E49

LIPOGENESIS, ADIPOSE TISSUE CELLULARITY AND DNA SYNTHESIS IN INTRAMUSCULAR AND SUBCUTANEOUS ADIPOSE TISSUES OF CALF- AND YEARLING-FED CLONED STEERS

A. A. BROCK, A. M. PAGE, J. J. HARRIS, D. K. LUNT, J. W. SAVELL, W. L. MIES, AND S. B. SMITH
Department of Animal Science, Texas A&M University, College Station, TX 77843-2471 USA.

INTRODUCTION

In the U.S., producers lose approximately $200 per steer or heifer due to the production of excess fat, and $30 per animal due to the inadequate production of marbling or other meat quality problems (Smith, 1992; Lorenzen et al., 1993). Whereas USDA yield grade has remained essentially unchanged over the last 20 years, there has been a substantial reduction in beef carcass quality during the same period. The decrease in marbling may be explained, at least in part, by more cattle being fed as calves rather than the more traditional yearling-feeding. However, there is little agreement in the literature concerning the impact of feeding calves versus yearlings on the deposition of marbling, particularly at the cellular level. Therefore, the objective of this study was to investigate the effects of time on feed and age on the genetic programming of subcutaneous and intramuscular (marbling) adipocyte proliferation and metabolism.

MATERIALS AND METHODS

Two groups of Brangus steers created by nuclear transplantation cloning were used in these experiments. The first group (n = 8) was calf- or yearling-fed to a constant age endpoint (Exp. 1). The second group (n = 10) was calf- or yearling-fed to a constant live weight endpoint (Exp. 2).

Experiment 1. Steers were assigned randomly at weaning (8 mo of age) to calf- or yearling-feeding (n = 4 per treatment). The calf-fed steers (CF) were started on a high energy finishing diet immediately after weaning, and the yearling-fed (YF) steers were allowed to graze bermuda grass pasture for 123 d before starting the feeding period. Both treatment groups were fed to an age constant endpoint of 16 mo, selected to allow sufficient time for the YF steers to spend approximately 120 d on pasture followed by approximately 100 d on feed. The CF and YF steers in Exp. 1 were fed for 217 and 93 d, respectively.

Experiment 2. The steers for this phase (n = 10) were assigned randomly at weaning (eight months of age) to the CF or YF treatments (n = 5 per treatment). The CF steers were placed on feed at weaning, while the YF steers were allowed to graze native central Texas pasture and(or) short oats for 120 d before beginning the feeding period (same diets as Exp. 1). Both treatment groups were fed to a constant live weight endpoint of approximately 530 kg. Actual time on feed for the CF and YF steers in Exp. 2 was 224 and 182 d, respectively. Thus, YF steers in Exp. 2 were approximately 80 d older than CF steers at slaughter.

At the end of the feeding period, all steers were processed at the Rosenthal Meat Science and Technology Center at Texas A&M University. Immediately after exsanguination, the 2nd to 6th lumbar region of the loin was removed; from this, overlying subcutaneous (s.c.) and intramuscular (i.m.) adipose tissues were dissected and used for the measurement of lipogenesis, DNA synthesis, and cellularity. Lipogenesis was measured as [1-^{14}C]acetate incorporation into total lipids during a 2-h incubation in vitro. DNA synthesis was measured as the incorporation of [methyl-^{3}H]thymidine into DNA during the last 24 h of a 36-h explant culture. Adipocyte cellularity was measured by and urea liberation of osmium-fixed adipocytes. All procedures are described in detail by May et al. (1994)

RESULTS

Experiment 1. Intramuscular fat has been recognized as a later-developing fat depot, and calf-fed cattle have been thought not to have sufficient maturity for accelerated marbling deposition. When slaughtered at the same age (Exp. 1), CF carcasses had higher ($P < .05$) marbling scores than did the YF carcasses (Table 1), due to differences in fatness and time-on-feed. In spite of the difference in fatness, s.c. and i.m. adipocyte cell diameter and number of adipocytes/100 mg adipose tissue (i.e., cell densisty) were the same in CF and YF steers. This indicates that age of the steers was more important in determining adipocyte size and density than overall carcass fatness.

As is typical in beef cattle (May et al., 1994), lipogenesis in vitro was greater in s.c. than in i.m. adipose tissue (Table 1). Although CF steers had more s.c. and i.m. carcass fat when raised to a constant age, lipid synthesis in vitro was not greater ($P > .05$) in s.c. and i.m. adipose tissues from CF steers than in adipose tissues from YF steers. There was signicantly more [^{3}H]thymidine incorporated into DNA in the YF steers, suggesting greater rates of adipocyte proliferation (May et al., 1994). However, DNA synthesis was high in both CF and YF steers, indicating that both groups were actively adding new cells to both their s.c. and i.m. depots.

