously at 90mg for 20 d with a withdrawal period of 4 d. Steers were finished to above typical slaughter weights (BW= 603.5 ± 48.1 kg) prior to harvest. After a 24 h chill period, standard USDA grading procedures were used to derive a calculated yield grade (3.7 ± 0.3) from hot carcass weight (HCW, 381.0 ± 11.2 kg), 12th rib s.c. fat depth (2.0 ± 0.2 cm), LM area (88.5 ± 2.9 cm²), and percentage of kidney-pelvic-heart fat (KPH%, 2.1 ± 0.2%) as well as a marbling score (Small32 ± 21 degrees) for each carcass. In addition, dressed carcass yield (64.4 ± 0.5 %) was calculated. The MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) was used for analysis. Fixed effects included treatment combinations and random effects included block and pair. Single df contrasts tested d 0 vs. 28, d 0 vs. 56, d 28 vs. 56, M vs. AL, and Control (CON) vs. ZH. Differences were considered significant at a \( P \)-value ≤ 0.05 and trends at a \( P \)-value ≥ 0.05 and ≤ 0.10. Hot carcass weight was impacted (\( P < 0.01 \)) by intake (M = 365.9, AL = 402.6 kg), days on feed (0 = 361.6, 28 = 368.2, 56 = 392.3 kg) and treatment (CON = 384.2, ZH = 400.3 kg). Similarly, dressed carcass yield was impacted (\( P < 0.01 \)) by intake (M = 65.0, AL = 64.3%) days on feed (0 = 63.2, 28 = 64.0, 56 = 64.9%) and treatment (CON = 63.9, ZH = 66.0%). Additionally, 12th rib s.c. fat depth was altered (\( P < 0.01 \)) by intake (M = 1.7, AL = 2.4 cm) and days on feed (0 = 1.6, 28 = 1.9, 56 = 2.1 cm). Dietary intake level and ZH supplementation affected (\( P < 0.05 \)) weighed KPH (M = 1.9, AL = 2.2%; CON = 2.3, ZH = 1.9%). Calculated yield grade differed (\( P < 0.05 \)) by intake (M = 3.30, AL = 4.24), days on feed (0 = 3.30, 28 = 3.54, 56 = 3.89), and treatment (CON = 3.86, ZH = 3.92). Neither marbling score nor LM area was impacted by ZH treatment or intake level. The results from this study indicate that the supplementation of ZH has an effect on economically
important carcass characteristics of beef steers fed at both maintenance and ad libitum dietary intake levels.

The effect of dry-rolled corn particle size on feed efficiency in feedlot finishing diets containing wet distiller’s grains E. F. Schwandt¹, C. D. Reinhardt¹, D. U. Thomson², S. J. Bartle³, T. E. Engle³, and J. J. Wagner³, ¹Kansas State University, Manhattan, ²College of Veterinary Medicine, Kansas State University, Manhattan, ³Colorado State University, Fort Collins

Cross-bred yearling steers (n = 360; initial BW = 871 ± 73 lb) were used to evaluate the effect of dry-rolled corn (DRC) particle size and steam-flaking on performance and carcass traits when included in feedlot finishing diets containing 20% wet distiller’s grains plus solubles (DMB). Average daily gain and feed efficiency, carcass characteristics, and fecal starch content were measured. Steers were utilized in a randomized complete block design and allocated to 36 pens (9 pens/treatment; 10 animals/pen). Treatments were: Coarse DRC (4,882 µm; COARSE), Medium DRC (3,760 µm; MEDIUM), Fine DRC (2,359 µm; FINE), and Steam-flaked corn (27 lb/bu; SFC). Final BW (1405, 1411, 1401, and 1413 ± 9.9 lb for COARSE, MEDIUM, FINE, and SFC) and ADG (4.35, 4.40, 4.32, and 4.40 ± 0.076 lb for COARSE, MEDIUM, FINE, and SFC) were not affected by treatment. Dry matter intake (26.05, 25.80, 25.86, and 24.55 ± 0.513 lb for COARSE, MEDIUM, FINE, and SFC) and F:G (5.99, 5.86, 5.98, and 5.57 ± 0.106 for COARSE, MEDIUM, FINE, and SFC) increased (P < 0.05) for steers fed DRC vs. SFC. There was a linear effect (P < 0.05) of decreasing particle size with decreasing DMI in the final 5 weeks on feed. Fecal starch (13.88, 10.32, 7.53, and 2.02 ± 0.610 % for COARSE, MEDIUM, FINE, and SFC) decreased linearly (P < 0.01) as DRC particle size decreased. In situ starch disappearance was lower for the DRC vs SFC treatments (P < 0.05) and increased linearly (P < 0.05) with decreasing particle size at 8h and 24h. Reducing DRC particle size did not influence growth performance but reduced fecal starch and influenced DMI of cattle on finishing diets.

