

ANSC/FSTC 607
Physiology and Biochemistry of Muscle as a Food
β-ADRENERGIC AGONISTS, GENETICS, AND MEAT QUALITY

I. β-adrenergic agonists and meat quality

A. Structure of β-adrenergic agonists used in early studies or currently in animal production

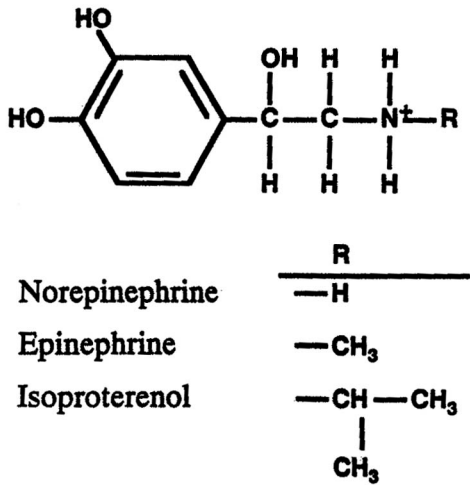


Figure 1. Structure of norepinephrine and analog.

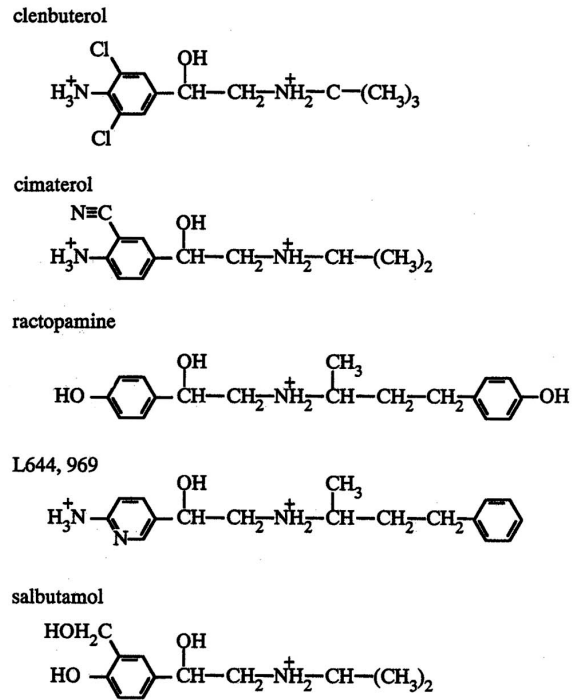
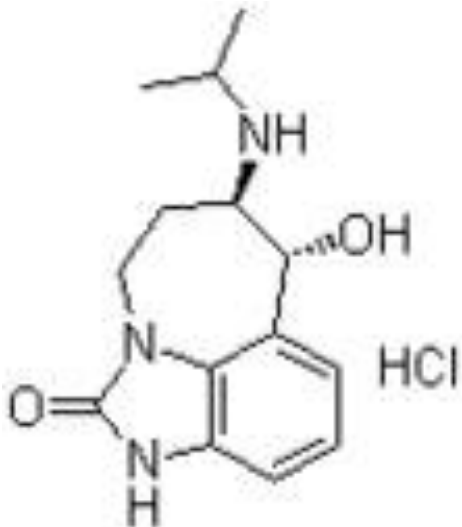


Figure 8. Structure of β-adrenergic agonists evaluated in livestock species.



Zilpaterol

[116x133 www.chemblink.com](http://www.chemblink.com)

B. β-Adrenergic agonists increase muscle mass.

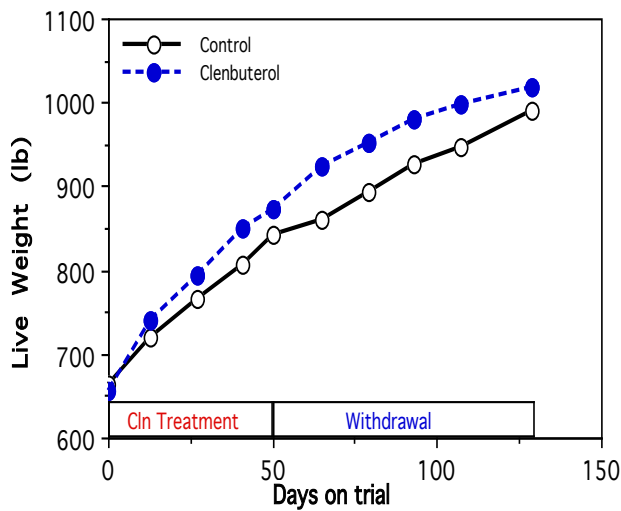
1. Type IIB (FG) fiber diameters always hypertrophy in response to treatment with clenbuterol, cimaterol, ractopamine, etc.
2. Other fiber types infrequently affected.

