795 ASAS Centennial Presentation: Discovery and application of energetic principles to feeding systems for beef cattle. C. Ferrell*[1] and J. Oltjen[2], [1]*USDA, ARS, U.S. Meat Animal Research Center*, *Clay Center, NE*, [2]*University of California*, *Davis*.

Development of nutritional energetics can be traced to the eras of Leonardo da Vinci (1452-1519) and Lavoisier (1743-1794), who discovered the basic concepts. Lavoisier established relationships among O_2 use, CO_2 production and heat production (HP). The laws of thermodynamics were discovered in the 1840's. They state that 1) energy can be neither created nor destroyed, but can be transformed from one form to another, 2) all forms of energy can be quantitatively converted to heat, and 3) heat loss in a chemical reaction is independent of path. These laws enabled the fundamental entity ME = RE + HP to be established. Objectives became 1) establish relationships between gas exchange and HP, 2) devise basis for evaluation of foods that could be related to energy expenditures, and 3) establish causes of energy expenditures. The bomb calorimeter was invented, allowing determination of the energy contents of organic compounds. Concepts and equipment for animal calorimetry were developed. Early systems for evaluation of foods for their value in supplying animal energy needs were based in measurements of ME and HP determined from calorimetry. Work in these areas arguably culminated in 1965 with the Brouwer equation for calculation of HP from O_2 use and CO_2, CH_4, and N excretion. For many years, primary efforts were devoted to measurement of ME and HP, with RE a secondary consideration. The California Net Energy System, developed for finishing beef cattle, was the first net energy system based on RE as determined by comparative slaughter and was the first to use two net energy values (NE_m and NE_g) to describe feed and animal requirements. This system has been broadened conceptually to encompass energy requirements during the life cycle of beef cattle. This system remains useful, but has limited capacity, due to its empirical and static nature, to capture the dynamics of energy utilization by diverse animals as they respond to changing environmental conditions.

Key Words: Calorimetry, Comparative Slaughter, Net Energy

796 ASAS Centennial Presentation: Discovery and application of energetic principles to feeding systems for beef cattle: Use of dynamic models. J. W. Oltjen*[1] and C. L. Ferrell[2], [1]*University of California*, *Davis*, [2]*USDA, ARS, U.S. Meat Animal Research Center*, *Clay Center, NE*.

Static feeding systems are being replaced by dynamic simulation models that attempt to capture the underlying biology which is sensitive to a wide range of genetic and environmental conditions. In 1986, the Davis Growth Model used cell number and size mechanisms of growth to predict growth and body composition as affected by frame size, implant status, and energy intake. Fat gain was underpredicted for high energy diets, because fat gain was computed after subtracting energy for maintenance and protein gain. France proposed an integrated model of growth, carbon and nitrogen metabolism. Synthesis and degradation were represented for each body pool based on animal factors and absorbed nutrient levels. Di Marco extended the Davis Growth Model to two pools of protein and included a digestion and metabolism element. Separation of the protein pools accounted for variable maintenance wherein a relatively smaller viscera was associated with decreased fasting heat production. The metabolism submodel corrected errors in prediction of fat gain since efficiency of each nutrient's use was explicitly represented. Input complexity precludes general use of these larger models. A dynamic sheep model of the visceral and muscle protein and fat pools was developed, with an upper bound for muscle and viscera. Heat production for maintenance depends on viscera size, hence nutritional history. New additions refine predictions at levels of energy intake at, or below maintenance. The model provides the structure for predicting composition of growing cattle, but has yet to be completely parameterized and tested. Generally, with each new system, advances in prediction accuracy came about by adding new terms to conceptually validated models.

Key Words: Modeling, Body Composition, Growth

797 ASAS Early Career Achievement Award Presentation: Advances in modeling ruminant nutrient utilization. E. Kebreab*[1], J. Dijkstra[2], A. Bannink[3], and J. France[4], [1]*University of Manitoba*, *Winnipeg, MB, Canada*, [2]*Wageningen University*, *Wageningen, the Netherlands*, [3]*Wageningen University and Research Centre*, *Wageningen, the Netherlands*, [4]*University of Guelph*, *Guelph, ON, Canada*.