Relationship Between the Prevalence of Horns and Prevalence, Anatomical Location, and Severity of Bruises on Beef Carcasses J.C. Simroth, M. Stephens, S. Bartle, D. Rethorst, C. Reinhardt, and D. Thomson, Kansas State University, Manhattan

Providing consumers with affordable, safe, wholesome, and high quality beef that has been produced in a responsible and humane way is a foundation of sustainability of the beef industry. One of the major animal welfare concerns is bruising of cattle during handling. Bruising causes a reduced profit to the producer due to trim loss and can be an indication of sub-standard cattle management. The objective of this study was to investigate the relationship between the presence of horns in cattle and the prevalence, anatomical location, and severity of bruising of carcasses.

Carcasses from 4,287 feedlot cattle were observed at one commercial beef packing plant in southwest Kansas. Cattle were scored on 3 separate days; no effort was made to select the types of cattle scored. Cattle were evaluated for presence or absence of horns and then scored for bruising after the hides had been completely removed. Identification of horned cattle, horn measurements, and recording of data were performed by 3 trained evaluators from the Beef Cattle Institute (BCI) at Kansas State University. Horn measurements taken were: 1) the length of the longest horn from base to tip, and 2) the tip to tip length. Bruises were evaluated by location and severity using the Harvest Audit Program developed by the BCI, which divides the carcass into 9 anatomical regions. Severity was scored at 3 levels; minor (-): ≤ 2”, moderate (0): 2 to 6”, and severe (+): > 6”. From the evaluated carcasses, 85% were from beef and 15% were Holsteins. Bruising and horn prevalence were 51 and 6% for beef carcasses and 70 and 11% for
Holstein carcasses. Of the total number of bruises, 25.6% were severe, 35.6% were moderate, and 38.8% were minor. Majority of bruises (61.8%) occurred on the dorsal mid-line of the carcass with similar bruising occurring on the left (18.6%) and right (19.5%) sides of the carcasses. The prevalence of bruising on the cranial third of the carcass (21.8%) was a third of the prevalence of bruising that occurred on the center (60.5%) and caudal (17.6%) portions of the carcass. Horn prevalence had a small contribution in explaining the variation and predicting the prevalence of bruising of beef carcasses ($r^2 = 0.09$). Further research during handling including loading and unloading techniques, transportation practices, and trailer design is needed to effectively reduce the incidence of carcass bruising and maximize animal welfare.

**Effects of level of DDG supplemented on pasture to performance in feedlot and carcass traits**  
W.B. Smith1, T.J. Machado2, L.O. Tedeschi3, J.P. Banta4, J.L. Foster5, K.C. McCuistion2, C.R. Long1 and F.M. Rouquette, Jr.1, 1Texas A&M AgriLife Research, Overton, 2Texas A&M University - Kingsville, Kingsville, 3Texas A&M University, College Station, 4Texas A&M AgriLife Extension Service, Overton, 5Texas A&M AgriLife Research, Beeville. 6Department of Animal Science, Texas A&M AgriLife Research, Overton

