TIMING OF EXPOSURE TO HIGH-CONCENTRATE DIETS VS. PASTURE ON CARCASS TRAITS AND MEAT QUALITY OF STEERS

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Abstract - Forty Angus steers (278 kg) were used to evaluate the effect of feeding treatment during stockering (Phase 1) and finishing (Phase 3) periods on carcass traits and meat quality. In Phase 1, steers were randomly assigned to a high-concentrate diet or high-quality pasture. In phase 2 all steers grazed high-quality pastures. In Phase 3, each group defined in Phase 1 was randomly divided in two and assigned to high-concentrate diet or high-quality pasture. Steers finished on high-concentrate diets during Phase 3 had greater hot carcass weight; fat thickness; kidney, pelvic and heart fat; less red and less yellow *Longissimus muscle*; and darker less yellow subcutaneous fat. Finishing in Phase 3 on high-concentrate diets increased proportion of monounsaturated fatty acids, lowered the proportion of n-3 polyunsaturated fatty acids (PUFA) and increased Warner Bratzler shear force compared to pasture. Steers fed high-concentrate diets in phases 1 and 3 had greater marbling score, lower proportion of n-3 PUFA and higher proportion of n-6 PUFA compared to pasture. Early and late exposure to high-concentrate diets altered carcass and fatty acid composition.

I. INTRODUCTION

Among the factors influencing beef quality, feeding system and type of feed have received great attention (1, 2). However, most studies have focused only on the effects of finishing diets, with less research aimed at timing of exposure to high-concentrate diets and its effects on beef quality. Recent research has shown that feeding strategy during the stockering phase affects physical and chemical characteristics of beef (3, 4). Additionally, evidence suggests that timing of exposure to high energy diets could affect intramuscular fat deposition and other meat traits related to beef quality (5).

Our study was designed to evaluate the effects of feeding treatment during the stockering and finishing phases on carcass traits and meat quality of steers.

II. MATERIALS AND METHODS

Forty Angus steers (278±21.4 kg, 9 mo.) were used to evaluate the effect of feeding treatment during stockering (Phase 1; 111 d; started 30 d after weaning) and finishing (Phase 3; to live weight endpoint of 568 kg) periods on carcass traits and meat quality. During Phase 1 steers were randomly assigned to high-concentrate diet or high-quality pasture. In phase 2, all steers grazed high-quality pasture for 98 days. During Phase 3, each group defined in Phase 1 was randomly divided in two and assigned to high-concentrate diet or high-quality pasture. In Phase 1, high-concentrate diet (13 % CP) was comprised of 65% cracked corn, 25% corn silage and 10% soybean meal. In Phase 3, high-concentrate diet was comprised by the same feedstuffs used in Phase 1 at a different proportion to reach 11% CP. Steers fed on pasture during phases 1 and 3, and all steers during phase 2 grazed high quality forage (winter annuals (*Avena sativa*, *Lolium multiflorum*), alfalfa (*Medicago sativa*) and non-toxic fescue (*Lolium arundinaceum*)). At the end of the experiment, steers were slaughtered at a commercial facility. At 24-h postmortem, carcasses were graded by trained personnel and a rib section encompassing the 6^{th} to 12^{th} ribs from the left side of each carcass was removed and shipped to the Clemson University Meat Laboratory, where they were maintained at 4°C and fabricated into steaks (2.5 cm thick) at 48 h postmortem. One steak (12^{th} rib) was used for proximal composition analysis, whereas 3 steaks (11^{th} to 10^{th} ribs) were removed, vacuum packaged and randomly assigned to postmortem aging treatments (2, 7 and 14 days, at 4°C). After postmortem aging treatment, samples were kept frozen at -20°C until analysis.

Longissimus dorsi and subcutaneous fat color were assessed at 12th rib with a Minolta chroma meter (CR-310, Minolta Inc., Osaka, Japan) (50-mm-diameter measurement area, D65 illuminant). Moisture content was determined by weight loss after drying at 100 °C for 24 h. Samples were freeze-dried and total lipids were extracted using an Ankom XT15 extractor with hexane as the solvent. Nitrogen content was determined by the combustion method using a Leco FP-2000 N analyzer, and crude protein (CP) was calculated multiplying nitrogen content by 6.25. Total ash content was determined by ashing at 600°C for 8 h (6). For fatty acid profile analyses, samples were transmethylated according to Park and Goins (7). Fatty acid methyl esters (FAME) were analyzed using an Agilent 6850 (Agilent, San Fernando, CA) gas chromatograph. Separation of FAME was accomplished according to Duckett *et al*. (8). Fatty acids were quantified by incorporating an internal standard, methyl tricosanoic (C23:0) acid, into each sample after methylation and expressed as g/100 g of total fatty acids.

For Warner Bratzler shear force (WBS) aged steaks were thawed (18 h, 4 °C), broiled on electric grills (71 °C), cooled down to room temperature, and six 1.27-cm-diameter cores were removed from each steak parallel to the longitudinal orientation of the *Longissimus dorsi* fibers. All cores were sheared perpendicular to the long axis using a Warner-Bratzler shear machine (G-R Manufacturing, Manhattan, KS). Adipocyte cell size of intramuscular and subcutaneous fat was determined by isolation of adipocytes according to Etherton *et al*. (9).

