

The influence of maternal energy status during midgestation on beef offspring carcass characteristics and meat quality¹

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ABSTRACT: Research has suggested that maternal undernutrition may cause the development of a thrifty phenotype in the offspring, potentially resulting in greater adiposity and reduced muscle mass. These alterations in adipose and muscle development could have lasting impacts on offspring growth, carcass characteristics, and meat quality. However, limited research exists evaluating the impact of maternal energy status on these economically important traits of the offspring. Therefore, the objective of this study was to determine the influence of maternal energy status during midgestation on offspring carcass characteristics and meat quality. To alter maternal energy status, cows either grazed dormant, winter range (positive energy status [PES]) or were fed in a drylot at 80% of the energy requirements for BW maintenance (negative energy status [NES]) during a mean period of 102 ± 10.9 to 193 ± 10.9 d of gestation. Changes in BCS, BW, LM area (LMA), and 12th rib backfat were measured throughout midgestation. At the end of midgestation, cows in the NES group had a reduction ($P \leq 0.05$) in BCS, BW, LMA, and 12th rib backfat

when compared with PES dams. Cows and calves were managed similarly after midgestation through weaning and calves were managed and fed a common diet through the receiving, backgrounding, and finishing phases in the feedlot. Calves were harvested after 208 d in the feedlot, carcass characteristics were recorded, and strip loins were recovered for analysis of objective color and Warner-Bratzler shear force (WBSF). Maternal energy status had no influence on offspring HCW, dressing percent, LMA, percent KPH, marbling score, percent intramuscular fat, objective color, or WBSF ($P > 0.10$). Progeny of NES cows tended to have improvements in 12th rib backfat and USDA yield grade ($P < 0.10$). Greater ratio of marbling score to 12th rib fat thickness and ratio of percent intramuscular fat to 12th rib fat thickness ($P < 0.05$) were discovered in progeny from cows experiencing a NES during midgestation. These results suggest that maternal energy status during midgestation may impact fat deposition in intramuscular and subcutaneous fat depots without impacting muscle mass.

Key words: beef, fat deposition, fetal programming

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INTRODUCTION

It has been well documented that maternal nutrition can impact both short- and long-term characteristics of the developing fetus (Barker et al., 1993, 2002; Barker, 1995; Zhu et al., 2004; Yan et al., 2013). Many of these revelations have occurred in studies of human health, establishing connections that link inadequate maternal nutrition to offspring health problems, potentially due to alterations in fetal development (Barker et al., 1993, 2002; Barker, 1995). Therefore, there is interest in determining

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whether fetal programming has application in livestock production.

Early research suggests that the fetus had precedence over the dam for nutrients (Hammond, 1943). However, recent research has revealed that fetal development can be negatively impacted by restricted maternal nutrition (Vonnahme et al., 2003, 2007), specifically that maternal undernutrition during pregnancy may result in offspring developing a “thrifty phenotype” that is more prepared to deal with sparse nutrient availability (Barker, 1995; Zhu et al., 2004; Du et al., 2011; Yan et al., 2013). Midgestation is a critical period for muscle and adipose tissue development in the bovine fetus (Russell and Oteruelo, 1981; Du et al., 2010); therefore, insults to maternal nutritional status during midgestation may cause alterations in carcass characteristics and meat quality of subsequent progeny. Therefore, the aim of this study was to determine the influence of positive or negative maternal energy status during midgestation on offspring carcass characteristics and meat quality.