The objective of this study was to evaluate carryover effects in long yearling stocker calves previously stocked on ‘Tifton 85’ (TIF) or ‘Coastal’ (COS) bermudagrass (*Cynodon dactylon* [L.] Pers.) and supplemented daily with varying levels of DDG. For TIF steers (n = 48, 877 lb ± 9.7 lb initial BW) were stratified by BW within source and breed type and allocated randomly to 1 of 16 pastures (1.5 ± 0.02 ac), and pastures were allocated randomly to 1 of 4 levels of DDG supplementation for the 110-d study: 0.0, 0.25, 0.5 or 1.0% BW hd$^{-1}$ d$^{-1}$. For COS, steers (n = 63, 776 lb ± 16.8 lb initial BW) were stratified by BW within source and breed type and allocated randomly to 1 of 9 pastures (3.2 ± 0.42 ac), and pastures were allocated randomly to 1 of 3 levels of DDG supplementation for the 96-d study: 0.0, 0.25 or 1.0% BW hd$^{-1}$ d$^{-1}$. Steers were weighed every 21 d. Data were analyzed using SAS® PROC MIXED. For TIF, steers supplemented at 0.25, 0.50 and 1.00% BW gained more (2.2, 2.2 and 2.5 lb, respectively; $P < 0.01$) than those receiving pasture only (1.5 lb) during the stocker phase, but there was no effect of pasture treatments ($P = 0.36$) during the feedlot phase. For COS, steers supplemented at 1.00% BW tended to gain more (2.0 lb; $P = 0.05$) through the stocker phase than those receiving pasture only (1.4 lb) or 0.25% BW DDG (1.3 lb), but there was no effect of pasture treatment ($P = 0.39$) during the feedlot phase. For TIF, there was no effect ($P = 0.64$) of pasture treatment on hot carcass weight (996, 1020, 1016 and 1034 lb for 0.0, 0.25, 0.5 and 1.0% BW, respectively). For COS, there was no effect ($P = 0.14$) of pasture treatment on hot carcass weight (733, 1010 and 1025 lb for 0.0, 0.25 and 1.0% BW, respectively). Likewise, there was no effect of pasture treatment on percent High Select ($P = 0.14$ and 0.95) or percent Low Choice ($P = 0.74$ and 0.86) for TIF or COS, respectively. Results are interpreted to suggest that steers may be supplemented on pasture with DDG for increased gains and returns during the stocker phase without any effect on subsequent feedlot performance or carcass characteristics.

**Alternative nutritional management strategies affect finishing residual feed intake, lung mass and carcass marbling score of finished steers**  
J. K. Smith1, H. S. Cassell1, D. D. Harmon1, M. D. Hanigan1, S. W. El-Kadi1, S. E. Johnson1, S. P. Greiner1, M. A. McCann1, Virginia Tech, Blacksburg

Beef producers are continually searching for alternative nutritional management options. Previous research has identified the ability of an early nutritional intervention to imprint beef
steers for reduced finishing residual feed intake (RFI) and enhanced carcass marbling score (MS), as well as an inverse relationship between finishing RFI and lung mass. In order to further evaluate the effects of alternative weaning and finishing strategies on finishing RFI, lung mass and MS, an experiment was conducted that included Angus (ANG) and Simmental (SIM) sired steers randomly assigned to one of two weaning treatments (early weaned [EW; n = 14] or conventionally weaned [CW; n = 14]) and one of two finishing treatments (high corn [HC; 69% of DM from steam-flaked corn; n = 14] or low corn [LC; 50% of DM from steam-flaked corn isoenergetically replaced with dried corn gluten feed; n = 14]) in a 2x2x2 factorial design. Following weaning, EW steers were fed a concentrate-based ration *ad libitum* for 122 d prior to commingling and pasture backgrounding with CW steers for 190 d, and finishing in a feedlot for 154 ± 64 d. Un-shrunk BW was measured at 21 ± 4 d intervals throughout the duration of the finishing phase, and feed intake was measured daily following a 42 d finishing ration adaptation period. Steers were harvested in groups upon reaching a common ultrasound-estimated 12th-rib subcutaneous fat thickness (SFT) of 1 cm. Lung mass was measured immediately following harvest, and chilled carcasses were evaluated to determine MS. All statistical analyses were conducted using the Fit Model procedure of JMP Pro. Observed ADFI was regressed against average BW0.75, ADG, average SFT and duration of the measurement period (R² = 0.76; P < 0.0001), and RFI was calculated as the difference between observed and predicted ADFI. ANOVA was conducted to determine the fixed interaction and main effects of weaning treatment, finishing treatment and sire breed. RFI of ANG HC steers was lower than ANG LC (-0.91 vs. 0.49 Mcal NEg; SEM = 0.22; P < 0.001), SIM LC (-0.91 vs. 0.20 Mcal NEg; SEM = 0.22; P < 0.01) and SIM HC (-0.91 vs. 0.10 Mcal NEg; SEM = 0.22; P < 0.05), and was lower for EW than CW steers (-0.27 vs. 0.21 Mcal NEg; SEM = 0.15; P < 0.05). Lung mass and MS was greater for EW than CW steers (6.14 vs. 5.61 g/kg of BW; SEM = 0.15; P < 0.05 and 741 vs. 680; SEM = 15; P < 0.01, respectively), and HC than LC steers (6.21 vs. 5.54 g/kg of BW; SEM = 0.16; P < 0.01 and 775 vs. 646; SEM = 17; P < 0.0001, respectively). Collectively, these results provide additional evidence that early and late nutritional management strategies affect finishing feed efficiency and marbling development, and that increased lung mass of EW and HC steers may play a role in the observed improvement in feed efficiency.