Nutrition modeling has been applied to study various aspects of the ruminant such as rumen function, post-absorptive metabolism and product composition. However, the objective of this study will be limited to advances in modeling rumen function with respect to environmental issues and animal health, particularly, rumen disorders. Interest in environmental issues comes from the potential to manipulate rumen functions to reduce energy losses as methane and utilization of nitrogen (N) by rumen microorganisms. Enteric methane production arises principally from microbial fermentation of hydrolysed dietary carbohydrates. A widely used empirical model estimates that 5.5% to 7.5% of gross energy (GE) intake is lost as methane. However, mechanistic models of rumen function are based on the laws of mass and energy conservation and take into account the rumen economy of primary substrates for ruminal methanogenesis (hydrogen and carbon dioxide). Mechanistic models have suggested that 3.8 to 7.4% of GE is lost as methane depending on the diet. They help understand the system under study and therefore provide more insight on how dietary manipulation reduces methane loss than empirical models. One such mitigating option is the use of starch, which, if used excessively, can lead to health problems such as sub-acute rumen acidosis (SARA) due to rumen pH depression. Mathematical models have been developed to describe changes in rumen pH and rumen fermentation. The models were used to determine the maximum amount of nonfiber carbohydrate to be included in the diet above which SARA would likely occur. Models that relate rumen temperature to rumen pH have also been developed and have the potential to aid in the diagnosis of SARA. Several empirical and mechanistic models have been constructed to predict N utilization in the rumen and the form in which N is excreted from the animal. These models show that the magnitude of feces to urine N ratio has implications on ammonia volatilization, nitrate leaching and contribution to greenhouse gas emission as nitrous oxide. A rumen model that integrates nutrient utilization and health has great potential benefit for ruminant nutrition research.

Key Words: Modeling, Ruminant, Nutrient Utilization

798 Effects of feeding high levels of byproducts in different combinations to finishing cattle. M. F. Wilken*, M. K. Luebbe, J. R. Benton, G. E. Erickson, and T. J. Klopfenstein, *University of Nebraska*, *Lincoln*.

Crossbred steers (n=288; BW=373 kg) were used to evaluate feedlot performance from feeding diets with no grain and different inclusions of wet distillers grains plus solubles (WDGS) and wet corn gluten feed (WCGF). A RCBD was utilized with steers being assigned randomly to 36 pens with 8 steers/pen and 3 weight blocks. Six treatments were tested (6 pens/treatment): 1) control (CON) of 82.5% dry rolled corn (DRC) and 5.0% molasses, 2) 43.8% WDGS and 43.8% DRC (WDGS), 3) low blend (CORN) with 32.8% WDGS, 32.8% WCGF, and 21.9% DRC, 4) soyhulls blend (HULLS) with 32.8% WDGS, 32.8% WCGF, and 21.9% soyhulls, 5) high blend (BYPROD) with 43.8% WDGS and 43.8% WCGF, and 6) WDGS and grass hay (HAY) with 65.6% WDGS and 21.9% grass hay (DM basis). All diets contained 5.0% supplement and 7.5% alfalfa hay. Data were analyzed using mixed procedures of SAS, with weight block fixed, and using a protected F-test. Steers fed HAY had greater DMI ($P < 0.05$) than those fed WDGS and BYPROD. Intake for BYPROD was lowest ($P < 0.05$). Comparing all diets, ADG was greatest for WDGS ($P < 0.05$) and least for HULLS ($P < 0.05$). Steers fed WDGS had greater G:F ($P < 0.05$) compared to all other diets. Steers fed HULLS had numerically lower G:F ($P = 0.06$) compared to HAY and was lowest in relationship to all diets. Interestingly, steers fed HAY and BYPROD were similar ($P > 0.05$) to CON when comparing ADG and G:F, allowing us to conclude it is possible to feed byproduct diets with no corn and not sacrifice feedlot performance.

Table 1. Yearling steer finishing feedlot performance

Item	CON	WDGS	CORN	HULLS	BYPROD	HAY	SEM
DMI, kg/d	11.8^{ab}	11.4^{bc}	11.8^{ab}	11.7^{abc}	11.3^{c}	12.1^{a}	0.4
ADG, kg/d	1.83^{x}	2.03^{w}	1.89^{x}	1.69^{y}	1.80^{x}	1.83^{x}	0.09
G:F	0.155^{xy}	0.177^{w}	0.160^{x}	0.145^{z}	0.160^{x}	0.151^{yz}	0.003

^{a,b,c}Within a row, means without common superscript differ ($P = 0.06$). ^{w,x,y,z}Within a row means without common superscript differ ($P < 0.01$).