MATERIALS AND METHODS

Animals

All animal care and experimental protocols were approved by the South Dakota State University (SDSU) Animal Care and Use Committee. Crossbred, 3- and 4-yr-old cows (second and third parity, respectively; $n = 140$) from 2 SDSU research stations in western South Dakota were naturally bred to Angus and SimAngus bulls over a 60-d breeding period to begin calving at the end of March. Thirty-eight days after the bulls were separated from the cows, the cows were evaluated for weight and BCS (1 to 9, with 1 = extremely emaciated and 9 = very obese; Pruitt and Momont, 1988), pregnancy, length of gestation, and calf sex. This allowed for the allotment of cows into mid-gestation management groups based on conception date, source, BW, age, and BCS. At this time, nursing calves were weaned at 5 to 6 mo of age and pregnant cows from both research stations were commingled to be managed similarly in native range pastures at the SDSU Cottonwood Field Station (Cottonwood, SD). At 56 d after bull removal, cows with a mean gestation length of 84 ± 11.3 d (based on pregnancy ultrasound) were allotted into 2 management strategies: 1) fed to achieve and/or maintain a BCS of 5.0 to 5.5 (positive energy status [PES]; $n = 73$) or 2) fed to lose 1 BCS over a 91-d period of midgestation (negative energy status [NES]; $n = 67$). Body condition scores were determined by the average of 4 trained evaluators at the beginning and end of the

Table 1. Formulations and compositions of midgestation pelleted supplements¹

Pelleted supplement, %	Positive ²	Negative ³
Soybean meal	52.20	52.20
Sunflower meal	20.00	20.00
Wheat middlings	19.30	69.33
Urea	3.06	3.04
Vitamins and minerals ⁴	5.44	4.88
Supplement DMI provided, kg · cow ⁻¹ · d ⁻¹ ⁵	1.35	1.17
Nutrient composition of pelleted supplement ⁶		
DM, %	95.83	95.37
CP, %	45.65	31.39
NDF, %	22.06	37.54
Ash, %	11.55	9.85

¹All values except DM on DM basis.

²Cows managed to maintain BCS during midgestation.

³Cows managed to lose 1 BCS during midgestation.

⁴Formulated to meet or exceed the vitamin and mineral requirements of 3-yr-old cows according to the NRC requirements.

⁵Average DMI per cow per day throughout midgestation treatment.

⁶Analyzed values determined through lab assays.

second trimester and cows were weighed every 28 d throughout midgestation. Cows were normalized for fill before determining initial and final BW of the midgestation treatment period (91 d) by managing them as a common group for a week before and after the treatment period. Additionally, ultrasound measurements (Aloka 500V real-time ultrasound machine; Aloka, Wallingford, CT) were collected to determine 12th rib subcutaneous fat thickness and LM area (LMA) at the beginning and the end of midgestation.

Cows managed for PES were managed on dormant, native range pasture consisting primarily of western wheatgrass (*Pascopyrum smithii*) as well as green needle grass (*Stipa viridula*), little bluestem (*Schizachyrium scoparium*), buffalo grass (*Buchloe dactyloides*), and blue grama (*Bouteloua gracilis*; 4.7% CP and 50.5% TDN). Cattle were supplemented to achieve energy balance relationships described by the *Nutrient Requirements of Beef Cattle* (NRC, 2000). Cows on pasture were provided a pelleted supplement (Table 1; 45.7% CP and 1.63 Mcal/kg NE_m, DM basis) at 12.71 g/kg metabolic body size (MBS) every other day. During this study, the period of midgestation (October 2010 through January 2011) was unusually mild and dry, resulting in pastures that were free of snowpack until mid January. In January, cows on pasture were supplemented with mature brome hay at 9.77 kg · cow⁻¹ · d⁻¹ (5.76% CP and 53% TDN) in addition to ad libitum native range and protein supplementation. Cows fed to lose 1 BCS were managed in 10 drylot pens and blocked by BW and, each day, were fed mature brome hay (5.76% CP and 53% TDN) at

65.83 g/kg MBS supplemented with a protein supplement (Table 1; 31.4% CP and 1.54 Mcal/kg NE_m) at 11.80 g/kg MBS, composing a diet that was 84.8% mature brome hay and 15.2% protein supplement.