C. Marbling scores are depressed by treatment with β-adrenergic agonists.

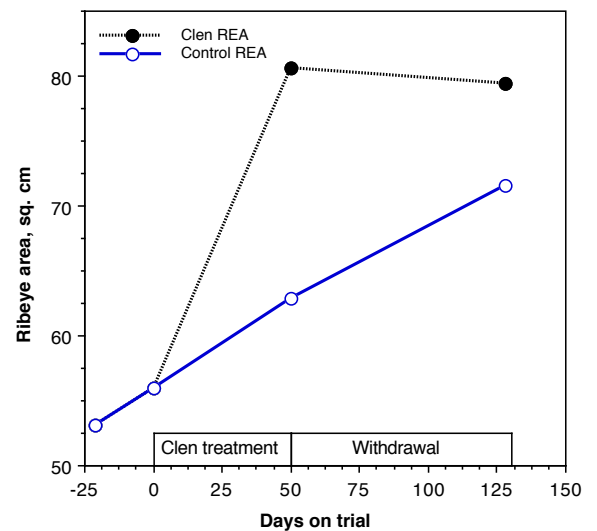
1. Cannot be reversed by extended withdrawal from treatment.
2. Results in the loss of one full quality grade.

D. Meat tenderness is decreased.

1. Cannot be reversed by extended withdrawal from treatment.
2. Cannot be reversed completely by CaCl₂ infusion.
3. There is little increase in myofibrillar fragmentation index, or decrease in Warner-Bratzler shear force, with aging of longissimus muscle from treated animals.



Changes in live weight in control Angus steers and in Angus steers fed clenbuterol for 50 d.



Changes in ribeye area in control Angus steers and in Angus steers fed clenbuterol for 50 d.

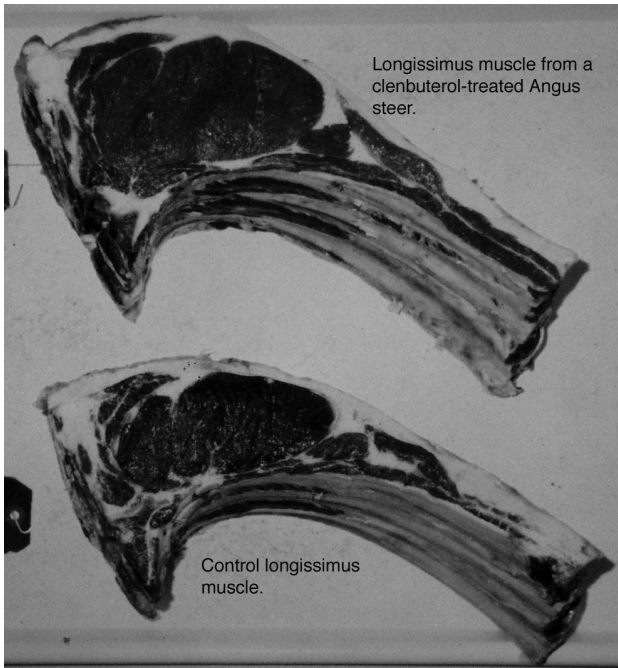
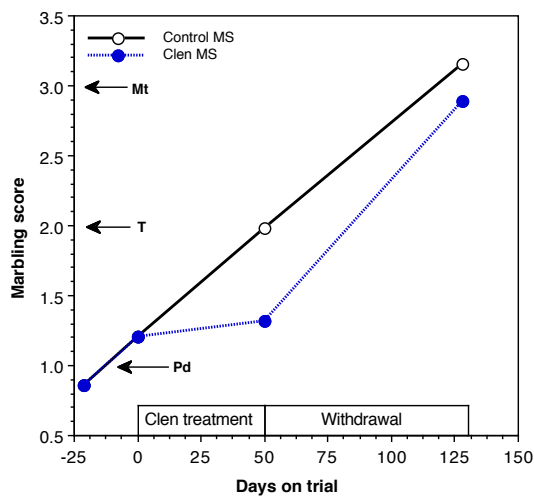


TABLE 6.6 EFFECT OF CIMATEROL ON MUSCLE FIBER TYPE COMPOSITION IN YOUNG FRIESIAN BULLS.