Key Words: Byproducts, Corn, Distillers Grains

799 Nutrient digestibility and utilization by cattle consuming cotton gin mote as a replacement for forage. C. M. Welch* and B. J. Rude, *Mississippi State University*, *Mississippi State*.

Cotton production provides a variety of by-products that can be utilized by beef cattle as an alternative roughage source which can reduce cost of production. The objectives of this study were to evaluate cotton gin mote as a forage replacement when fed to cattle by determining nutrient digestibility and nitrogen and energy retention. A seven day metabolism trial was conducted using twelve steers (249 ± 18.0 kg BW) allotted to one of three treatments: 0% mote (100% hay); 50% mote + 50% hay; and 100% mote. Steers consuming 0% mote consumed less ($P = 0.0029$) DM (1.45% BW/d) compared to those consuming 50% and 100% mote (1.93 and 2.29% BW/d, respectively). Digestibility of DM, OM, CP, and energy was least ($P < 0.0005$) by steers consuming 50% mote (56.3, 58.0, 35.9, 55.8%, respectively) with steers consuming 100% mote digesting more (59.4, 60.5, 42.1, 58.1%, respectively) and steers consuming 0% mote digesting the most (61.5, 63.8, 53.3, 62.4%, respectively). Digestibility of NDF and ADF was greater ($P = 0.0032$) for steers consuming 0% mote (62.1 and 61.3%, respectively) compared to steers consuming 50 % mote (58.3 and 57.1%, respectively) and 100% mote (57.2 and 54.8%, respectively). Hemicellulose digestibility was greatest ($P = 0.001$) for steers consuming 100% mote (64.8%) and least for steers consuming 50% mote (60.9 %) with 0% mote (63.2%) being in between. Fat digestibility tended to be greatest ($P = 0.0699$) by steers consuming 0% mote (79.7%) and least by steers consuming 100% mote (74.3%) with 50% being intermediate (55.8%). Steers consuming 0 and 50% mote retained less ($P = 0.0065$) protein (17.8 and 13.4 g/d, respectively) than those consuming 100% mote (24.5 g/d). Likewise, steers consuming 0 and 50% mote retained less ($P = 0.0100$) energy (100.1 and 115.3 kcal/d, respectively; no gaseous losses accounted for) than those consuming 100% mote (145.0 kcal/d). It appears that cotton gin mote can be used to replace up to 100% hay. However, additional protein and energy may need to be supplemented as their digestibility may be decreased by animals consuming cotton gin mote.

Key Words: Cotton Mote, Roughage, Digestibility

800 Beef steer intake and performance when fed whole cottonseed free-choice with hay. G. M. Hill*[1], M. H. Poore[2], D. J. Renney[1], and A. J. Nichols[1], [1]*University of Georgia*, *Tifton*, [2]*North Carolina State University*, *Raleigh*.

Steers were fed whole cottonseed (WCS) free-choice (FC) with hay. Supplement treatments (TRT) were fed for 42 d in a feedlot (Phase 1) to allow adjustment to high WCS intake on the FC diet, and then individually-fed the diets for17-d (Phase 2). In Phase 1, steers (n=32; 452.9 ± 55.2 kg initial BW; Brahman derivative breeding) were ranked by BW, randomly assigned to four TRT (4 steers/pen; 2 pens/TRT). Steers were fed round bale bermudagrass hay (93.0% DM, 13.4% CP, 78.8% NDF, 52% TDN) FC using hay rings in a feedlot with FC minerals. Supplement TRT included hay without WCS (H); or with WCS (DM basis: 25.4% CP, 45.6 % ADF, 59.0% NDF, 15.6% crude fat) fed at three levels (LCS = WCS at 0.25 % initial BW; MCS = WCS at 0.5% initial BW; and FCS = WCS fed FC). During Phase 1, DMI and ADG (kg) least squares means with initial BW as a covariable, for H, LCS, MCS, and FCS with SE, were: Hay DMI, 11.13, 8.51, 5.83, 5.21, 1.23, ($P < 0.12$); WCS DMI, 0.0, 1.06, 1.84, 2.99, 0.17, ($P < 0.01$) ; Total DMI, 10.93, 9.53, 7.70, 8.24, 1.25, ($P < 0.44$); ADG, 0.54, 0.46, 0.85, 0.88, 0.11, ($P < 0.02$). In Phase 2, steers (n=28; 494.2 ± 51.3 kg initial BW) were individually-fed the four TRT for 17 d. Hay (Tifton 85; 92.6% DM, 16.8% CP, 38.9% ADF, 75.2% NDF, 53% TDN) was coarsely ground (5 to 7 cm, length of cut), and WCS (DM basis: 25.5% CP, 45.6% ADF, 61.7% NDF, 15.3% crude fat) was fed as in Phase 1. The DMI (kg) least squares means with initial BW as a covariable, for H, LCS, MCS, and FCS with SE, respectively, were: Hay DMI, 7.43a, 6.75ab, 6.33b, 5.65c, 0.24; WCS DMI, 0.0d, 1.04c, 2.18 b, 3.55a, 0.03, and Total DMI, 7.56a, 7.93ab, 8.64b, 9.34c, 0.24; means followed by uncommon letters differ ($P < 0.01$). Dietary digestibility and blood components are being analyzed. In Phase 1 and Phase 2, steers fed FCS had reduced hay DMI, but higher Total DMI. Feeding FCS increased DMI of WCS above recommendations, which was not cost effective, it increased gossypol toxicity risk, and it has reduced dietary fiber digestibility.

