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Mineral retention of growing and finishing beef cattle across different production systems[1]

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ABSTRACT

Calcium, P, Mg, K, and S retention in carcass, offal, and viscera were measured in 2 beef cattle experiments. Experiment 1 used 30 steers (245 kg of BW; SE = 4 kg) wintered at 3 levels of gain: grazing wheat pasture at a (1) high or (2) low rate of gain or (3) grazing dormant native range, and all were finished on a common diet (71% corn, 9% cottonseed hulls, 5.35% soybean meal). Experiment 2 used 46 steers (240 kg of BW; SE = 4 kg) fed 3 growing diets with similar rate of gain: (1) sorghum silage, (2) program-fed high-concentrate diet, or (3) wheat-pasture grazing, or placed directly into the feedlot. In Exp. 1, retention of Mg, K, and S (g/100 g of protein gain) during the finishing period was greater for treatments wintered at a low rate of gain during the growing period ($P \leq 0.02$). There were no treatment differences for P or Ca retention during the finishing period ($P \geq 0.39$). In Exp. 2, no differences were noted due to treatment ($P \geq 0.25$) or feeding period ($P \geq 0.37$) for Ca, P, Mg, K, and S retention (g/100 g of protein gain). Concentrations of Cu, Fe, Mn, and Na were greater in offal than carcass tissues in both experiments ($P < 0.01$). In both experiments, expressing mineral retention on a protein gain basis minimized effects due to BW or rate of gain, allowing for a better comparison of mineral retention across a variety of animals and diets.

Key words: beef cattle, calcium, phosphorus, mineral requirement, mineral retention

INTRODUCTION

Research evaluating the mineral composition of beef cattle carcasses is limited. A few studies have been conducted testing whole carcasses for mineral retention, with Ca and P being the most commonly analyzed minerals, and more commonly evaluated in dairy than beef cattle (Rumsey et al., 1985; Kegley et al., 1991; Delaquis and Block, 1995; Knowlton et al., 2001). The rate and composition of gain can be quite different for dairy and beef breeds, suggesting that mineral retention could also differ (Duncan, 1958).

Gain requirements discussed in the NASEM (2016) for Ca and P are largely based on a slaughter study conducted by Ellenberger et al. (1950) using 132 Holstein animals, from a 135-d-old, 1.8-kg fetus to a 12-yr-old, 723-kg cow. Similar work of this magnitude has not been completed to calculate the gain requirements of Mg, K, and S. Cattle (genetics, nutrition, and management) and technology have evolved since these data were collected, potentially creating differences in mineral retention due to changes in cattle (Erickson et al., 2002), or advances in analytical methods used to measure mineral content (Peters, 2003). A better understanding of mineral requirements is critical not only for animal health and performance, but also for calculating nutrient excretion values for the proper application of manure to crop fields (ASAE, 2010).

Mineral retention is related to gain and may be largely affected by rate of gain during the growing and finishing periods (AFRC, 1991; NASEM, 2016). Mineral requirements for gain are typically expressed on a protein gain basis, although other methods [retention on a daily basis or relative to empty BW (**EBW**) gain] may provide better estimates of retention (Block et al., 2004). Therefore, the objectives of the current study were to evaluate the mineral composition of whole carcasses of beef steers under different growing strategies to calculate mineral retention during the growing and finishing periods.

MATERIALS AND METHODS

The present study was an ad hoc component to 2 backgrounding experiments conducted at Oklahoma State Uni-

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versity previously described by Hersom et al. (2004a,b) and McCurdy et al. (2010a,b). The objectives of the original experiments were to determine the effects of backgrounding diet and rate of gain on finishing performance, body composition, and organ mass. All procedures used in these studies were approved by the Oklahoma State University Institutional Animal Care and Use Committee.