Fiber Type (%)	Control	Treated	% Change
Type 1	24.0	20.4	-15
Type 2A	24.2	8.6	-65
Type 2B	51.7	71.1	+38

Vestergaard *et al.* (1994) JAS 72:2298.



Changes in marbling score (MS) in control Angus steers and in Angus steers fed clenbuterol for 50 d.

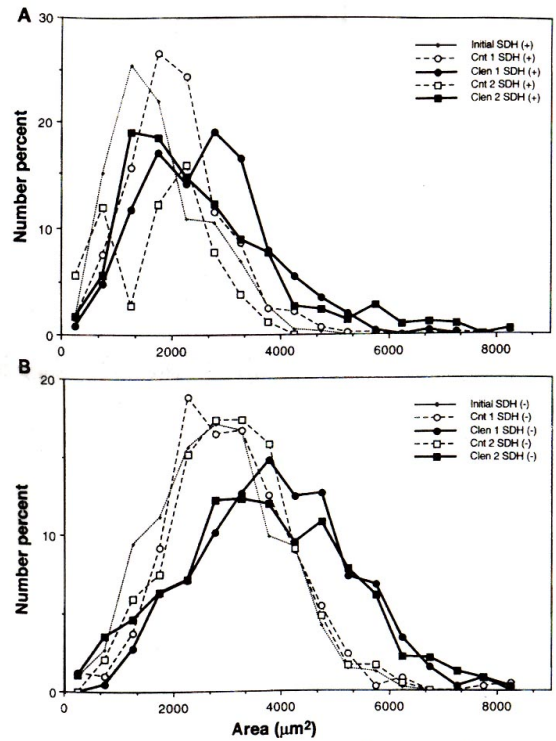
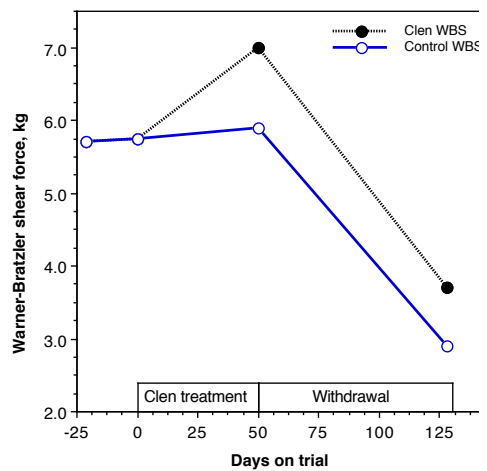


Fig. 5. Cross-sectional area distributions of longissimus dorsi myofibers from control and clenbuterol-treated steers. A: area distributions of succinic dehydrogenase-positive [SDH(+)] myofibers from initial group of steers; from control steers at 50 (Cnt 1) or 128 days (Cnt 2) on trial, and from steers treated with clenbuterol for 50 days (Clen 1) or after 78 days withdrawal (Clen 2). B: area distributions of SDH-negative [SDH(-)] myofibers. Each data point represents mean for 8 animals/treatment and time period.

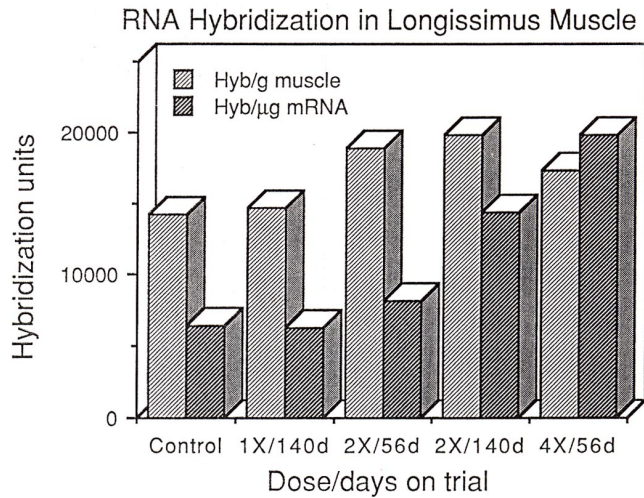
Clenbuterol increases the cross-sectional area and proportion of type IIB muscle fibers.



