The Influence of Body Weight and Marbling EPD on the Relationship of Intramuscular Fat Content and the Value of Lean Retail Product in Serially Slaughtered Angus Steers

K. W. Bruns
South Dakota State University

R. H. Pritchard
South Dakota State University

D. L. Boggs
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K. W. Bruns[1], R. H. Pritchard[2], and D. L. Boggs[3]
Department of Animal and Range Sciences

SDSU

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Summary

It is unclear how age, physiological maturity, and genetics affect intramuscular fat (**IM**) desposition in cattle. The study used beef cattle of known age and parentage to study the development of primal cuts, total carcass fat and IM fat depots as part of the growth process.

Selecting cattle for marbling with the use of paternal grandsire's EPD for marbling was not indicative of differences in the onset or the rate, of development of marbling. Greater differences in EPD for marbling may be needed to observe phenotypic differences. Harvest group affected the level and extent of marbling (P<.10), however there was no harvest group x marbling group interactions indicating no differences occurred in the pattern of marbling development due to marbling EPD. Carcasses expressed a Small degree of marbling between the hot carcass weights of 550 and 650 lbs. and at a back fat depth of approximately .30 in. In this study utilizing non-implanted steers of the same breed, we found that as days on feed increased, hot carcass weights, back fat depth, and percent carcass fat increased along with marbling score as well as percent 12th rib lipid content. No differences were observed in the weight of the primal cuts when expressed as a percentage of the chilled carcass between marbling groups at each of the five end points. As HCW increased across harvest groups, primal weight increased without a change in the percentage of the carcass represented by the middle meats (sirloin, shortloin, rib).

Introduction

Excess carcass fat and inadequate marbling have been identified as common defects in beef (NBQA, 1995). It is known that these traits are inversely related, (Arnold et al., 1991) (Lamb et al., 1990) (Wilson, 1987) creating difficulty in resolving the problem. Evidence exists that the genetic correlation between these traits is minimal, (Wilson, 1987) thereby opening the opportunity to use breeding to correct these defects. The development of Expected Progeny differences (**EPD**) for marbling represents a technology available today that may speed progress in this area.

Research (Vieselmeyer et al., 1996 and Gwartney et al., 1996) has shown that progeny of sires with high marbling EPDs produce beef with a greater degree of marbling. What researchers have not been able to identify is whether cattle that have greater genetic potential to deposit intramuscular fat do so via an earlier onset of intramuscular (IM) fat deposits or a more rapid accumulation of IM fat deposits throughout the feeding phase.

Marbling and cutability account for only part of carcass value. The proportion of the chuck and round to the higher-priced middle meats and total retail weight also affect the total retail value of the carcass. Consequently monitoring it is important to the change in carcass weight and the proportion of wholesale cuts in the carcass throughout the feeding phase, while seeking the most desirable endpoint associated with quality grade.

Materials and Methods

This was a two year study that used Angus steers of know genetic background and age (n=40, year 1; n=46, year 2), selected from one breeder. In both years of the study, steers were handled and allocated to trial in the same

[1]Instructor
[2]Professor
[3]ARS Department Head

fashion. Steers were received in October and backgrounded on a receiving trial from weaning until the end of December. Steers were then sorted by paternal grandsire marbling EPD into high (**HIGH**) and low (**LOW**) marbling groups and assigned to one of 5 harvest groups. The five harvest groups (Table 1) were targeted at carcass weights of 1) 450; 2) 550; 3) 650; 4) 750; and 5) 850 lbs. Live weights of 1) 900; 2) 1040; 3) 1146; 4) 1258; and 5) 1403 lb. prior to a 4 % shrink were targeted based from dressing percentages of 52, 55, 59, 62 and 63 %, respectively. In year one of the study, 4 paternal grandsires were represented in the high marbling group and 2 paternal grandsires represented in the low marbling group. The average EPD of the paternal grandsires for marbling +.21 for HIGH and -.19 for LOW. More sires were used in the second year of the study. Both the HIGH and the LOW group used five paternal grandsires each with average EPD for marbling of +.28 for HIGH and -.02 for LOW.

