BEEF CATTLE NUTRITION SYMPOSIUM: A LOOK AT THE LATEST BEEF CATTLE NRC RECOMMENDATIONS

1021 Overview of the process and changes in the eighth edition of the Nutrient Requirements of Beef Cattle.

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The National Research Council's (NRC) series on *Nutrient Requirements of Beef Cattle* has been an essential information resource for practicing nutritionists and academicians for decades. Standards set by NRC publications have improved the economic and environmental sustainability of the beef industry, and each revision has provided a stimulus for further research. The committee responsible for the eighth edition invested more than 2 yr in producing a revision that would meet the high standards set by previous publications in the series. Following the Statement of Task, the committee updated the seventh revised edition by reviewing the scientific literature on the nutrition of beef cattle for all life phases and various production settings. Several new sections were added, including beef cattle production systems, food quality, and safety; ruminant anatomy and digestion; carbohydrates; lipids; compounds that modify digestion and metabolism; nutrition and the environment; and byproduct feed ingredients. Chapters from the seventh edition were updated, with substantial effort to provide improved prediction equations for modeling nutrient supply and metabolism. Specifically, new equations for predicting microbial protein synthesis and recycled nitrogen that is incorporated into microbial products were added. New information was included relative to the role of sulfur in beef cattle production, particularly as it relates to high-sulfur byproduct feeds. Greater clarity is provided on recommendations for provision of vitamin E in various production settings, and new equations were provided for the prediction of feed intake by growing/finishing beef cattle. The body condition score-based system was changed to include a fixed percentage of shrunk BW change per unit of BCS, and updated guidelines for adjustments to dietary ME values associated with the use of ionophores are provided. A new chapter is devoted to the potential effects of livestock operations on the environment, and prediction equations for nutrient excretion and enteric methane production are included. Byproduct feeds are described in much greater detail, and a statistically based evaluation of a feed composition data from commercial laboratories is provided. The new computer model, with options for empirical and mechanistic solutions, is more intuitive and user-friendly than software provided with the seventh edition. The eighth edition of the *Nutrient Requirements of Beef Cattle* is a major revision that should have a significant effect on beef cattle research and production over the next decade.

Key Words: beef cattle, nutrient requirements, revision

1022 The eighth revised edition of the Nutrient Requirements of Beef Cattle: maintenance and growth.

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The objectives of this review are to discuss updates to maintenance and growth components of the eighth revised edition of the Nutrient Requirements of Beef Cattle. From an energy supply standpoint, the traditionally held relationship of DE to ME (ME = DE × 0.82) needs to be reassessed. Maintenance requirements are computed by adjusting the base NEm requirement for breed, lactation, and heat loss vs. heat production (HE), which is ME intake minus retained energy (RE). Adjustments for animal insulation and environmental conditions are considered. The NEm requirement is computed based on the basal metabolism coefficient (a1) and adjustment factors for previous temperature (a2), breed (BE), lactation(L), gender, and previous plane of nutrition (COMP) as follows: NEm = $SBW^{0.75}$ × (a1 × BE × L × COMP × SEX + a2), where a1 = 0.077 and is the basal metabolism coefficient in Mcal/$kg^{0.75}$ daily, BE is breed factor, L is lactation factor, COMP = 0.8 + (BCS – 1) × 0.05 and is the NEm adjustment for previous nutrition, SEX is gender effect (1.15 bulls vs. 1 for others), a2 = 0.0007 × (20 – Tp) with a2 being the acclimatization factor in Mcal/$kg^{0.75}$ daily, and Tp is the previous temperature in °C. The seventh revised edition of the Beef NRC adjusted the a1 coefficient by 10% for all *Bos indicus* cattle; in the revised edition, this adjustment is removed for Nellore cattle. Previous adjustments to NEm for cold or heat stress are retained in the revised version, but users are cautioned on applying current equations, and this is an area of research need. Previous adjustments for the physical activity of grazing have been removed in the eighth revised edition, and additional research is needed on energetic costs of physical activity. Methods to estimate MP for maintenance remain unchanged. Growth equations from the previous NRC were retained. Additional data were used to evaluate equations for predicting retained energy and protein, with resulting satisfactory accuracy for predicting RE, but improvements are needed for predicting retained protein. Serial slaughter data measuring body composition in modern cattle with and without growth technologies are needed. Problems and barriers associated with accurately predicting NE and protein requirements for growth were delineated and discussed.