**Evaluation of chromium propionate to feedlot steers at various physiological states**

Z. K. Smith, A. R. Taylor, and R. H. Pritchard, South Dakota State University, Brookings

Differences in gain efficiency between yearling and calf-fed steers may be caused by differences in insulin sensitivity impacting efficiency of cellular level nutrient uptake. In ruminants results of supplemental chromium (Cr) on indicators of glucose metabolism and insulin sensitivity have been inconsistent. Two experiments were conducted to determine the effect of dietary chromium propionate supplementation on insulin responsiveness in finishing steers. The two models were feedlot steers of different ages. (**Exp. 1**): 12 steers; 24 mo old (BW=1,727 ± 63 lb), (**Exp. 2**): 24 steers; 14 mo old (BW=1,378 ± 54 lb). The 2 dietary treatments included: 0 ppb added Cr (CON); or 400 ppb added Cr (CrP) as Cr propionate (KemTRACE 0.4% Chromium Propionate). An i.v. insulin challenge was accomplished by administering a jugular infusion of insulin (0.45 IU bovine insulin/ kg of BW0.75, INS). The addition of a jugular sham infusion of PBS (SHAM) was included in Exp. 2. The insulin challenges occurred 7 d prior to harvest after steers had been on finishing diets for 84 d (Exp. 1) and 86 d (Exp. 2). Blood samples were collected at (-30, 120, 195, 255, and 315 min) relative to their morning feed delivery. After the t-30 and t120 blood sampling steers were returned to their home pens with access to feed. Steers
were group housed by diet. Intake for the week prior to the INS challenges was not affected by Cr. The DMI were 24.0 lb hd⁻¹ · d⁻¹ (Exp. 1) and 23.5 lb hd⁻¹ · d⁻¹ (Exp. 2). The high concentrate diets were formulated to meet or exceed NRC requirements (NRC, 1996) and included monensin (29 g/T). Steers were fed twice daily, offering ad libitum access to feed in a clean bunk management system. Exp. 1 was analyzed as a CRD with the main effects of Cr, time and Cr x time. Exp. 2 was analyzed as a 2x2 factorial design of factors Diet (CON or CrP) and Insulin (SHAM or INS). In both experiments pre- and post-infusion data were analyzed separately and steer was the experimental unit. There were no Cr x time interactions for plasma metabolites in either experiment and exogenous insulin effectively cleared GLS in both classes of cattle. Exp. 1 Plasma glucose (GLS) concentrations were constant (P > 0.05) from t⁻30 to t₁₂₀. Plasma GLS concentration changed from from 74 mg·dL⁻¹ at t₁₂₀ to 54 mg·dL⁻¹ at t₁₉₅ (75 min post-infusion). Post-insulin infusion, CrP caused higher (P < 0.05) PUN concentrations when compared to CON steers. Exp. 2 Plasma GLS concentrations decreased (P < 0.05) from t⁻₃₀ to t₁₂₀. The PUN concentrations were not affected by CrP pre- or post-insulin infusion. Overall, a jugular infusion of INS caused a 15 mg·dL⁻¹ change in GLS (P < 0.05). The CrP supplemented steers had greater (P < 0.05) GLS concentrations at t₁₉₅ (75 min post-infusion) when compared with CON steers (82 vs. 77 ± 1.8 mg·dL⁻¹). These data suggest that plasma metabolites in 24 mo old and 14 mo old steers being supplemented with Cr respond differently to INS in the fed state. Differences in metabolite responses to supplemental Cr may be due to age dependent differences in insulin sensitivity. Responses may also be influenced by the likely differences in capacity for lean tissue accretion between old, heavy steers and younger, lighter steers.