Steers were weighed on test on 12/27/96 (year 1) and 12/23/97 (year 2). Pens contained 4 or 5 steers each and were penned by marbling group and harvest group. Steers were fed a typical feedlot finishing diet which consisted of a corn based 90% concentrate diet formulated to meet all nutrient requirements (NRC, 1996). (Table 3) Steers were fed once daily in the afternoon. Steers were weighed approximately every 28 d to monitor weight gain and to schedule appropriate harvest dates. There was no restriction of feed or water availability prior to weighing the steers. When the mean weight of the harvest group reached the desired weight, feed was removed the afternoon prior to harvest. Steers were individually weighed and transported to the SDSU Meat Lab on campus for harvest the following morning. After harvest, the carcasses were chilled for 48 h. Carcass data collected included hot carcass weight, longissimus area (REA), backfat thickness (BF) and percent kidney, pelvic and heart fat (KPH) depots. Estimates of bone maturity and marbling score (to the nearest 1/10) were recorded. Yield grade (YG) was calculated from carcass measurements obtained. Wholesale primals were cut according to The Meat Buyers Guide by the National Association of Meat Purveyors (NAMP, 1988) and weighed.

To better understand the rate and development of marbling, muscle samples were obtained from the longissimus muscle at the12th rib, and analyzed for lipid content by ether extract (AOAC, 1990). Samples were obtained and frozen for storage at –20° C. The 9-10-11 rib section was removed from the right side of the carcass and chemical analysis of the soft tissue was conducted to determine nitrogen, water and ether extract (fat) content. The composition of the 9-10-11 rib section was used to estimate total carcass fat and protein content (Hankins and Howe, 1946).

Carcasses were broken down into the following five wholesale cuts as outlined by the National Association of Meat Purveyors (1998); rib, shortloin, sirloin, round and chuck. Cuts were removed and weighed without trimming excess fat. Weights were compared to analyze differences in percentages of wholesale cuts relative to HIGH and LOW marbling groups.

Statistical Analysis. Statistical analysis of data were performed using analysis of variance generated using the General linear Models procedure of SAS (SAS, 1985). An individual steer was used as the experimental unit and the model sum of squares was partitioned into year (1 or 2), marbling group (High or Low), harvest group (1, 2, 3, 4,or 5), and the year x harvest group x marbling group interactions (Dammon and Harvey, 1987). The means presented for marbling group and harvest group are presented here to demonstrate the magnitude as well as direction of change in the measured traits.

Regression equations were developed for the relationship of carcass traits to live weight, hot carcass weight and percent carcass fat. Data were compared for linear, quadratic and cubic relationships as outlined by Steel and Torrie, 1960.

Results

One steer was removed from the trial in year 2 due to structural unsoundness. The harvest schedule and production traits are reported in Table 1 by year. Body weight within harvest group was not different between high or low marbling groups. Body weight for harvest groups 1, 2, 3, 4 and 5 were heavier in year 1 than in year 2 ($P<.10$, Table 1). Average daily gains decreased as anticipated with progressing harvest group. Mean hot carcass weights (HCW) increased linearly and in a quadratic fashion due to the desired endpoints and differed ($P<.01$) between harvest groups (Table

2). Regression equations were developed to quantify the change in carcass characteristics and composition throughout the feeding phase. A quadratic equation described the increase (P<.10) in BF, KPH, and calculated YG between harvest groups and followed the anticipated upward trend in a quadratic fashion. Hot carcass weight, REA, %KPH, marbling score and percent intramuscular fat (PIMF) content of the 12^{th} rib were all found to be linear. No differences were found for carcass traits when comparing HIGH vs. LOW (Table 3).

Changes in carcass composition are shown in Table 4. Carcass fat (%) increased (P<.10) with progressing harvest groups. As anticipated, carcass protein (%) and water (%) were inversely related to carcass fat (%) and decreased (P<.10) in a quadratic fashion with each harvest group. Bone as a percent of the carcass was higher (p<.10) at the first harvest group, but remained the same in harvest group 2, 3 and 4, but decreased (P<10) at harvest group 5 relative to proceeding groups.

Marbling group (H or L) averaged over both years (1 and 2), had no affect on the carcass variables measured (Table 3). Measurements of quality indicators were not different between the high and low marbling lines (Table 3). However, a year by marbling EPD group interaction existed for PIMF (Table 5). In year 1 of the study the HIGH group had greater (P<.10) PIMF content at the 12^{th} rib than the LOW group. In year 2 of the study there was no difference between HIGH or LOW groups. The HIGH group was also greater (P<.10) in year one of the study than in year 2. While there was no difference between years 1 and 2 for the PIMF content of the 12^{th} rib for the L OW marbling group.