After completion of the 91-d mid-gestation period, all cows were commingled and managed as a common group on range through calving. Final BW was recorded 7 d into this phase to normalize fill across treatments. At calving, calf birth weight, date of birth, and sex were recorded and bull calves were banded at birth. Birth dates of the calves in this study spanned from March 30 to May 19, with a median birth date of April 11. After calving, cows and calves were managed as a common group following field station protocol until weaning. At weaning (October 12), calves meeting protocol-specified criteria for the postweaning portion of the study ($n = 125$) were shipped approximately 535 km to the SDSU Research Feedlot in Brookings, SD. Calves were then sorted into pens by sex and dam management strategy in which each sex and dam management strategy combination consisted of 4 pens containing 7 or 8 animals per pen. Common receiving, backgrounding, and finishing diets were fed across all gestational management by sex groups. Nutritional compositions of the diets for each phase in the feedlot are shown in Table 2. Calves were marketed when all of the progeny were estimated to average 1.0 cm of 12th rib backfat thickness (208 d on feed). At both 21 and at 208 d in the feedlot, a subsample ($n = 12$) of steers from each gestational management group was harvested at the SDSU Meat Laboratory (Brookings, SD). The remaining 101 calves were slaughtered at a commercial abattoir and are reported herein.

Carcass Characteristics and Strip Loin Collection

Before harvest, cattle were weighed in the morning and then shipped approximately 240 km to a commercial abattoir (Tyson Foods, Dakota City, NE). Cattle were allowed free access to water overnight and were harvested the following morning. Individual animal identification was maintained throughout harvest processes. Hot carcass weight for each individual carcass was recorded at slaughter whereas LMA, 12th rib backfat, and marbling score were determined using camera grading following carcass chilling (approximately 30 h). Additionally, percentage of KPH was estimated by a USDA grader. Hot carcass weight, LMA, 12th rib backfat, and KPH were then used to calculate USDA yield grades. At 2 d postmortem, carcasses were tracked through the fabrication floor, where full strip loins were collected from 1 side of each carcass. Recovered strip loins ($n = 96$) were vacuum packaged, boxed, and transported to the SDSU Meat Laboratory.

Table 2. Nutrient composition of diets in feedlot phases^{1,2}

Item	Receiving	Backgrounding	Finishing
DM, %	66.01 (1.54)	56.90 (2.20)	73.45 (1.51)
CP, %	12.58 (0.31)	12.94 (0.24)	12.21 (0.26)
NDF, %	33.14 (0.53)	31.15 (0.84)	19.74 (0.68)
ADF, %	17.95 (0.30)	16.87 (0.62)	8.27 (0.34)
Ash, %	7.47 (0.18)	7.11 (0.25)	3.54 (0.11)
Ether extract, %	3.41 (0.04)	3.64 (0.09)	3.63 (0.10)
NE _m , Mcal/kg	1.80 (0.013)	1.85 (0.020)	1.98 (0.003)
NE _g , Mcal/kg	1.09 (0.013)	1.14 (0.020)	1.31 (0.003)

¹DM basis; calculated from weekly feed analysis.

²Mean (SD).

At 3 d postmortem, strip loins were processed for the analysis of percent intramuscular fat, objective lean color, and tenderness evaluation through Warner-Bratzler shear force (**WBSF**). Steaks were removed from the anterior end of the strip loin, beginning with a sample for the evaluation of percent intramuscular fat followed by three 2.54-cm steaks used for WBSF, and the first of the WBSF steaks was also used for objective lean color measurements. Steaks for the analysis of WBSF were vacuum packaged and stored at 4°C for postmortem aging periods of 3, 14, or 21 d.

Intramuscular Fat Percentage

At 3 d postmortem, a 0.635-cm-thick steak was removed from the anterior portion of each recovered strip loin and frozen at -20°C. Steaks were trimmed free of external fat and additional muscles; then, samples were minced, immersed in liquid nitrogen, and powdered using a commercial blender. Duplicate powdered samples (5.6 g) were weighed into dried tins, covered with dried filter papers, and dried in an oven at 100°C for 24 h. Dried samples were then placed into desiccators and samples were reweighed after cooling. Samples were then extracted with petroleum ether in a side-arm Soxhlet extractor (Thermo Fischer Scientific, Rockville, MD) for 60 h followed by drying at room temperature for 1 h and subsequent drying in an oven at 100°C for 4 h (Ether Extract; as described by Bruns et al., 2004). Dried, extracted samples were placed in desiccators to cool for 1 h and then reweighed. Intramuscular fat was calculated as the difference between pre- and postextraction sample weight and expressed as a percent of the preextraction sample weight.