Statistics analysis: Data were analyzed in a completely randomized design, including in the model Phase 1, Phase 3 and the two-way interaction, using Proc GLM of SAS (SAS Inst. Inc., Cary, NC). For WBS, postmortem aging and the respective two- and three- way interactions were added to the previous model. Degree of doneness was added as a covariate but since it was not significant (P>0.05) it was removed from the model.

III. RESULTS AND DISCUSSION

Average daily gain (ADG) was affected by Phase 3 (Table 1). Steers finished on a high-concentrate diet gained +24.7% more than steers finished on pasture. Because of this, steers finished on pasture were slaughtered 49 days later to reach the target final body weight. Phase 1 did not affect ADG. Hot carcass weight; dressing percentage; fat thickness and kidney, pelvic and heart fat were greater for steers finished on a high-concentrate diet in Phase 3 compare to pasture (Table 1). Accordingly, size of subcutaneous adipocytes was greater in steers finished on a high-concentrate diet (Phase 3) than those finished on pasture (Table 1).

Steers stockered on a high-concentrate diet (Phase 1) had greater ribeye area and lower skeletal maturity when they were finished (Phase 3) on a high-concentrate diet compared to steers finished on pasture (Table 1). Steers stockered on pasture (Phase 1) had greater yield grade when they were finished (Phase 3) on a high-concentrate diet than when finished on pasture (Table 1).

Marbling score was affected (P<0.05) by finishing strategies as well as by Phase 1; steers stockered on a high-concentrate diet had a greater marbling score compared to those stockered on pasture (Table 1). According to Cianzio *et al.* (10), differences in adult adiposity seemed to be present early in adipose tissue development in terms of the number of preadipocytes. An apparent cell hyperplasia in intramuscular fat depot was shown to occur in cattle from 11 to 15 mo. of age (10). Despite differences in marbling score, the amount of total lipids did not differ (P>0.05) between treatments, and the average size of intramuscular adipocytes was only affected (P<0.0001) by Phase 3 feeding strategy (Table 1).

Longissimus L* was not affected (P>0.05) by Phase 1 or Phase 3 feeding strategies (Table 1). *Longissimus* from steers finished on pasture was redder (higher a*) and more yellow (higher b*) compare to high-concentrate diet (Table 1). Steers stockered (Phase 1) on pasture showed a more yellow *Longissimus* color than those from high-concentrate diet (Table 1). The diet offered during the Phase 1 did not influence (P>0.05) the color score of subcutaneous fat, however, it was affected by Phase 3 (Table 1). Subcutaneous fat of pasture finished steers was

Table 1. Average daily gain, carcass traits, and fat cell size of steers fed on a high-concentrate diet or pasture during stockering (Phase 1) and finishing (Phase 3) periods.

Phase 1	High-concentrate		Pasture			p value[1]		
Phase 3	High-concentrate	Pasture	High-concentrate	Pasture	EE	Phase 1	Phase 3	interaction
n	10	10	9	10				
Average daily gain, kg/d	1.046	0.834	1.020	0.820	0.0328	NS	<0.0001	NS
Hot carcass weight, kg	326.45	304.73	323.38	297.18	6.570	NS	0.001	NS
Dressing percentage, %	60.20	58.05	59.09	56.64	0.374	0.002	<0.0001	NS
Ribeye area, cm^2	82.4 a	71.7 b	76.6 ab	75.7 ab	2.09	NS	0.0102	0.0277
Skeletal maturity[2]	155 b	174 a	167 a	174 a	2.0	0.0029	<0.0001	0.0057
Fat thickness, cm	1.08	0.89	1.31	0.80	0.130	NS	0.012	NS
KPH[3], %	2.2	1.9	2.4	1.6	0.15	NS	0.001	NS
Yield grade	2.65 ab	2.74 ab	3.17 a	2.34 b	0.200	NS	NS	0.0271
Marbling Score [4]	580	531	508	472	20.5	0.0033	0.0495	NS
LM[5] L*	43.9	42.1	42.2	42.3	0.68	NS	NS	NS
LM a*	25.0	28.7	25.5	29.6	0.41	NS	<0.0001	NS
LM b*	10.6	11.6	10.9	12.2	0.20	0.0275	<0.0001	NS
s.c.[6] L*	75.9	77.8	75.1	78.1	1.06	NS	0.0285	NS
s.c. a*	9.6	12.2	10.2	12.5	0.76	NS	0.0038	NS
s.c. b*	18.9	22.0	19.4	22.9	0.88	NS	0.0007	NS
LM fat cell size, µm	63.7	52.3	59.2	53.9	1.58	NS	<0.0001	NS
s.c. cell size, µm	62.3	54.7	57.9	51.3	2.22	NS	0.0033	NS

[1]NS: statistically no significant (p>0.05); [2]Skeletal maturity: 100-199= A; [3]KPH: kidney, pelvic and heart fat as percentage of carcass weight; [4]Marbling score: 400= $slight^0$ 500= $small^0$; [5]LM: *Longissimus dorsi*; [6]s.c.: subcutaneous fat.