Key Words: energy, maintenance, protein

1023 The eighth revised edition of the Nutrient Requirements of Beef Cattle: reproduction.

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The eighth Revised Edition includes updates to the calculation of body energy (BE) and protein reserves in beef females, empty BW (EBW, kg) change per BCS, and Mcal of BE change per BCS. Energy and protein requirements for the maintenance and growth of bulls, heifers, and cows and for milk production remain largely unchanged from the seventh Revised Edition. Replacement heifer target weights at the beginning of the breeding season are unchanged from the seventh Revised Edition (55% for dual purpose or dairy breeds, 60% for *Bos taurus*, and 65% for *Bos indicus*), but the eighth Revised Edition model allows the user to change this variable. A more complete description of BCS 1 through 9 has been created, and a BCS decision tree has been added. A discussion regarding the effect of cow nutrition on fetal and developmental programming has been added to the narrative. While the previous body reserves model assumed a variable BW change per BCS, the new body reserves model assumes a fixed BW change per BCS, and it is computed as 7.105% of the empty body weight at BCS 5. Within the model, the user can modify the 7.105% adjustment. For primiparous females, based on limited data, an adjustment factor of 1.6 × 7.105% is suggested for the EBW change needed to increase 1 BCS. Similarly, it is suggested that an adjustment factor of 0.4 × 7.105% be used for EBW change needed to lose 1 BCS for primiparous females. Energy content of 1 kg cow weight gain in the eighth Revised Edition has been changed from a constant of 5.826 Mcal/kg of SBW to a variable number ranging from 3.69 for a BCS 1 cow to 7.99 Mcal/kg of SBW for a BCS 9 cow. The estimated DMI calculation for cows in the model remains unchanged, but a DMI calculation based on neutral detergent fiber (NDF) intake, as a percentage of BW, has been added to the model output for user evaluation of DMI. It is often suggested that 1.1% be used for low- to medium-quality forages. Only minor adjustments have been made to the vitamin and mineral (Co) requirements for reproducing beef females.

Key Words: beef cattle, reproduction, requirements

1024 The eighth revised edition of the Nutrient Requirements of Beef Cattle: protein and metabolic modifiers.

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The eighth Revised Edition includes updates to the proteins and digestive and metabolic modifiers sections of the report reflecting new information since the seventh Revised Edition was published. The MP system was adopted in the seventh Revised Edition. It accounts for rumen degradation of dietary protein and separates requirements into the needs for ruminal microorganisms and the needs of the animal. Rumen degradable protein (RDP) provides ruminal microorganisms with various sources of nitrogen (N). In contrast, ruminally undegraded protein (RUP) is not hydrolyzed in the rumen. The amount of RDP required is based on prediction of synthesis of microbial CP (MCP). Published data from studies using cattle fitted with intestinal cannulas were used to develop and evaluate empirical equations for the prediction of MCP based on total digestible nutrient intake (TDNI), fat-free TDNI (FFTDNI), and CP intake as independent variables. Equations based on TDNI and FFTDNI are provided to estimate MCP depending on the ether extract percentage of the diet. The MP supply is absorbed amino acids from protein digested in the intestine and supplied by microbial protein and RUP. Reported values for RUP digestibility are variable, but most estimates for forages are less than 60%. The digestibility of RUP for forages was decreased from 80% to 60%. Regression analysis of literature data based on the dual-labeled urea isotopic approach was used to update equations to estimate urea N kinetics. A more complex rumen model is needed to include recycling directly in the beef cattle nutrient requirements model. A number of feed additives and other compounds that improve animal health and the efficiency of nutrient use, increase growth rate, and decrease the environmental impact of beef cattle were reviewed. These include compounds that alter rumen fermentation, additional aspects of gastrointestinal tract function, or post-absorptive metabolism. Review of feed additives with the potential to provide an alternative to inclusion of dietary antibiotics, such as plant secondary metabolites, direct-fed microbials, and feed enzymes, was included. Ionophores change microbial populations in the rumen and improve feed efficiency. Predicted DMI is decreased by 3% when monensin is fed. In addition, dietary ME was increased by 2.3 or 1.5% for monensin or lasalocid, respectively, to account for improvements in ADG and feed efficiency when feeding ionophores.