The ratio of marbling score to 12th rib fat thickness (**MRatio**; as described by Kern et al., 2014) and ratio of percent intramuscular fat to 12th rib fat thickness (**IRatio**) were calculated to compare marbling

and percent intramuscular fat, respectively, with external carcass fat. The MRatio was calculated as

$$\left[\frac{(Obs \text{ Marb} - \text{Marb } \bar{x})}{\text{Marb } S_d} \right] - \left[\frac{(Obs \text{ BF} - \text{BF } \bar{x})}{\text{BF } S_d} \right]$$

in which Obs = Observed; S_d = standard deviation; Marb = marbling score, BF = 12th rib backfat, and \bar{x} = the population mean. This calculation allowed for the comparison of marbling score and 12th rib backfat as an indicator of the relationship of marbling to subcutaneous fat deposition. Similarly, the IRatio was calculated as

$$\left[\frac{(Obs \%IMF - \%IMF \bar{x})}{\%IMF S_d} \right] - \left[\frac{(Obs \text{ BF} - \text{BF } \bar{x})}{\text{BF } S_d} \right],$$

in which %IMF = percent intramuscular fat. This calculation allowed for the comparison of percent intramuscular fat and 12th rib backfat as an additional tool to evaluate changes in fat deposition.

Objective Color

Objective color measurements were measured using a Minolta colorimeter (model CR-310; Minolta Corp., Ramsey, NJ; 50 mm diameter measuring space and D65 illuminant). At 3 d postmortem, a 2.54-cm steak was removed for analysis of 3-d WBSF; this steak also was used to evaluate objective lean color. To ensure consistency of blooming (exposure of muscle to oxygen), each steak used for color analysis was given 30 min to bloom before 1 color measurement was taken from the center of the steak for evaluation of L^* , a^* , and b^* .

Warner-Bratzler Shear Force

Steaks designated for WBSF determination were thawed for 24 h at 4°C. Steaks were cooked on an electric clam shell grill (George Forman Indoor/Outdoor Grill, model GGR62; Applia Consumer Products, China) to 71°C. Peak internal cooked temperature measurements were recorded for each steak using a handheld thermometer (model 39658-K; Atkins Technical, Gainesville, FL). Cooked steaks were cooled for 24 h at 4°C before removing 6 cores (1.27 cm in diameter) parallel to the muscle fiber orientation (AMSA, 1995). A single, peak shear force measurement was obtained for each core using a Warner-Bratzler shear machine (G-R Electric Manufacturing Company, Manhattan, KS). The peak shear force was recorded for each core and averaged to obtain a single shear force value for each steak.

Statistical Analysis

Least squares means of cow measurements taken during midgestation were computed using PROC GLM procedures of SAS (SAS Inc., Cary, NC). Differences due to the main effects of cow energy status and block were tested using the interaction of these main effects as the error term. Means were tested to a predetermined significance level of $P < 0.05$ with trends considered at $P < 0.10$.

Statistical analyses of offspring carcass data were conducted using each carcass as the experimental unit. Least squares means for all data were computed using PROC GLM procedures of SAS, determining differences due to the main effects of cow energy status and calf sex as well as the cow energy status \times calf sex interaction. Means were tested to a predetermined significance level of $P < 0.05$ with trends considered at $P < 0.10$.

RESULTS AND DISCUSSION

During fetal development, myogenesis is paramount to achieving maximal muscle mass potential. The most important period for muscle development in the bovine fetus appears to be during the second trimester of gestation (Zhu et al., 2004; Du et al., 2010, 2011, 2013). Primary myogenesis occurs during the first 2 to 3 mo of gestation in bovine; yet during this phase of development, a limited number of muscle fibers are created (Du et al., 2010). Many muscle fibers are formed during secondary myogenesis, which occurs during the fetal stage of development, beginning at about the third month of gestation and lasting until about 7 or 8 mo of gestation (Russell and Oteruelo, 1981; Du et al., 2010). Adipogenesis is thought to occur during the last 5 mo of gestation and to continue after birth (Du et al., 2010). Therefore, the developmental period of midgestation emerges as a critical period for both muscle and adipose tissue development in the beef fetus. Inadequate nutrition due to poor quality forage, lack of rainfall for pastures, and low-cost feeding programs often coincide with this production period in spring calving herds of the northern Great Plains (DelCurto et al., 2000; Olson, 2005). The cows used in this study were manipulated to be in either a PES or NES during this developmental period of midgestation. Cows used in this study had a mean gestation length of 84 ± 11.3 d (based on pregnancy ultrasound; 102 ± 10.9 d based on calf birth date with a 283-d gestation length) at the beginning of the midgestation treatment period.