lighter (higher L*), redder (higher a*), and more yellow (higher b*) compared to high-concentrate diet. *Longissimus* fatty acid profile is shown in Table 2. The proportion of saturated fatty acids was not influenced (P>0.05) by any phase. Steers finished (Phase 3) on a high-concentrate diet showed a greater proportion of monounsaturated fatty acid compared to pasture. Polyunsaturated fatty acid omega 6 (PUFA n-6) proportion was higher for steers stockered (Phase 1) on high-concentrate diet compared to pasture, however, it was not affected by the diet offered during Phase 3. The proportion of PUFA n-3 was greater in steers finished (Phase 3) on pasture compared to high-concentrate diet and was increased in animals stockered (Phase 1) on pasture compared to high-concentrate diet regardless the Phase 3 finishing strategy. Similarly, Pordomingo *et al*. (4) observed a greater proportion of PUFA n-3 for heifers

Table 2. Proximal composition, fatty acid profile and Warner Bratzler Shear force (WBS) of *Longissimus dorsi* of steers fed on a high-concentrate diet or pasture during stockering (Phase 1) and finishing (Phase 3) periods.

Phase 1	High-concentrate diet		Pasture			p value[1]		
Phase 3	High-concentrate	Pasture	High-concentrate	Pasture	EE	Phase 1	Phase 3	Interaction
Proximal composition[2]								
Moisture	72.56	72.77	72.95	73.10	0.299	NS	NS	NS
Total lipids	4.63	4.09	4.25	3.73	0.358	NS	NS	NS
Crude protein	20.47	21.50	20.93	21.56	0.206	NS	0.0003	NS
Ash	1.20	1.12	1.40	1.13	0.086	NS	NS	NS
Fatty acid profile[3]								
SFA[4]	44.47	44.72	46.26	45.12	0.589	NS	NS	NS
MUFA[5]	44.64	42.59	43.63	42.72	0.494	NS	0.0055	NS
PUFA[6]	4.18	4.85	4.41	4.30	0.298	NS	NS	NS
PUFA n-6	3.20	3.28	2.84	2.48	0.209	0.0099	NS	NS
PUFA n-3	0.98	1.57	1.57	1.82	0.107	0.0005	0.0004	NS
PUFA n-6/PUFA n-3	3.28 a	2.18 b	1.83 c	1.36 d	0.069	<0.0001	<0.0001	<0.0001
WBS, kg	3.59	2.73	3.50	2.90	0.172	NS	0.0001	NS

[1]NS: statistically no significant (p>0.05); [2]g/100 g wet basis; [3]g/100 g of total fatty acids; [4]SFA: saturated fatty acids; [5]MUFA: monounsaturated fatty acids; [6]PUFA: polyunsaturated fatty acids.

stockered on pasture compared to high-concentrate diet. Steers fed on a high-concentrate diet during Phase 1 showed higher PUFA n-6/PUFA n-3 ratios compare to pasture. Similarly, Pordomingo *et al*. (4) reported higher PUFA n-6/ PUFA n-3 ratio for pasture finished heifers backgrounded on a high-concentrate diet compared to pasture. Warner Bratzler shear force (WBS) was not affected by Phase 1 diet (Table 2). However, feeding the animals on a high-concentrate diet during Phase 3 increased ($P<0.0001$) the mean WBS of steaks compared to those finished on pasture. We hypothesize a greater hypertrophy of muscle fibers in the animals finished in a high-concentrate diet, which can be confirmed by a larger REA. There was a significant interaction ($P<0.05$) between postmortem aging and Phase 3; WBS was greater for steers finished on a high-concentrate diet compared to pasture at day 2 of postmortem aging, but it was similar ($P>0.05$) at days 7 and 14 of postmortem aging (Figure 1).

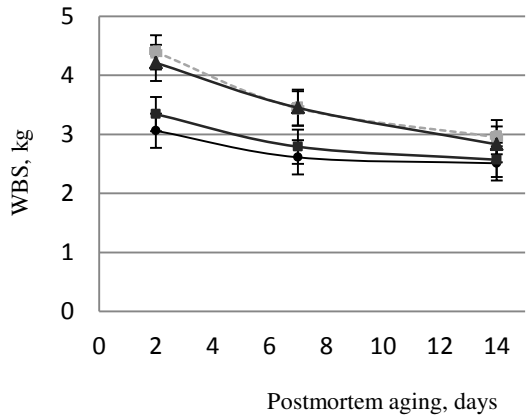

Figure 1.Warner Bratzler Shear force (WBS) of steaks aged for 2, 7 or 14 d. --■--, high-concentrate diet (Phase 1) - high-concentrate diet (Phase 3); –▲–, pasture (Phase 1) - high-concentrate diet (Phase 3); –●--, high-concentrate diet (Phase 1) - pasture (Phase 3); –■–, pasture (Phase 1) – pasture (Phase 3).

IV. CONCLUSION

Timing of exposure to high-concentrate diets altered beef quality composition. Similar quality composition could be achieved with an early or late exposure to high-concentrate diets.

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