Key Words: beef cattle, ionophores, microbial protein synthesis, urea recycling

1025 The eighth revised edition of the Nutrient Requirements of Beef Cattle: minerals, vitamins, and water. T. E. Engle*[1], J. S. Caton[2], M. L. Galyean[3], L. O. Tedeschi[4], N. A. Cole[5], C. R. Krehbiel[6], G. E. Erickson[7], K. A. Beauchemin[8], R. P. Lemenager[9], and J. H. Eisemann[10], *[1]Colorado State University, Fort Collins, [2]Department of Animal Sciences, North Dakota State University, Fargo, [3]Texas Tech University, Lubbock, [4]Texas A&M University, College Station, [5]USDA Agricultural Research Service, Bushland, TX, [6]Oklahoma State University, Stillwater, [7]University of Nebraska, Lincoln, [8]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [9]Purdue University, West Lafayette, IN, [10]North Carolina State University, Raleigh.*

The objective of this review is to briefly discuss the updates made to the minerals, vitamins, and water sections contained in the eighth revised edition of the Nutrient Requirements of Beef Cattle publication. Relevant data for determining mineral, vitamin, and water requirements for beef cattle published since the seventh revised edition as well as recommendations from recently published NRC publications were added where appropriate. Although long identified as essential components in the diets of beef cattle and required for many biochemical reactions, the interactions among minerals, vitamins, water, and metabolic processes are extremely complex. The minerals chapter provides an update of macro- and micro-mineral requirements for beef cattle and discusses factors that can affect mineral requirements as well as mineral-specific diseases that can influence beef cattle production. New information has been added relative to the role of sulfur in beef cattle production that focuses on factors affecting sulfur requirement and maximum tolerable concentrations of sulfur. Dietary cobalt requirements were increased from 0.10 to 0.15 mg Co/kg DM for all classes of beef cattle, and maximum tolerable concentrations of certain minerals were adjusted based on published data. The vitamins chapter provides an update of beef cattle vitamin nutrition, with new information regarding fat- and water-soluble vitamins. Of special note is the greater clarity that has been provided with respect to recommendations for provision of vitamin E in various production settings. The review articulates issues associated with specific deficiencies and excesses and suggests areas for additional research. New research focusing on the influence of diet type, physiological status, and stress would be useful to more accurately predict the vitamin and mineral requirements of beef cattle. Of the six essential nutrient classes, water is the single most important nutrient for beef cattle. The water chapter provides an update of equations to predict water intake by beef cattle and discusses certain factors that influence water intake, including the role of water quality in beef cattle production. In Chapter 19, the water intake model includes a response surface regression to predict water requirements for different effective temperature indexes for growing and finishing beef cattle.