Table 1. Carcass and biochemical characteristics of subcutaneous and intramuscular adipose tissues from calf-fed and yearling-fed steers (Exps. 1 and 2 combined)

	Constant age		Constant weight	
Tissue/item	Calf-fed	Yearling-fed	Calf-fed	Yearling-fed
Subcutaneous				
Adjusted fat thickness, mm	18.0[a]	8.6[b]	18.9[a]	15.7[a]
Adipocytes/100 mg, (x 10^{-5})	.63	.58	.79	.49
Mean adipocyte diameter, µm	52.0[a]	55.4[a]	39.7[b]	56.1[a]
Lipogenesis, nmol/10^5 cells	472[a]	1386[a]	212[b]	52[c]
Elongase, pmol/mg protein	ND	ND	89.1[a]	112.4[a]
Desaturase, pmol/mg protein	ND	ND	.49[a]	.22[b]
[^{3}H]thymidine, dpm/10^5 cells	5205[b]	7639[a]	869[c]	50[d]
Intramuscular				
Marbling score	453[a]	340[b]	490[a]	462[a]
Cells/100 mg, (x 10^{-5})	2.49[a]	3.46[a]	.74[b]	.59[b]
Mean diameter, µm	47.3[a,b]	45.3[a,b]	38.1[b]	49.5[a]
Lipogenesis, nmol/10^5 cells	42[a]	60[a]	23[b]	17[b]
Elongase, pmol/mg protein	ND	ND	40.9[a]	98.3[b]
Desaturase, pmol/mg protein	ND	ND	.28[a]	.09[b]
[^{3}H]thymidine, dpm/10^5 cells	1845[b]	3367[a]	297[c]	24[d]

[a,b,c,d]Means within the same row lacking a common superscript differ ($P < .05$). ND = not determined.

Experiment 2. Adjusted fat thickness and marbling score did not differ between CF and YF steers when raised to a constant weight (Table 1). However, s.c. and i.m. adipocytes were smaller, and there were more adipocytes/100 mg adipose tissue in CF than in YF steers. This is consistent with the younger age of the CF steers. By the time of slaughter, the adipose tissues from the steers in Exp. 2 exhibited very low rates of lipogenesis and [^{3}H]thymidine incorporation into DNA, indicating that these tissues were approaching a terminal stage in their physiological maturity. This was especially true in the older, YF steers.

The activities of the fatty acid elongase and desaturase enzyme systems were measured in Expt. 2, as these typically indicate overall rates of lipogenesis and/or adipocyte differentiation (St. John et al., 1991; Cameron et al., 1994). Elongase activity tended to be higher in adipose tissues from YF steers (Table 1). However, consistent with the lesser lipogenesis and [^{3}H]thymidine incorporation into DNA, desaturase activity was higher in s.c. and i.m. adipose tissues from CF steers.

CONCLUSIONS

Data presented in this study indicate that animal age at feeding is more important than feeding regimen in determining specific measurements of adiposity such as mean adipocyte diameter or adipocytes/100 mg adipose tissue. However, for overall fatness (both in s.c. and in i.m. adipose tissues), dietary influences had a greater effect than age of animal. From a practical standpoint, therefore, production practices such as calf- versus yearling-feeding will not markedly alter carcass composition if the animals are raised to a consistent carcass endpoint.

REFERENCES

Cameron, P. J., M. Rogers, J. Oman, S. G. May, D. K. Lunt, and S. B. Smith. 1994. Stearoyl coenzyme A desaturase enzyme activity and mRNA levels are not different in subcutaneous adipose tissue from Angus and American Wagyu steers. J. Anim. Sci. 72:2624.

Lorenzen, C. L., D. S. Hale, D. B. Griffin, J. W. Savell, K. E. Belk, T. L. Frederick, M. F. Miller, T. H. Montgomery, and G. C. Smith. 1993. National Beef Quality Audit: Survey of producer-related defects and carcass quality and quantity attributes. J. Anim. Sci. 71:1495.

May, S. G., J. W. Savell, D. K. Lunt, J. J. Wilson, J. C. Laurenz, and S. B. Smith. 1994. Evidence for preadipocyte proliferation during culture of subcutaneous and intramuscular adipose tissues from Angus and Wagyu crossbred steers. J. Anim. Sci. 72:3110.

Smith, G. C., J. W. Savell, R. P. Clayton, T. G. Field, D. B. Griffin, D. S. Hale, M. F. Miller, T. H. Montgomery, J. B. Morgan, J. D. Tatum, and J. W. Wise. 1992. Improving the consistency and competitiveness of beef – A blueprint for total quality management in the fed-beef industry. The final report of the National Beef Quality Audit – 1991.

St. John, L. C., Lunt, D. K., and Smith, S. B. 1991. Fatty acid elongation and desaturation enzyme activities of bovine liver and subcutaneous adipose tissue microsomes. J. Anim. Sci. 69:1064.