A comparison of performance, carcass characteristics and meat quality from intact male beef cattle to castrated male beef cattle administered growth promotion technology M.E. Stephens¹, S.J. Bartle¹, D.N. Rethorst¹, C.D. Reinhardt¹, M.G. Siemens², and D.U. Thomson¹,¹Kansas State University, Manhattan, ²Cargill Meat Solutions, Wichita, KS

Castration is a painful surgical procedure in yearling bulls and can be an animal welfare concern; therefore the purpose of this study is to investigate the effect of castration of yearling bulls and changes in carcass quality, performance in castrated vs. uncastrated yearling bulls that are not fit for reproduction purposes. Yearling bulls (n=19) Black, (n=5) Red Angus (605 kg ± 37) average 16 m of age were fed a rolled corn based finishing ration with a NEg of 0.64 Mcal/lb. Animals were fed for 62 d (680 +/-37 kg) then harvested. Samples of the longissimus muscle and data was collected at a commercial abattoir. Cattle were randomly assigned to either intact (BULL) and castrated (STR) treatment. Cattle assigned to STR were implanted with 120 mg trenbolone acetate and 24 mg estradiol and fed ractopamine hydrochloride 300mg/d the last 28 d of feeding. Cattle in BULL treatment had an increased ADG (1.40 vs. 1.05 kg; P < 0.05) and tended to have increased G:F (0.09 vs 0.07 kg ; P < 0.10). Feed intake for BULLS and STR (14.87 vs 15.05 kg P < 0.05) was not different. There was no difference between groups for quality grade (QG), yield grade (YG), HCW, back fat thickness (BFT), and dressing %. Ribeye area (REA) was greater in BULL compared to STR REA (100.1 cm² vs. 89.3 cm²; P < 0.05). There was no difference in tenderness for the beef from BULLS and STR based WBSF measures (4.82 and 4.32 kg of force; P < 0.05). Sensory panel showed no difference between BULL and STR for; myofibrillar tenderness, juiciness, beef flavor intensity, connective tissue amount. The increased G:F and ADG noted in this study for the BULL treatment is consistent with previous work. The castration of non-breeding potential yearling bulls did not improve carcass characteristics. When considering animal welfare, castrating yearling bulls does not make an
improvement, and is deemed an unnecessary procedure for this age group of bulls. This study suggests that the feeding of intact yearling bulls has great potential.

**Effects of increased inclusion of algae meal on finishing steer performance and carcass characteristics**
Rebecca S Stokes, Daniel D. Loy, and Stephanie L. Hansen, Iowa State University, Ames