To document that nutritional modifications had a biological impact on the dam, changes in cow BW, BCS, fat thickness, and LMA due to mid-gestation

Table 3. Least squares means for days of gestation at midgestation and cow BCS, BW, LM area (LMA), and fat thickness at the beginning and end of the mid-gestation treatment period¹

Trait	Cow energy status			P-value	
	Positive ³	Negative ⁴	SEM	Status	Block
Days of gestation ²	101	102	1.4	0.5710	0.0652
Initial BCS	4.80	4.92	0.052	0.2001	0.0092
Final BCS	4.97	4.28	0.044	<0.0001	0.0050
Change in BCS	0.17	-0.64	0.050	<0.0001	0.1938
Initial BW, kg	464	462	2.3	0.6851	<0.0001
Final BW, kg	517	437	2.4	<0.0001	<0.0001
Change in BW, kg	53	-25	2.1	<0.0001	0.0612
Initial LMA, cm ²	57.71	59.48	0.948	0.2104	0.0005
Final LMA, cm ²	60.70	53.05	1.038	<0.0001	0.0002
Change in LMA, cm ²	2.99	-6.43	0.723	<0.0001	0.6235
Initial 12th rib fat thickness, cm	0.39	0.40	0.014	0.9407	0.0076
Final 12th rib fat thickness, cm	0.42	0.35	0.011	0.0113	0.0389
Change in 12th rib fat thickness, cm	0.02	-0.05	0.009	0.0071	0.2735

¹Measurements taken at beginning and end of mid-gestation treatment period normalized by fill.

²Days of gestation at beginning of mid-gestation treatment using conception date = calving date - 283 d.

³*n* = 73.

⁴*n* = 67.

energy status were determined using measurements taken at the beginning and end of the mid-gestation period and can be found in Table 3. Cows in the NES group displayed reductions in BCS, BW, 12th rib fat thickness, and LMA relative to the PES cows ($P < 0.05$) during midgestation (Table 3).

Whereas the influence of maternal nutrition on beef carcass characteristics remains unclear, research in sheep has shown that lambs from nutrient-restricted dams have increased adiposity, particularly in kidney and pelvic fat depots (Bispham et al., 2005; Zhu et al., 2006; Ford et al., 2007). Meanwhile, Tong et al. (2008) concluded that marbling development could be influenced by maternal nutrition after evaluating fetal muscle of lambs from overfed ewes. Therefore, inadequate nutrient availability may influence offspring body composition and carcass characteristics by altering fetal development, leading to an interest in how maternal energy status may impact beef carcass traits.

Whereas there were no dam energy status \times calf sex interactions for carcass traits ($P > 0.10$), steers produced heavier carcasses, with less 12th rib backfat and KPH, reduced marbling score and percent intramuscular fat, and larger LMA than their heifer contemporaries ($P < 0.05$; Table 4). No differences in HCW, dressing percent, LMA, KPH, marbling score, and percent intramuscular