The Nutrient Requirements for Beef Cattle (NRC, 1996) assumes that cattle reach the choice grade when percent body fat reaches 28% on an empty body weight basis. A level of 4% PIMF content of the 12^{th} rib slices is indicative of $small^0$ degree of marbling (Rouse and Wilson, 1994). Equations were developed for HCW relative to PIMF content of the 12^{th} rib for both the HIGH and LOW groups (Figure 1). The LOW group reached 4% PIMF content at a HCW of 565 pounds versus 600 pounds for the HIGH group. Because there was no interaction between marbling groups and harvest group there was no difference in the rate or onset of the PIMF content of the 12^{th} rib. Thus based on the equations developed from the regression analyses of the combined data set carcasses reached 4% PIMF content carcass fat at 570 pounds (Figure 2). This would be representative of a shrunk live body weight of Carcasses with a 4% PIMF content of the 12^{th} rib had a % body fat content of 24.5%. The research used to establish the 28% empty body fat (EBF) level was based on an accumulation of trials (Harpster 1978, Danner et al., 1980; Lomas et al., 1982: Woody et al., 1983). Serial harvest was not a component of those experiments, which limited researchers to analyze the data in a linear fashion. Results of this experiment indicate a need to further research the current concept of cattle reaching $small^0$ at 28% carcass fat.

A better understanding of the change in the proportionality of the carcass can be obtained by evaluation of the cuts as a percent of carcass weight. Table 6 depicts the changes in the percentage of each cut at each harvest group. The percentage of shortloin and chuck relative to carcass weight did not change across harvest groups. The percentage of rib responded in a quadratic fashion with the greatest percentage of rib at Harvest group 4. The percentage of sirloin, when tested against harvest group decreased in a linear fashion (P<.01). The proportion of the round decreased (P<.10) linearly at each harvest group. Thus the round made up 4.39% less of the total carcass weight at harvest group 5 compared to harvest group 1.

Implications

Recent serial slaughter trials (Gwartney, et al., 1996; Vieselmeyer, et al., 1996) involving cattle of known genotype have only focused on a two endpoint harvest model. Researchers assumed development of tissues was linear and did not quantify the accumulation of fat depots. This experiment provides a better understanding of the manner in which fat depots are developed. Further research is needed on the effects of carcass quality when manipulating the growth curve with exogenous agents, genetics as well as level of nutrition.

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Table 1. Harvest Data By Year

Harvest Group	Yr	Date	DOF	High Marbling EPD n	High Marbling EPD Avg EPD	High Marbling EPD Live Wt.	High Marbling EPD ADG lb	Low Marbling EPD n	Low Marbling EPD Ave. EPD	Low Marbling EPD Live Wt.	Low Marbling EPD ADG lb	SEM Live Wt.	SEM ADG
1	1	2/04/97	66	4	.22	861	3.34	4	-.19	869	4.25	8.5	.11
2	1	4/08/97	101	4	.22	1043	4.19	4	-.19	956	3.82	7.3	.14
3	1	6/03/97	157	4	.22	1160	3.56	4	-.19	1092	3.41	15.7	1.57
4	1	7/15/97	199	4	.16	1268	3.42	4	-.19	1289	3.49	13.0	.08
5	1	9/02/97	248	4	.23	1411	3.26	4	-.19	1284	2.84	18.3	.12
1	2	2/10/98	48	4	.30	804	3.54	4	.02	814	3.30	20.7	.15
2	2	3/10/98	76	4	.23	932	3.55	4	.02	921	3.44	29.2	.17
3	2	4/28/98	125	5	.30	1056	3.00	5	-.01	1051	2.95	9.2	.07
4	2	6/16/98	174	5	.25	1221	3.54	4	-.02	1281	3.49	24.7	.21
5	2	9/02/98	252	5	.30	1341	2.76	5	-.10	1296	2.55	24.3	.09