Changes in Warner-Bratzler shear force (WBS) in control Angus steers and in Angus steers fed clenbuterol for 50 d.

II. Mechanisms

- A. Myofibrillar protein synthesis increased (should have no effect on tenderness).
- B. μ-Calpain and m-calpain activities increased slightly. (Less autolysis?)
- C. Calpastatin activity is doubled.



Expression of myosin light chain-1 in longissimus muscle of steers fed ractopamine at different concentrations and durations.

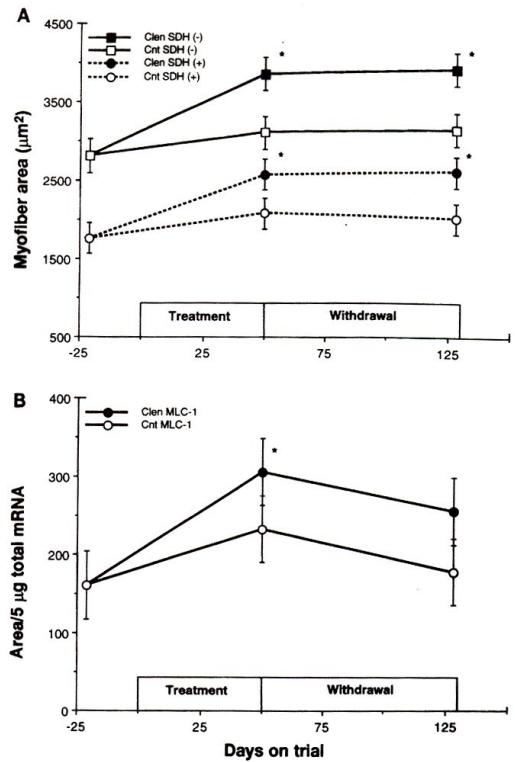
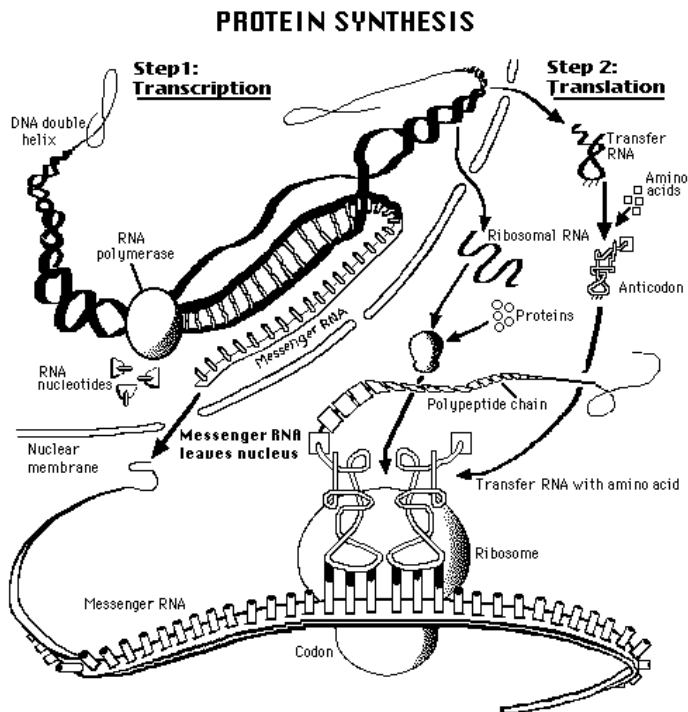


Fig. 6. Changes in longissimus dorsi myofiber cross-sectional areas and MLC-1_f mRNA amount of control and clenbuterol-treated steers. **A:** each data point represents mean for 8 animals/treatment and time period for SDH-positive and -negative fibers. Vertical bars, SE for each myofiber type, averaged across treatment and time period. **B:** mean laser densitometric areas of slot blots of 5 μg total RNA from bovine longissimus dorsi muscle hybridized to bovine MLC-1_f cDNA clone. Each data point represents mean for 7 animals in initial group and 8 animals per subsequent treatment and time period. Vertical bars, SE, averaged across treatment and time period. Control (Cnt MLC-1) and clenbuterol (Clen MLC-1) groups were compared with initial group with two-tailed Student's *t*-test; **P* < 0.05.