Key Words: Cottonseed, Steer, Hay

801 WITHDRAWN

802 Influence of roughage source and level in feedlot diets containing wet distillers grains on ruminal metabolism and nutrient digestibility in steers. J. R. Benton*, G. E. Erickson, T. J. Klopfenstein, N. F. Meyer, and C. D. Buckner, *University of Nebraska*, *Lincoln*.

Six ruminally fistulated steers (347 ± 25 kg) were used in a 6x6 Latin square to determine effects of roughage source and level in feedlot diets containing wet distillers grains plus solubles (WDGS) on ruminal metabolism and nutrient digestibility. Treatments were arranged as a 2x3 factorial with alfalfa hay or corn stalks included at a normal, low, or zero roughage (zero) level consisting of: 1) 8% alfalfa (8ALF); 2) 4% alfalfa (4ALF); 3) 0% alfalfa (0ALF); 4) 6% corn stalks (6STK); 5) 3% corn stalks (3STK); 6) 0% corn stalks (0STK). Diets were balanced to provide equal percentages of NDF from roughage at each level and contained 30% WDGS (DM basis). Periods included a 9-d adaptation and 5-d collection. Steers were fed once daily at 0730 h, and ruminal pH and DMI were continuously monitored during collection. There was not a source x level interaction for digestibility or rumen pH. There were no differences ($P > 0.05$) in DMI (9.4 kg/d) or CP digestibility (77.6%) across diets. No differences ($P > 0.16$) in DM and OM digestibility (DMD, OMD) were observed between cattle fed alfalfa or corn stalks. A linear increase ($P < 0.01$) was observed in DMD and OMD as roughage decreased with 81.7, 82.5, and 86.4% DMD for normal, low, or zero roughage levels, respectively. Cattle fed alfalfa had greater ($P < 0.05$) NDF digestibility (NDFd) compared to corn stalks (75.8 and 72.2%, respectively). A linear increase ($P = 0.02$) in NDFd was observed as roughage level decreased with 72.1, 72.9, and 76.9% NDFd for normal, low, or zero roughage levels, respectively. Average daily ruminal pH decreased linearly ($P < 0.05$) as roughage decreased and measured 5.70, 5.49, and 5.31 for normal, low, or zero roughage levels, respectively. Roughage source did not affect ($P > 0.50$) ruminal pH. Acetate:propionate ratio was lowest for cattle fed 6STK and highest for cattle fed 0ALF, 0STK, and 3STK (source x level interaction; $P < 0.01$). In summary, these data indicate roughages can be exchanged on an equal NDF basis and that roughage levels can be decreased but not removed in feedlot diets containing 30% WDGS.

Key Words: Cattle, Distillers Grains, Roughage

803 Feedlot performance of Holstein steers fed treated-wheat straw-distillers grains diets as a corn replacement pellet. J. R. Sewell[1], L. L. Berger*[1], M. J. Cecava[2], N. A. Pyatt[2], and P. H. Doane[2], [1]*University of Illinois*, *Urbana*, [2]*ADM Animal Nutrition Research*, *Decatur, IN*.