Table 2. Carcass Data by Harvest Group – Combined Years 1 & 2

	1	2	3	4	5	SEM	Contrasts Linear	Contrasts Quad
Hot Carcass Wt, lbs.	459	542	652	778	840	6.9	.0001	NS
Back fat, in	.19	.26	.37	.56	.75	.02	.0001	.02
Ribeye, in^2	9.1	9.7	10.7	11.7	11.5	.16	.0001	NS
KPH, %	2.1	2.6	3.1	3.8	4.7	.09	.0001	.02
Yield Grade	2.2	2.6	3.1	3.8	4.7	.09	.0001	.02
Marbling Score	412	453	544	636	712	9.8	.0001	NS
12^{th} Rib lipid Content, %	2.57	3.65	5.02	6.50	8.44	.24	.0001	NS

Table 3. Carcass Data by Marbling Group – Year 1 & 2 Combined

	High	Low	SEM	P ≤
Hot Carcass Wt, lb	657	651	9.8	.39
Back fat, in	.41	.44	.03	.58
Ribeye Area, in^2	10.4	10.7	.22	.31
KPH, %	3.0	3.1	.11	.05
Yield Grade	3.3	3.3	.12	.73
Marbling Score	557	545	14.0	.5
% 12^{th} Ribfat	4.21	4.74	.34	.15

Table 4. Composition Data by Harvest Group – Combined Years 1 & 2

Percent Carcass							Contrasts	
Componet	1	2	3	4	5	SEM	Linear	Quad
Fat	17.7	22.6	28.1	30.3	34.0	.99	.0001	.06
Protein	14.5	13.9	12.6	12.0	11.6	.27	.0001	NS
Water	51.3	48.0	43.9	42.3	40.1	.70	.0001	.03
Bone	16.4	15.4	15.4	15.3	14.3	.22	.0001	NS

Table 5. Intramuscular Fat Content at 12^{th} Rib by Year and Marbling Group

	Year		
EPD Group	1	2	Mean (Combined Years)
High	6.5^{ac}	4.2^{bc}	5.35^{c}
Low	5.5^{ad}	4.7^{ac}	5.12^{c}

Year Effect: ^{a,b}means without common superscripts differ (P<.10)
EPD Effect: ^{c,d}means without common superscripts differ (P<.10)

Table 6. Percent Primal Cut Weight for the 5 High Priced Cuts for Harvest Group – Combined Year 1 & 2

	1	2	3	4	5		Contrasts	
	% weight of fabricated side (lbs.)					SEM	Linear	Quad
Rib	9.08	9.29	9.70	9.80	9.49	.22	.01	.02
Shortloin	6.28	5.96	5.90	5.58	6.10	.21	.09	.01
Sirloin	7.98	7.40	7.57	7.22	7.26	.21	.003	NS
Round	27.00	25.96	24.08	23.65	22.61	.31	.0001	.08
Chuck	26.04	26.35	26.30	26.07	26.26	.35	NS	NS
% Middle Meat	23.35	22.65	23.18	22.62	22.86	.31	.10	NS

Figure 1. Percent Intramuscular Fat and Hot Carcass Wt.

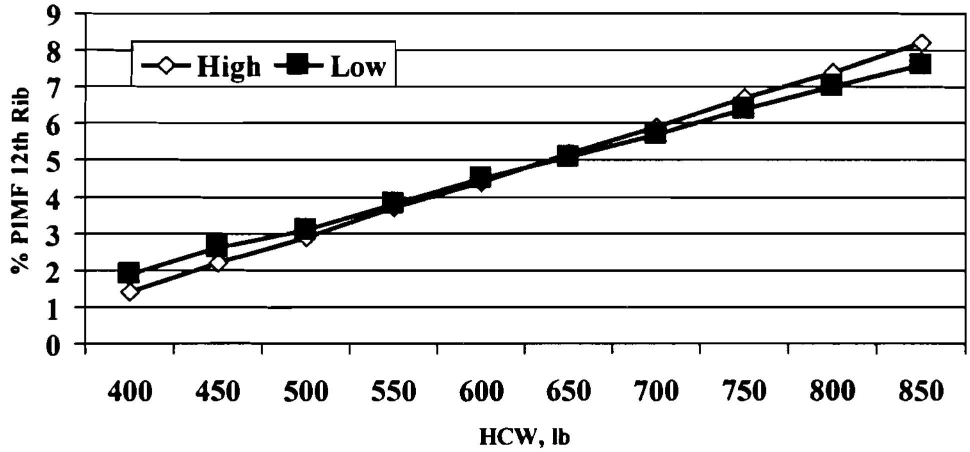

Figure 2. Accretion of Carcass Fat and PIMF 12th Rib