De-oiled microalgae from large scale production of heterotrophic microalgae can be combined with soyhulls to form a novel feedstuff called algae meal (ALG). To determine the effects of replacing corn in a finishing diet with ALG on growth and carcass characteristics, crossbred steers (168) were blocked by BW (952.8 ± 67.9 lbs) into pens of 6 steers (7 pens per treatment) and assigned to 1 of 4 diets: a corn-based control (CON), 14% ALG (ALG14), 28% ALG (ALG28), and 42% ALG (ALG42). Corn was replaced by ALG on a DM basis. Steer BW were taken on d 0, 1, 28, 56, 74, 101, and 102, and steers were harvested on d 103. Pen was the experimental unit and DMI, ADG, and F:G data were analyzed as repeated measures. Two steers per pen were selected for sampling of blood (d -1 and 96). Overall DMI linearly increased (*P* < 0.01) as ALG increased in the diet (27.9, 29.6, 30.5, and 31.7 ± 0.32 lbs/d for CON, ALG14, ALG28, and ALG42, respectively). There was a treatment by time effect for ADG (*P* < 0.01), with ADG linearly decreasing (*P* ≤ 0.03) in the first and third month, not differing (*P* = 0.95) in the second month, and linearly increasing (*P* < 0.01) in the fourth month as ALG increased in the diet. Final BW did not differ (*P* = 0.74) between CON and ALG-fed cattle. There was a treatment by time effect for F:G (*P* < 0.01), with F:G linearly decreasing (*P* < 0.01) in the first 3 months as ALG increased in the diet, while F:G linearly increased (*P* < 0.01) in the fourth month. Yield grade linearly decreased (*P* = 0.02), and there was a tendency for dressing percent and 12th rib backfat to linearly decrease (*P* ≤ 0.10) as ALG increased in the diet. Plasma Cu, Fe, and Mg concentrations were not different (*P* ≥ 0.31) in CON vs. ALG cattle; however, plasma Zn concentrations linearly increased (*P* = 0.03) as ALG increased in the diet (1.2, 1.1, 1.3, and 1.3 ± 0.05 mg/L for CON, ALG14, ALG28, and ALG42, respectively). It appears ALG has less energy than corn; however, minimal effect on carcass performance suggests ALG may serve as a potential replacement for corn in feedlot diets.

*Adapted from an abstract submitted to 2015 Joint Animal Science Meetings*

**Effects of transportation and commingling on calf health and performance during a forty-two-day receiving period**
L. A. Trubenbach, T. A. Wickersham, and J. E. Sawyer, Texas A&M University, College Station

An experiment was conducted utilizing newly-weaned steers from controlled sources, such that treatment effects could be effectively isolated from confounding factors often resulting from unknown or variable cattle source. Home-raised steer calves were selected from two Texas A&M AgriLife Research herds: Beef Cattle Systems Research Unit, College Station, TX (BCSR; n = 87); McGregor Research Center, McGregor, TX (MCGR; n = 102). Calves were similar in genotype and reared according to similar handling, health and weaning protocols. Calves were weaned approximately one week prior to the experiment, and calves born at MCGR were shipped approximately 145 km to BCSR 3 d prior to processing. Treatments were applied in a completely randomized 2×2 factorial design. The first factor (TRANS) included two levels: non-transported (NT) calves from BCSR and transported (TR) calves from MCGR. The second factor also included two levels: non-commingled (NC) and commingled (CO) calves. Non-commingled calves were isolated into pens (n = 8) with only calves from their respective source, while
Commingled calves were housed in pens (n = 4) with calves from both sources. Body weights were collected on d 0, 14, 28 and 42. A trained individual assessed cattle daily for clinical signs of respiratory disease. Calves displaying symptoms of disease were pulled from pens, and a rectal temperature was collected; calves with temperature > 40° C were treated. Subcutaneous injection of Baytril® 100 (enrofloxacin, 27 mL) was administered to calves at their first treatment. If symptoms persisted after a 48 h moratorium period, an injection of Nuflor® (florfenicol, 18 mL) was administered subcutaneously. No interactions were observed relative to occurrence of morbidity. Morbidity (single treatment) was greater (P < 0.01) in NT (16/87) than TR (3/102), but was not affected by commingling. There were no effects on re-treats (multiple treatments) observed. An interaction occurred during d 0-14, when ADG was lower in NT than TR (P = 0.02) and lower in CO than NC (P < 0.01), but decreased more severely for NT:NC (1.52 kg) versus TR:NC (1.53 kg) versus TR:CO (1.40 kg; P = 0.03). During d 15-28, ADG was lower in TR than NT (P = 0.01), but was not significantly affected by commingling (P = 0.27). There were no treatment effects on ADG observed during d 29-42. Total ADG was lower in CO than NC (P < 0.01), but tended to decrease more severely for NT:NC (1.57 kg) versus NT:CO (1.31 kg) than TR:NC (1.51 kg) versus TR:CO (1.44 kg; P = 0.10). Results suggest that commingling of cattle did not affect morbidity, but that its effects on ADG transpired during the first two weeks of the receiving period, especially in NT, with enough severity to reduce total ADG by 10%. Transportation did not affect ADG, but morbidity was lower in TR, which is unexpected. We conclude that transportation effects on morbidity were likely related to disease naivety in NT or resistance in TR, rather than the process of transportation. A future experiment is planned to include the examination of source-related health effects.