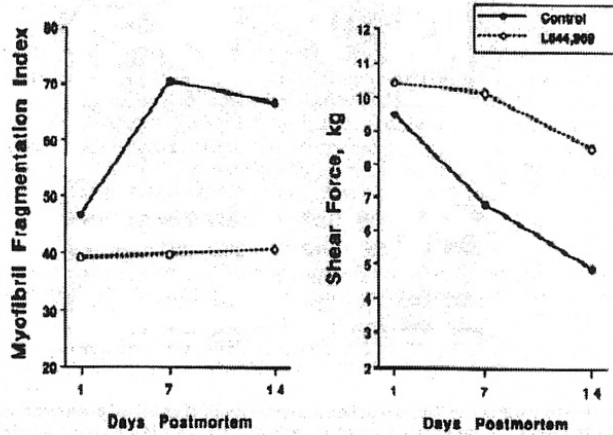


Figure 1. Effects of postmortem storage and β-adrenergic agonist (L-644,969) feeding on the shear force and myofibril fragmentation index (MFI) of longissimus muscle in wether lambs. The SE of the interaction were .8 and 2.9 for shear force and MFI, respectively.

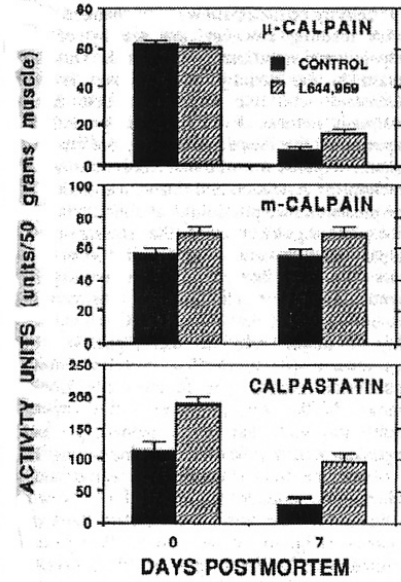
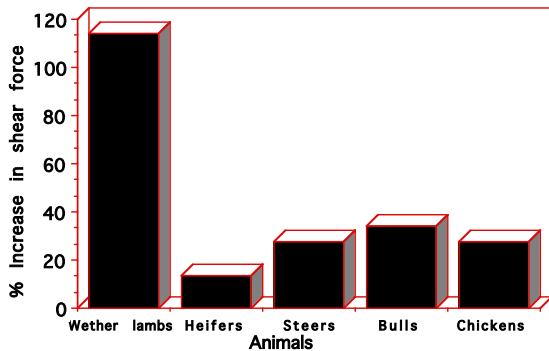
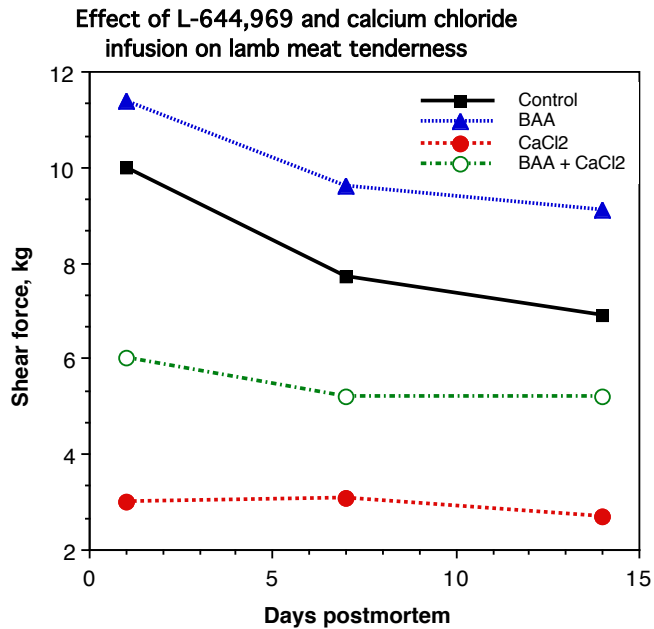