Key Words: beef cattle, minerals, vitamins, water

1026 The eighth revised edition of the Nutrient Requirements of Beef Cattle: environmental issues. N. A. Cole*[1], K. A. Beauchemin[2], G. E. Erickson[3], L. O. Tedeschi[4], and M. L. Galyean[5]. *[1]USDA-ARS Conservation and Production Research Laboratory (retired), Bushland, TX, [2]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [3]University of Nebraska, Lincoln, [4]Texas A&M University, College Station, [5]Texas Tech University, Lubbock.*

Since publication of the of seventh Revised Edition of the *Nutrient Requirements of Beef Cattle*, (1996/2000), there has been growing concern among producers, regulators, and the general public about the impacts of livestock operations on the environment. Beef cattle typically retain less than 20% of the nutrients they consume. The remainder is lost via feces, urine, or respiration. The effects of these excreted nutrients, as well as pharmacologically active compounds (PAC) and pathogens on ground waters, surface waters, air quality, global climate change, environmental sustainability, land use, biodiversity, and quality of life are potentially affected by nutritional and management programs used by producers. Although environmental concerns normally revolve around concentrated animal feeding operations, some effects can also be a concern in extensive systems, such as pasture-based cow-calf and stocker operations. This new chapter in the eighth Revised Edition summarizes the environmental concerns associated with beef production in North America and reviews the latest scientific approaches to mitigation. Possible dietary effects on surface and ground water and air quality are discussed. Water quality concerns include the loss of nutrients, such as nitrates and phosphorus and PAC, to ground and surface waters. Air quality issues of greatest concern include emissions of ammonia and the greenhouse gases methane and nitrous oxide. Empirical equations are provided to estimate the excretion of organic matter, nitrogen, and phosphorus and for emissions of ammonia and enteric methane. A nonlinear equation is recommended to calculate the proportion of total nitrogen that is excreted in urine. Enteric methane production of cattle is highly dependent on factors such as forage quality, forage concentration, DMI, dietary fat, ionophores, and grain processing; therefore, multiple empirical equations are proposed to estimate enteric methane production from cattle fed high-forage, medium-forage, and low-forage diets. The effects of many co-products, such as distiller's grain, on enteric methane are variable and dependent on the control diet composition. By more precisely feeding and supplementing

livestock to meet their nutrient requirements, excess nutrient losses can be decreased. Under practical conditions, however, the use of precision feeding systems to manage environmental impacts is limited and challenged by factors such as: 1) inherent biological inefficiencies in the animal, 2) variability in animal performance and/or nutrient requirements, 3) variability in composition of feed ingredients, 4) high nutrient concentrations in many co-products, and 5) other factors.

Key Words: environment, beef cattle, nutrients, greenhouse gas, ammonia

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1027 The eighth revised edition of the Nutrient Requirements of Beef Cattle: byproducts and feed composition. K. A. Beauchemin*[1], G. E. Erickson[2], H. Tran[3], J. S. Caton[4], N. A. Cole[5], J. H. Eisemann[6], T. E. Engle[7], M. L. Galyean[8], C. R. Krehbiel[9], R. P. Lemenager[10], and L. O. Tedeschi[11], *[1]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [2]University of Nebraska, Lincoln, [3]National Animal Nutrition Program, University of Kentucky, Lexington, [4]Department of Animal Sciences, North Dakota State University, Fargo, [5]USDA-ARS Conservation and Production Research Laboratory (retired), Bushland, TX, [6]North Carolina State University, Raleigh, [7]Colorado State University, Fort Collins, [8]Texas Tech University, Lubbock, [9]Oklahoma State University, Stillwater, [10]Purdue University, West Lafayette, IN, [11]Texas A&M University, College Station.*