The effect of energy intake level and zilpaterol hydrochloride supplementation on empty body composition and energetics of beef steers

L. J. Walter¹, A. N. Schmitz¹, W. T. Nichols², J. P. Hutcheson², and T. E. Lawrence¹, ¹West Texas A&M University, Canyon, ²Merck Animal Health, Summit, NJ.

A trial was conducted to examine nutrient accretion, energetic efficiency, and empty body (EB) composition of steers fed at maintenance (M) or an ad libitum (A) level of intake with or without zilpaterol hydrochloride (ZH) supplementation. Single-sired, beef steers (n=60; 574 ± 36 kg) blocked (n=2) by weight and terminal implant were further sorted into pairs (n=14 per block) by weight. Pairs of steers were assigned to 0, 28 or 56 d of feeding, and within 28 and 56 d to M or A intake. Steers within a pair assigned to 56 d were randomly assigned to either 20 d of ZH supplementation (90 mg/hd/d) plus a 4d withdrawal or to no ZH supplementation (C). Steers were housed and fed in individual pens. Steers were weighed individually on d-1, 1, 11, 21, 27, 28 and 55 and 56 with intake adjustments for maintenance steers made on d12, 22 and 29 depending upon BW loss or gain. Weights of all harvest components were documented at slaughter with samples of hide, blood, and washed internal ground cavity taken for proximate analysis. Carcasses were fabricated and ground 48h postmortem with samples of lean, fat and bone taken for analysis. Data was analyzed using the mixed procedure of SAS®, fixed effects included treatment combinations and random effects of block and pair. Performance data were analyzed using days on diet as the repeated measure and animal as the subject. Single df contrasts were calculated for d0 vs. d28, d0 vs. d56, d28 vs. d56, M vs. A and C vs. ZH. Significance was declared at P ≤ 0.05 and trends are discussed at P ≤ 0.10. Treatment impacted (P < 0.01) ADG; 28-56d AZH exhibited the highest ADG (1.69) vs. 0-28d A (1.03) and 28-56d
MC (0.37) and MZ (0.55) exhibited improved ADG vs. 0-28d M (-0.44). Contrasts of ADG exhibited differences between d28 vs. 56 (P < 0.01), M vs. A (P < 0.01) and C vs. Z (P = 0.05). Results for adjusted HCWG yielded treatment (P < 0.01) and contrast differences; 0-28d M exhibited the lowest carcass gain (-0.44), 28-56d ALZ (1.65) exhibited improved carcass gain vs. 28-56d AC (0.69), and 28-56d MZ (1.05) exhibited improved carcass gain vs. 28-56d MC (0.46). Treatment with ZH improved (P < 0.01) final BW and EBW in a parallel fashion; d56AZH had a higher BW and EBW (P < 0.01; 667 and 615 kg) than M cattle, d0, and d28AC whereas d56AC was not greater than d28AC for either BW or EBW. Tissue components of the carcass and internal cavity were effected (P < 0.01) by ZH treatment whereas hide and blood were not altered (P > 0.10). Yields of carcass (g/kg EBW) increased over 28 and 56d (P < 0.01) and with ZH treatment (P < 0.01) whereas internal cavity (g/kg EBW) decreased (P < 0.02) from d28 to d56 and tended to decrease (P = 0.06) from d0 to d56 with significant differences between M vs. A and ZH vs. C (P < 0.01). Internal organs (liver, heart, kidneys, pancreas and stomach and intestines) were effected by treatment (P < 0.01) while KPH and outer mesenteric fat tended to be impacted by treatment (P = 0.06). Liver and stomach/intestines decreased with M intake and ZH supplementation (P < 0.01) while liver also reduced with every 28d increment (P < 0.01). Fat content of the EB and carcass was impacted by treatment; 56d AC exhibited higher EBF and carcass fat than all other treatments except 28d AL and M had reduced EBF and carcass fat (P = 0.01) vs. AL. Moisture and protein in the EB tended to be increased by ZH treatment (P < 0.10). Similarly, carcass moisture was increased (P ≤ 0.05) by M intake and ZH treatment. Additionally, EB moisture, fat and protein daily gains were impacted by treatment (P < 0.05); M intake decreased (P < 0.01) gains of all components vs. A intake and ZH increased (P =0.05) moisture vs. C and tended to increase daily protein gain (P = 0.09). Regression of empty body components against live feeding factors yielded equations for both A and M intake levels. At A intake, EBF = 4.567 + (1.364*DOF) - (3.319*TRT; ZH=1, CON=0) + (0.0447*BW) {0.49 Adj R², P < 0.01, RMSE=4.786}. At M intake, EBF = 4.818 - (2.644*TRT; ZH=1, CON=0) + (0.0454*BW) {0.46 Adj R², P < 0.01, RMSE=4.922}. In conclusion, intake and ZH shifted EB tissue proportions and impacted live growth performance, nutrient accretion and energy retention.