Figure 3. The μ-calpain, m-calpain, and calpastatin activity (total activity/50 g of muscle) isolated from longissimus muscle of control and β-adrenergic agonist (L-644,969)-fed lambs immediately after slaughter (d 0) and after 7 d of postmortem storage.



Effects of β-adrenergic agonists on shear force values of meat from wether lambs, heifers, steers, bulls and chickens. Data are expressed as percentage change from control for clenbuterol-fed lambs, heifers and steers and cimaterol-fed bulls and chickens. Significant increases in shear force were observed in all experiments.



Calcium chloride infusion reduces shear force in control and β-adrenergic agonist-fed sheep.

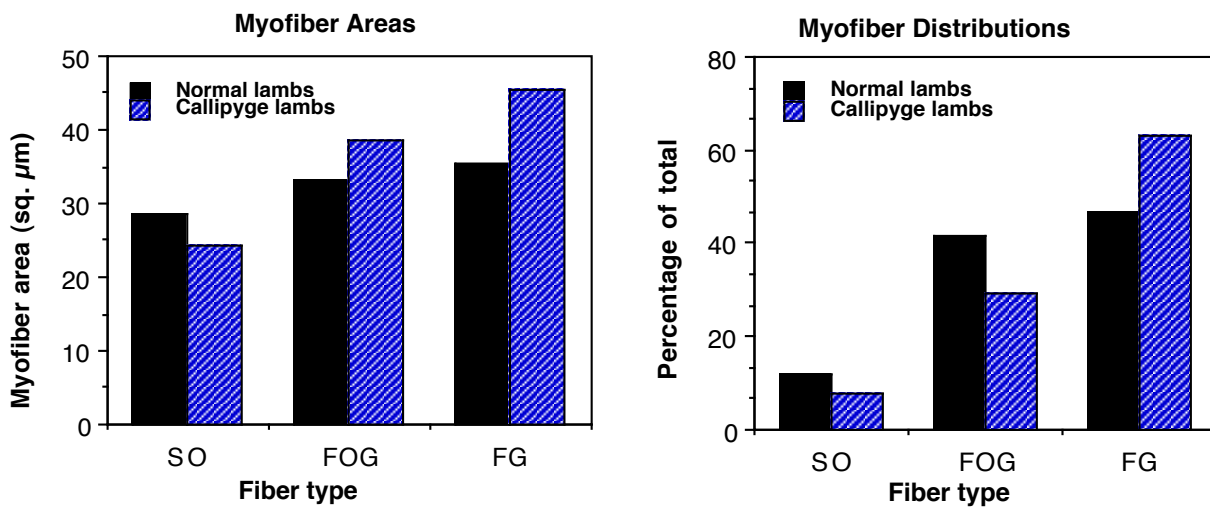
III. Effect of Callipyge genotype on meat quality

A. Callipyge lambs exhibit extreme muscle hypertrophy.

1. Type IIA and IIB fibers are larger, type I fibers smaller in Callipyge lambs.
2. The percentage of type IIB fibers is greater, and that of type IIA and I fibers less, in callipyge lambs.

B. Meat tenderness is decreased by the Callipyge genotype.

1. Shear force values of Callipyge longissimus muscle exceeds 10 kg.
2. There is little increase in myofibrillar fragmentation index, or decrease in Warner-Bratzler shear force, with aging of Callipyge longissimus muscle.