Byproduct feeds are important in beef cattle production, often providing cost-effective energy and protein. The focus of the review in the eighth revised edition was on corn and soy byproducts, as corn and soybean production are the two largest crops produced in the U.S. Use of distillers grains plus solubles, distillers solubles, corn gluten feed, Sweet Bran (Cargill corn milling, Blair, NE), soybean hulls, and glycerin was reviewed. The focus for grain milling byproducts (distillers and gluten feed) was on protein characteristics and use as a protein or an energy supplement and to replace grain in finishing diets. Effects of initial grain used to produce ethanol on distillers grains characteristics was also reviewed. The associative effects of using grain milling byproducts was reviewed to illustrate the important interactions of corn processing, roughage inclusion, and dietary inclusions relative to energy content realized from distillers grains and corn gluten feed. Similar to the seventh Revised Edition of the Beef NRC, a comprehensive feed composition review was conducted. Data were summarized from 3 commercial laboratories that included 170 feeds. Nutrient data on DM, ash, TDN, DE, ME, NEm, NEg, sugar, starch, fat, NDF, ADF, lignin, CP, RDP, RUP, soluble CP, ADIN, and minerals (Ca, P, Mg, K, Cl, S, Co, Cu, I, Fe, Mn, Mo, Se, and Zn) were provided. Considerable effort was made to ensure feeds had proper nomenclature and to avoid duplication by evaluating normal distribution, mean, and SD. Feeds with less than 20 entries were removed from the database. Likewise, nutrient values greater or less than 3.5 SD were removed from the database but only for that nutrient within a particular feed. Once the final data were available, mean, SD, and sample size were calculated and reported, and composition data for these 170 feeds was included in the computer model database. Feed composition data should only be used as a guide in the absence of feed analysis and to indicate which nutrients are variable and may require assay before formulation. These data can also be used to compare analyzed nutrients to a known database. Additionally, grazed forages from different regions were provided from the literature and focused on masticate collections when available. Grazed forage data only include TDN, NDF, and CP but illustrate how season and region can affect grazed forage quality.

Key Words: beef cattle, byproducts, feed composition

1028 The eighth revised edition of the Nutrient Requirements of Beef Cattle: development and evaluation of the mathematical model. L. O. Tedeschi*[1], M. L. Galyean[2], K. A. Beauchemin[3], J. S. Caton[4], N. A. Cole[5], J. H. Eisemann[6], T. E. Engle[7], G. E. Erickson[8], C. R. Krehbiel[9], and R. P. Lemenager[10], *[1]Texas A&M University, College Station, [2]Texas Tech University, Lubbock, [3]Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [4]Department of Animal Sciences, North Dakota State University, Fargo, [5]USDA-ARS Conservation and Production Research Laboratory (retired), Bushland, TX, [6]North Carolina State University, Raleigh, [7]Colorado State University, Fort Collins, [8]University of Nebraska, Lincoln, [9]Oklahoma State University, Stillwater, [10]Purdue University, West Lafayette, IN.*

The beef cattle nutrient requirements model (BCNRM) is a spreadsheet-based computer software program compatible with Microsoft Excel 2007 or earlier versions. The BCNRM contains two levels of solutions (empirical = ELS and mechanistic = MLS) to compute the supply of energy and nutrients to the animal. The calculation of animal requirements for energy and nutrients is the same for ELS and MLS. In the ELS, users can choose to use tabular values for ME and NE or compute NE, ME, and DE from tabular TDN. Methane (CH_4) is computed based on empirical equations that combine animal and dietary chemical information. In contrast, the MLS computes TDN based on: 1) rumen digestibility of five carbohydrate pools (CA = sugars, CB1 = starch, CB2 = pectin, CB3 = available NDF, and CC = unavailable carbohydrate) and three protein pools (PA = NPN, PB = soluble CP, and PC = ADIN), assuming their fractional degradation rates (kd, %/h) and a fractional passage rate (kp, %/h) for each feed; 2) intestinal

digestibilities for CB1, CB2, and PB for each feed; and 3) endogenous matter production for each feed. Then, similar to ELS, NE, ME, and DE are computed from TDN. In the MLS, CH_4 is computed based on the stoichiometric relationship of VFA produced in the rumen. The BCNRM includes an optimizer to assist with diet formulation and balancing, an ability to perform stochastic modeling, and a table generator that allows the user to create tables of nutrient requirements through an optimization procedure. The BCNRM was compared with NRC (1996, 2000) levels of solution 1 (L1) and 2 (L2) using data from 20 experiments (n = 2539 pen-fed animals). For ME-allowable gain, ELS and L1 predictions were nearly identical (r^2 of 0.999, root of mean square error (RMSE) of 0.018 kg/d, and accuracy (Cb) of 0.998). The MLS predictions tended to be greater than L2 predictions by approximately 0.158 kg/d, though there was a strong correlation between them (r^2 of 0.999 and Cb of 0.9). The opposite was observed for MP-allowable gain, and MLS and L2 predictions were nearly identical (r^2 of 0.999, RMSE of 0.023 kg/d, and Cb of 0.998) while ELS and L1 predictions differed by 0.234 kg/d (r^2 of 0.975 and Cb of 0.9). A stochastic simulation (n = 5000) predicted 122 and 97 g CH_4/d for ELS and MLS, respectively, with a 67% prediction overlap.