Weaning strategies for beef cows fed in intensive management (confinement): Effects of calf age on cow-calf performance and feed utilization by cow-calf pair J. M. Warner1, K. H. Jenkins2, R. J. Rasby1, M. K. Luebbe2, G. E. Erickson1, and T. J. Klopfenstein1, 1University of Nebraska, Lincoln, 2Panhandle Research and Extension Center, University of Nebraska, Scottsbluff

The objective of this research was to measure the effect of calf age at weaning on cow and calf performance and the feed utilization by the cow-calf pair of producing a weaned calf to 205 d of age between early and normal weaning when pair fed a common diet. In a 2 yr study, multiparous (4.6 ± 1 yr), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (n = 156) with summer-born calves at side were blocked by prebreeding BW (H, M, L), stratified by calf age, and assigned randomly to 1 of 4 treatments within strata. The experiment was a randomized complete block design with a 2 x 2 factorial arrangement of treatments with three replications (pens) per treatment per year (total n = 24). Treatment factors were: 1) location; eastern (ARDC) or western (PHREC) Nebraska and 2) calf age at weaning; 91 ± 18 (EW) or 203 ± 16 (NW) d of age. Regardless of location, EW cows and calves and NW pairs were fed a common diet (60:40 distillers grains:crop residue [yr 1];
40:40:20 corn silage:distillers grains:crop residue [yr 2], DM basis) from the time of early (October) to normal weaning (January). EW cows were limit-fed (15.3 lb DM/cow daily) while EW calves were offered *ad libitum* access to feed (8.8 lb DM/calf daily). NW pairs were limit-fed the equivalent amount of DM consumed by EW cows and calves (23.9 lb/pair daily). A 60 d natural service breeding season began for all cows prior to the time of early weaning. All cattle were managed in earthen feedlot pens, with pen serving as the experimental unit. Body weight and BCS in October were similar (*P* ≥ 0.26) between EW and NW cows. By normal weaning time in January, BW change was 37 lb greater (*P* ≤ 0.01) for weaned than nursing cows. Calf weaning age did not impact cow BCS in January (*P* = 0.60) or BCS change from October to January (*P* = 0.38). Cow pregnancy rates (≥ 85%) were not different among treatments. Although calf BW at normal weaning time in January was similar between NW and EW treatments (*P* = 0.90), ADG tended (*P* = 0.09) to be greater for nursing calves. A calf weaning age by location interaction was observed (*P* < 0.01) for cow-calf pair G:F (calf gain per unit of total pair TDN intake). At ARDC, pair G:F was greater for NW than EW (0.109 vs. 0.090, respectively), but NW and EW pairs had similar feed efficiencies at PHREC. Similar feed energy intake resulted in comparable cow and calf performance between weaning treatments. This suggests total feed energy requirements are similar between weaned cows and calves and nursing pairs and that early-weaning may not improve efficiency of the entire system. Thus, decisions regarding early weaning should be made at the discretion of management as opposed to feed efficiency.