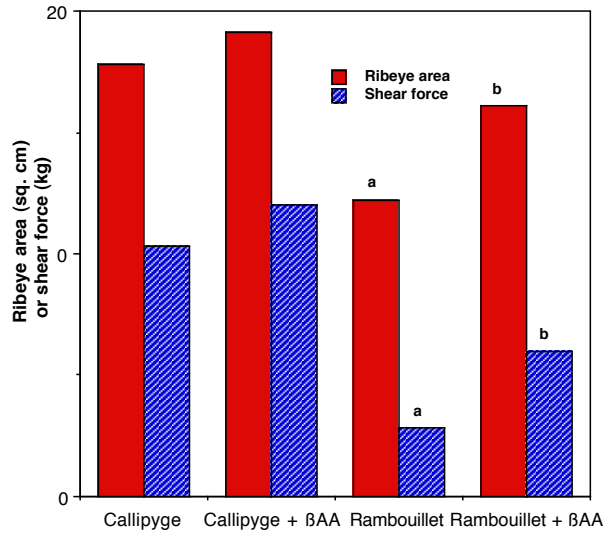
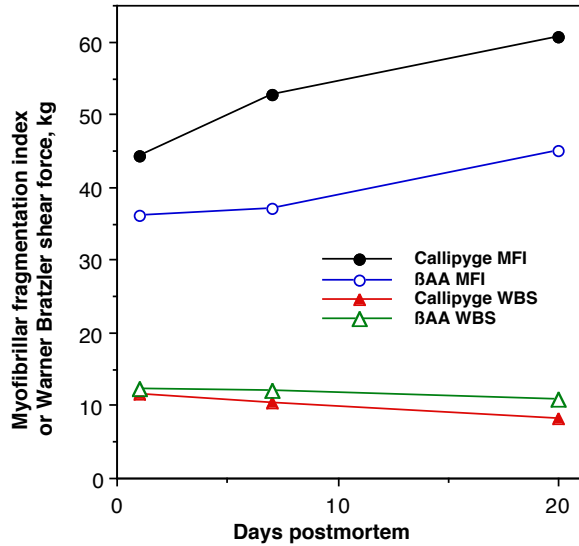


IV. Combined effects of β -adrenergic agonists and the Callipyge phenotype

A. β -Adrenergic agonist treatment of Callipyge lambs caused no significant increase in ribeye area or shear force.

B. Myofibrillar fragmentation index was decreased in Callipyge lambs treated with a β -adrenergic agonist.

C. In general, the results indicated that muscle hypertrophy (and toughness!) is at its genetic maximum in Callipyge lambs.



IV. Influence of *Bos indicus* genetics

- A. *Bos taurus* beef typically is more tender than *Bos indicus* beef.
- B. Shear force in *Bos indicus* beef never decreases to levels seen in *Bos taurus* beef with postmortem aging.
- C. Meat tenderness
 - 1. Brahman beef starts out tougher and stays tougher than Hereford beef.
 - 2. There is much less fragmentation of fibers in Brahman samples than in Hereford samples after 14 d of aging.
- D. The primary difference between breed types is in calpastatin activity.
 - a. The μ-calpain (CDP-I) activity initially is greater in meat from Hereford steers.
 - b. The inhibitor, calpastatin, initially is higher in meat from Brahman steers.
 - c. Both contribute to less protein turnover in Brahman beef.

TABLE 2. MEAN VALUES FOR ACTIVITY OF COMPONENTS OF THE CALCIUM-DEPENDENT PROTEASE SYSTEM BY BREED ASSAYED IMMEDIATELY OR AT 1 DAY POSTMORTEM^a

Component ^b	0 d ^c		1 d	
	Hereford ^c	Brahman	Hereford	Brahman
CDP-I	95.0 ^f ± 9.5	50.2 ^g ± 8.9	56.8 ^h ± 6.9	71.2 ^h ± 7.7
CDP-II	72.5 ± 5.2	77.6 ± 4.7	66.7 ± 6.3	73.8 ± 4.8
Inhibitor	185.3 ^g ± 14.4	240.3 ^f ± 20.6	121.7 ^h ± 13.4	129.6 ^h ± 15.5