fat ($P > 0.10$) occurred due to mid-gestation energy status. Of note, maternal energy status had no influence in degree of muscling of the offspring as measured by LMA, although alterations in maternal energy status occurred during what has been suggested to be the period of maximal fetal muscle fiber development. Tendencies for reduced 12th rib backfat and lower USDA final yield grade were observed in offspring from NES dams ($P < 0.10$), indicating that maternal nutritional status may have influenced beef carcass cutability. Previous research evaluating bovine maternal nutrition effects on offspring carcass characteristics have reported inconsistent results. Underwood et al. (2010) reported offspring from dams grazing native range (restricted protein) were harvested with a decreased HCW, 12th rib backfat, and percent intramuscular fat than offspring from dams grazing improved pasture during d 120 to 180 of gestation. Similarly, Greenwood et al. (2009) reported a decreased HCW and retail yield for offspring from nutrient restricted dams as indicated by calves sorted into low birth weight and high birth weight categories. Larson et al. (2009) compared offspring from protein-supplemented dams with nonsupplemented dams during late gestation in winter grazing systems and reported that offspring from nonsupplemented dams had reduced marbling scores and a lower percentage of carcasses grading USDA Choice or better. In another study, Long et al. (2012) reported that dams experiencing a nutrient restriction (70% restriction in NE_m and CP) from d 45 to 185 of gestation produced offspring that, when compared to controls, were not different in HCW, LMA, KPH, 12th rib backfat, or dressing percent yet had a significantly higher USDA yield grade. Whereas maternal nutritional status appears to have an impact on beef carcass characteristics, the conflicting results in the literature may be attributed to differences across studies in the time of nutrient restriction, the degree of nutrient restriction, specific nutrient manipulated, and small sample sizes used in many of the reports.

Offspring from NES dams in the present study produced carcasses with improved MRatio and IRatio ($P < 0.05$) when compared to offspring from PES dams. The MRatio and IRatio improvements found in offspring from dams in a NES during midgestation highlight shifts in fat deposition that could lead to improvements in carcass value and indicate that significant alterations may occur in adipogenesis in utero that persist throughout life. Additionally, these alterations in fat deposition may create new management opportunities to positively impact marbling and subcutaneous fat thickness relative to lean muscle during prenatal development. The shift in adipose distribution may be consistent with the theory of the fetus developing a thrifty phenotype due to inadequate nutrient availabil-

Table 4. Carcass characteristics of offspring from dams in a positive or negative energy status during midgestation

Trait	Cow energy status			Sex			P-value		
	Positive	Negative	SEM	Heifers	Steers	SEM	Status	Sex	Status × sex
HCW, ¹ kg	330	325	4.2	310	346	4.2	0.3735	<0.0001	0.5896
Dressing percent ^{1, 2}	63.09	62.93	0.202	63.22	62.80	0.205	0.5575	0.1199	0.3332
12th rib backfat, cm ²	1.24	1.13	0.048	1.28	1.10	0.048	0.0819	0.0070	0.8510
LMA, ³ cm ²	83.52	84.23	1.154	82.15	85.60	1.164	0.6496	0.0285	0.6111
KPH, ⁴ %	2.09	2.10	0.030	2.25	1.94	0.030	0.9605	<0.0001	0.8986
USDA yield grade ⁴	2.88	2.67	0.086	2.85	2.70	0.087	0.0768	0.2004	0.9916
Marbling score ^{4, 5}	431	443	8.9	454	420	9.0	0.3200	0.0052	0.7309
MRatio ^{4, 6}	-0.24	0.30	0.182	0.04	0.01	0.183	0.0297	0.9191	0.6699
Intramuscular fat, ⁵ %	4.12	4.47	0.190	4.60	3.99	0.190	0.1715	0.0176	0.2130
IRatio ^{7, 8}	-0.30	0.32	0.170	-0.03	0.05	0.170	0.0079	0.7428	0.2756

¹Positive: *n* = 55; Negative: *n* = 46; Heifers: *n* = 57; Steers: *n* = 44.

²Calculated using final live BW with 4% shrink.

³LMA = LM area.

⁴Positive: *n* = 55; Negative: *n* = 45; Heifers: *n* = 56; Steers: *n* = 44.

⁵300 = Slight⁰⁰; 400 = Small⁰⁰; 500 = Modest⁰⁰.

⁶MRatio = ratio of marbling score to 12th rib fat thickness.

⁷Positive: *n* = 53; Negative: *n* = 43; Heifers: *n* = 53; Steers: *n* = 43.

⁸IRatio = ratio of percent intramuscular fat to 12th rib fat thickness.

ity. It stands to reason that a fetus preparing itself for a sparse-nutrient environment would attempt to create a body composition that is more efficient, potentially resulting in greater intramuscular fat deposition to increase energy storage within muscle that could theoretically be easily used by nearby muscle cells when needed.