Exp. 1—Winter Grazing

Experiment 1 used 30 Angus × Angus-Hereford steers (initial BW = 245 kg, SE = 4 kg) wintered at 3 levels of gain and then finished on a common diet; cattle were assigned randomly to treatment. A detailed description of the procedures used and cattle performance results of the study have been previously reported by Hersom et al. (2004a,b). Only samples from yr 1 of 2 were available for mineral analysis and determination of retention. Treatments included (1) high gain wheat (**HGW**), cattle were stocked on wheat pasture at a low rate (1.10 steers/ha) to achieve a high rate of gain (1.31 kg/d); (2) low gain wheat (**LGW**), cattle were stocked on wheat pasture at a high rate (2.45 steers/ha) to achieve a low rate of gain (0.54 kg/d); and (3) cattle grazed dormant native range (**NR**) supplemented with 0.91 kg/d of cottonseed meal (41% CP) and gained 0.16 kg/d. Mineral composition of diets did differ during the grazing period. Gains presented are the actual gains measured throughout the study. The grazing season lasted 120 d. Following the grazing season, all cattle were stratified by BW within winter grazing program and assigned to feedlot pens (4 steers per pen and 3 pens per treatment). Cattle were fed a common finishing diet composed primarily of dry whole-shelled corn, cottonseed hulls, soybean meal, and fat included at 70.9, 9.0, 5.35, and 3.0% of diet DM, respectively. Nutrient composition of the finishing diet was 13.4% CP, 0.48% Ca, 0.34% P, 0.14% Mg, 0.46% K, and 0.14% S (Table 1). A trace mineral premix was included at 0.04% of diet DM and consisted of 13.5% Zn, 6.0% Mn, 3.6% Cu, and 1.43% Fe. Cattle gained 1.79 to 1.82 kg/d during the finishing period. Cattle were fed to a targeted endpoint of 1.5 cm of 12th rib backfat (range 1.49 to 1.63 cm), which corresponded to 89, 116, and 163 d on feed for HGW, LGW, and NR, respectively.

At the end of the winter grazing season, 4 steers were selected randomly and slaughtered from each treatment group for complete carcass composition evaluation. Feedlot performance was measured on the remaining 18 steers. Following the finishing period, 6 additional steers from each treatment were slaughtered (2 steers per pen selected randomly) for complete carcass evaluation. Thus, 30 total steers (10 per treatment) were used to determine carcass composition, and performance was measured on 48 steers.

Exp. 2—Growing Programs

Experiment 2 used 260 British crossbred steers (initial BW = 237 kg, SE = 5 kg) grown at different rates and on different diets and then finished on a common diet; 46 of these steers (initial BW = 240, SE = 4 kg) were serially slaughtered for carcass composition measurements included in this manuscript. A detailed description of the procedures used and cattle performance results have been reported by McCurdy et al. (2010a,b). At the initiation of the experiment, 4 randomly selected steers (269 kg of BW) were slaughtered to determine initial complete carcass composition. The remaining 256 steers were blocked by initial BW and allotted randomly among 4 treatments (64 steers per treatment): (1) calf-feds placed directly into the feedlot on a high-concentrate diet (**CF**; 1.63 kg/d ADG; 8 pens and 8 steers per pen); (2) grazing wheat pasture (**WP**) gaining 1.15 kg/d (3 pastures and 21 or 22 steers per pasture); (3) fed a sorghum silage–based growing diet gaining 1.10 kg/d (**SF**; 8 pens and 8 steers per pen); and (4) program fed a high-concentrate diet to have similar BW gain as SF cattle (**PF**; 1.18 kg/d; 8 pens and 8 steers per pen). Mineral concentration of diets is shown in Table 1. At the conclusion of the 112-d growing period, 6 steers were selected randomly from each of the 3 growing treatments (WP, SF, and PF) and slaughtered to determine complete carcass composition. The remaining 174 steers were placed into the feedlot on the same finishing diet as CF steers (8 pens and 7 or 8 steers per pen). The common finishing diet consisted of 76.14% steam-flaked corn, 11.76% sorghum silage, 3.00% condensed corn distillers solubles, 3.50% yellow grease, 2.26% soybean meal, and 3.34% supplement. Remaining steers were slaughtered at approximately 1.37 cm of 12th rib backfat (range of 1.24 to 1.63 cm), which was 196, 123, 104, and 104 d on feed for CF, WP, SF, and PF treatments, respectively. During the finishing period, ADG was 1.63, 1.64, 1.85, and 2.02 kg/d for the CF, WP, PF, and SF treatments, respectively. At the conclusion of the finishing period, 6 steers from each treatment were selected randomly for complete carcass composition. Across the entire trial, 260 steers were used

Table 1. Mineral concentration of diets fed to beef cattle expressed as a percentage of diet DM

Item	Ca	P	Mg	K	S
Exp. 1					
Finishing diet[1]	0.48	0.34	0.14	0.46	0.14
Exp. 2[2]					
SF	0.95	0.21	0.31	1.92	0.18
PF	0.91	0.28	0.26	0.97	0.15
CF	0.78	0.28	0.26	0.72	0.14

[1]All cattle were finished on a common diet.

[2]Treatments include diet fed during the growing period: fed a sorghum silage–based diet (SF), program fed a high-concentrate diet (PF), or placed directly into the feedlot as calf-feds (CF). All cattle were finished on the CF diet.

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