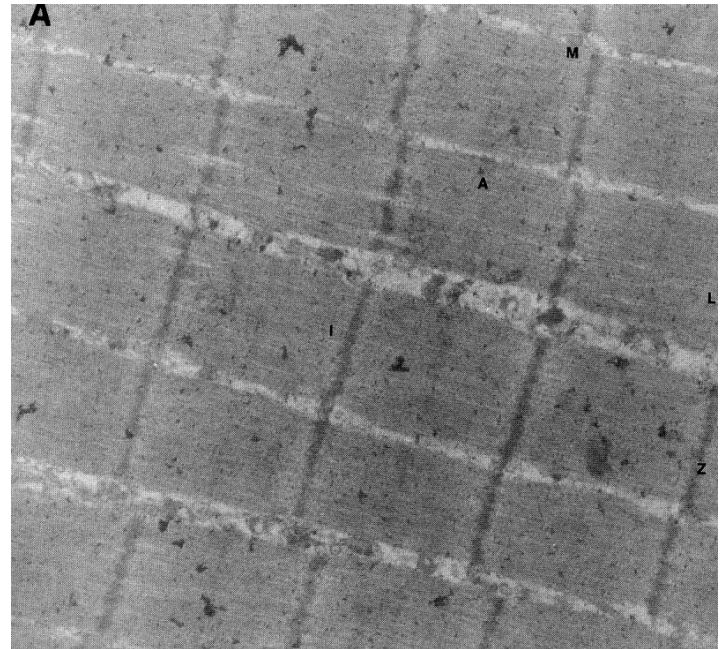
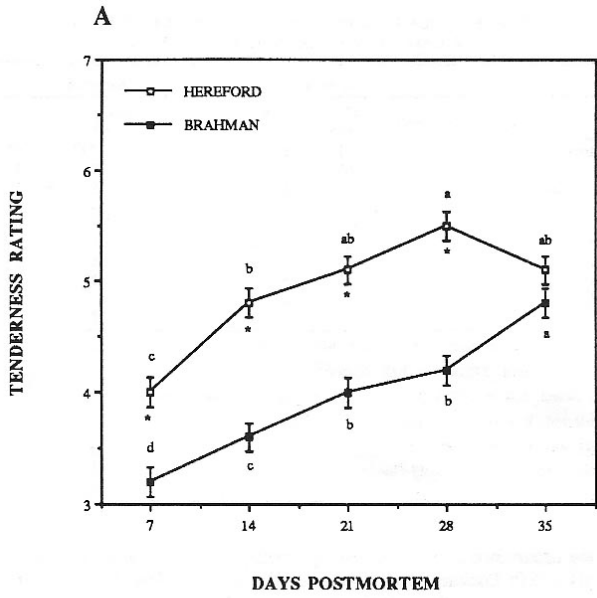
^aActivity = total A₂₇₈/100 g muscle.

^bCDP I = μm calcium-requiring form of protease; CDP II = mM calcium-requiring form of protease.

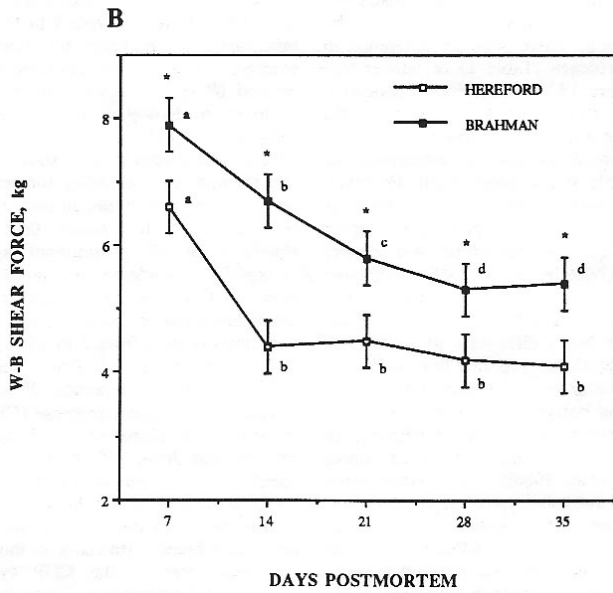
^cTen min postmortem.

^{f,g}Means in a row, within day, with a common or no superscript are not different (*P* > .05).

^hMeans for 1 d postmortem are different (*P* < .05) from 0 d, regardless of breed.



Transmission electron micrograph of myofibrils from 14-d aged Brahman longissimus muscle.



Transmission electron micrograph of myofibrils from 14-d aged Hereford longissimus muscle.

Tenderness ratings and Warner-Bratzler shear force values for Brahman and Hereford longissimus muscle.