Additional meat quality attributes are reported in Table 5, highlighting differences in objective color measurements (Minolta L*, a*, and b* values) and WBSF of LM steaks with various aging periods. In this study, 10 carcasses were classified as “dark cutters” (carcass that is considered less desirable as a

consequence of pre-harvest stress, which depletes muscle glycogen leading to an abnormally high pH and dark color of the ribeye; Scanga et al., 1998) by USDA graders, including 8 heifers and 2 steers. Of these, 6 carcasses were from NES dams and the other 4 from PES dams, indicating that the incidence of dark cutters was unlikely to be related to maternal energy status. Still, to prevent skewed results in objective color and WBSF, we removed 15 carcasses (12 heifers and 3 steers; 9 NES and 6 PES calves) based on L* value. Criteria followed guidelines set by Wulf and Wise (1999), who concluded that beef carcasses with an L* value below 36.5 should be classified as dark

Table 5. Maternal nutrition status effects on offspring L*, a*, b* values and Warner-Bratzler shear force (WBSF) of longissimus dorsi steaks

Trait	Cow energy status			Sex			P-value		
	Positive ¹	Negative ²	SEM	Heifers ³	Steers ⁴	SEM	Status	Sex	Status × sex
L* ⁵	42.06	42.12	0.357	41.69	42.49	0.333	0.8999	0.0945	0.9797
a* ⁶	22.74	22.61	0.219	22.35	23.00	0.204	0.6361	0.0266	0.7918
b* ⁷	8.05	8.00	0.175	7.86	8.19	0.164	0.8163	0.1592	0.8597
3-d WBSF, kg	4.08	4.13	0.180	4.59	3.62	0.168	0.8151	<0.0001	0.8547
14-d WBSF, kg	3.07	3.07	0.101	3.22	2.91	0.094	0.9690	0.0210	0.5295
21-d WBSF, kg	3.11	3.06	0.106	3.28	2.89	0.097	0.6943	0.0051	0.5158

¹*n* = 47.

²*n* = 34.

³*n* = 41.

⁴*n* = 40.

⁵L*: 0 = black and 100 = white; taken 3 d postmortem.

⁶a*: negative values = green and positive values = red; taken 3 d postmortem.

⁷b*: negative values = blue and positive values = yellow; taken 3 d postmortem.

cutters. Removal of these 15 carcasses from this portion of the analysis resulted in the evaluation of objective color and WBSF on 81 individuals. Objective color measurements performed at 3 d postmortem indicated a tendency for increased L^* values ($P < 0.10$) and a higher a^* value ($P < 0.05$) in the strip loins of steers when compared to heifers. No differences due to maternal energy status were observed for L^* , a^* , and b^* values ($P > 0.10$). At 3, 14, and 21 d postmortem, WBSF of steaks from steers were lower than WBSF of steaks from heifers ($P < 0.05$). No differences were observed for WBSF at any aging period when comparing steaks from offspring of NES or PES dams ($P > 0.10$). Very limited data exists evaluating the impact of bovine maternal nutrition on offspring meat color and tenderness. Whereas no differences were observed in WBSF in the present study, Underwood et al. (2010) reported that offspring from dams experiencing nutrient restriction by grazing native range had steaks with increased 14-d WBSF values compared with offspring from dams grazing improved pasture. Differences in WBSF results between the present study and the research conducted by Underwood et al. (2010) may be attributed to differences in nutrients restricted (energy in the present study versus primarily protein in Underwood et al. [2010]) and the scope of the experiment (86 animals in the present study versus 15 animals in Underwood et al. [2010]). Findings by Underwood et al. (2010) indicate the potential exists for alterations in fetal development that may have a lasting impact on beef tenderness.

Implications

Maternal energy status during midgestation may play an important role in offspring carcass characteristics. Reduced maternal energy status similar to what could be encountered with grazing cattle operations in the northern Great Plains appears to have the potential to improve carcass cutability and, more importantly, improve the amount of intramuscular fat relative to subcutaneous fat in carcasses of the resulting offspring. Therefore, maternal nutrition during midgestation could be a critical management period to maximize both offspring quality and cutability. Still, more research is necessary to evaluate how maternal energy status may impact other production aspects in beef cattle.

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