Thirty-two Holstein steers (BW 185.2 ± 0.9 kg) were utilized in a 120-d study to evaluate growth performance when fed wheat straw (WS) or a corn fiber-wheat chaff (CFWC) corn replacement pellet (CRP) compared with a corn-based diet or native (NAT) WS. Crop residues were processed with 5% calcium oxide (DM basis) and 35% water in a double-shaft enclosed mixer (Readco Kurimoto Continuous Processor) and subsequently pelleted with distillers grain plus solubles (DDGS) to form a CRP. Individual feed intakes were monitored using the GrowSafe® feeding system (GrowSafe Systems, Ltd, Airdrie, AB). Steers were fed a common diet for 14 d prior to allotment and for 7 days before termination of trial. Upon initiation and termination of the trial, the average of two consecutive-day weights served as starting and final weights. All dietary treatments contained 25% DDGS, 15% corn silage, and 10% supplement. The remaining portion of the four diety treatments were: 1) 50% cracked corn, 2) 50% CFWC CRP (containing 56.25% CF, 18.75% WC and 25% DDGS), 3) 50% WS CRP (containing 75% WS and 25% DDGS), and 4) 50% NAT wheat straw. Digestibilities were estimated using acid insoluble ash by collecting fecal grab samples from individual animals at 7 d after initiation, midterm, and prior to the end of the trial.

Table 1. Performance and DM digestibility of Holstein steers fed corn replacment pellets

		Treatment			
Item	Control	CFWC CRP	WS CRP	Nat WS	SEM
Initial wt., kg	195.2	193.1	194.8	193.1	
Final wt., kg	362.6[a]	360.4[a]	349.4[a]	290.6[b]	18.7
Gain, kg/d	1.35[a]	1.44[a]	1.38[a]	0.92[c]	0.13
Intake kg DM/d	7.07[a]	7.86[a,b]	8.65[b]	8.24[b]	0.35
Gain:feed, g/kg	201[a]	177[c]	149[b]	101[d]	10
DM digestibility, %	65.9[a]	62.0[a]	60.0[a]	42.1[b]	4.2

[a,b,c,d]Different superscripts within row differ $P<0.05$

Key Words: Treated Wheat Straw, Distillers Grains, Corn Replacement

804 Characterizing quality and composition of beef from cattle fed combinations of steam-flaked corn, dry-rolled corn, and dried corn distiller's grains with solubles. P. L. Black*[1], G. L. Parsons[1], M. K. Shelor[1], M. E. Dikeman[1], K. K. Karges[2], M. L. Gibson[2], and J. S. Drouillard[1], [1]*Kansas State University*, *Manhattan*, [2]*Dakota Gold Research Association*, *Sioux Falls, SD*.

Color shelf life, lipid oxidation, and sensory attributes were evaluated for longissimus steaks from crossbred heifers (n=689, 302 ± 65 kg initial BW) fed finishing diets consisting of combinations of steam-flaked corn (SFC), dry-rolled corn (DRC), and dried corn distiller's grains with solubles (DDG). The study was a randomized complete block design with a 2 × 2 factorial arrangement of treatments. All diets contained SFC, and factors consisted of levels of DDG (0 or 25%) and DRC (0 or 25%). Heifers were individually weighed and blocked into heavy and light groups. Within block, heifers were assigned randomly to pens containing 25 animals each, with 6 pens per treatment. Heifers were fed once daily *ad libitum*, and the heavy and light weight blocks were harvested after 137 and 157 d, respectively. Four heifers were randomly selected from each of 24 pens (3 pens per treatment at each harvest point), and the wholesale rib sections were removed from one side of each carcass following a 24-h chill. Steaks (2.54-cm thick) were evaluated for color shelf life during a 7-day retail display period, as well as for purge loss during a 21-day aging period, weight loss during cooking, and lipid oxidation (TBARS). Sensory traits of initial tenderness, juiciness, chewiness, beef flavor, residual connective tissue, mealy texture, fiber awareness, bloody/serumy flavors, metallic flavors, and rancidity were evaluated by a 5-member professional profile panel using a 12-point scale. Steaks from cattle fed the different diets did not differ in color display attributes or TBARS values ($P > 0.20$). Weight loss during cooking was greater for steaks from heifers fed DRC diets compared with counterparts without DRC ($P < 0.05$). Replacing portions of SFC with DRC or DDG had no effect ($P > 0.10$) on sensory traits, lipid oxidation, or retail color display attributes.

Key Words: Sensory Attributes, Beef, Distiller's Grains