Key Words: computer, modeling, simulation, spreadsheet

NON-NUTRITION: THE FUTURE OF NUTRITION?

1029 Why the intersection of microbiology and neurobiology matters to animal health: microbial endocrinology as a means to examine the host-microbiota interface.

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Microbial endocrinology represents the intersection of two seemingly disparate fields, microbiology and neurobiology, and is based on the shared presence of neurochemicals that are exactly the same in structure in the host as well as in the microorganism. The ability of microorganisms not only to respond to but also to produce many of the same neurochemicals that are produced by the host, such as during periods of stress, has led to the introduction of this evolution-based mechanism that has a role in the pathogenesis of infectious disease as well as the microbiota-gut-brain axis. Production of neurochemicals by microorganisms usually employs the same biosynthetic pathways as those utilized by the host, indicating that acquisition of a neurochemical-based signaling system in the host may have been acquired due to lateral gene transfer from microorganisms. Such recognition of a common shared signaling system suggests that there is a common mechanistic pathway by which the host may interact with the microbiota in a bi-directional fashion influencing aspects of both disease and health. In the case of infectious disease pathogenesis, the consideration of a microbial endocrinology-based mechanism in which infectious bacteria can directly respond to host-derived neurochemicals, such as those present during periods of stress, has demonstrated, for example, that the prevalent use of catecholamine-based synthetic drugs in the clinical setting contributes to the formation of biofilms in indwelling medical devices, leading to increased morbidity and mortality. At the same time, the ability of the microbiota to produce neurochemicals that constitute the host's own neuronal signaling systems means that a common pathway exists for the microbiota to influence host neurophysiology. One of the most prevalent examples by which neurochemical production by microbiota may influence the host's brain and ultimately behavior can be seen with the increasing use of probiotics as a means to influence behavior. Numerous probiotics in current use produce large amounts of neurochemicals, such as GABA, which are known to have well-recognized roles in behavior. That both the host and microorganism produce and respond to the same neurochemicals means that there is bi-directionality contained within the theoretical underpinnings of microbial endocrinology. Such a shared pathway argues for a role of microbiota-neurochemical interactions in animal health.

Key Words: gut endocrinology, microbiome

1030 The gut microbiome as a virtual endocrine organ: implications for host physiology and behavior.

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The gut microbiome exerts a marked influence on multiple aspects of host physiology including not just host metabolism and body composition but also brain function and behavior. This impact relates to its ability to produce or indirectly control a large range of hormonal agents that can play a regulatory role in the activity of local and distal systems and organs. Dysfunction of the hypothalamic–pituitary–adrenal (HPA) axis in particular has been a striking consequence to disrupting the gut microbiota in preclinical studies. The translational relevance of these findings is apparent in stress-related disorders, such as irritable bowel syndrome. Unlike other endocrine organs, however, the gut microbiota exhibits compositional plasticity and can itself be subject to fluctuation as a result of stressors or dietary factors with implications for the associated functionality. This includes stress experienced prenatally, postnatally, and during adulthood. Farm animals regularly encounter a variety of such stressors related to handling practices, weaning, housing systems, and transport that potentially affect welfare and productivity. While optimizing nutrition to promote the gold standard assembly and maturity of the microbiota is one option to counteract the detrimental impact of stress exposure, more targeted interventions may be necessary at various critical points of control across the lifespan. Understanding how best to manipulate the gut microbiota to control host physiological