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THERMAL SHRINKAGE TEMPERATURE OF INTRAMUSCULAR COLLAGEN OF BULLS AND STEERS^{1,2}

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Summary

The thermal shrinkage temperature (T_s) of bull muscle collagen was higher ($P < .01$) than that of steers when averaged over three slaughter ages of 12, 15 and 18 mo. Collagen T_s from bull muscles increased from 12 to 15 mo and decreased from 15 to 18 mo of age, whereas that of steer muscles did not change with age (age $\times$ sex interaction, $P < .01$). No breed effects (7/8 Charolais, 7/8 Simmental, Angus and Hereford) were detected nor were there breed $\times$ sex or breed $\times$ age interaction effects on collagen T_s . Carcass electrical stimulation did not affect collagen T_s in steer muscle, but there was a trend toward reduction of T_s in collagen of bull muscle.

(Key Words: Collagen Shrinkage, Bulls, Steers, Age, Breed, Electrical Stimulation.)

Introduction

Most of the research studies on the tenderness of bull meat have shown it to be slightly less tender and distinctly more variable in tenderness than meat from steers (Seideman et al., 1982). Bocard et al. (1979) reported that collagen solubility of bull muscles was greater than that of steers at 12 mo of age but decreased markedly between 12 and 16 mo of age;

tenderness of bull meat decreased between 8 and 16 mo of age, partially coinciding with the decrease in collagen solubility. Those studies were conducted on Afrikaner and Friesland cattle and the sex-associated differences in collagen solubility and tenderness were present in both breeds.

Judge and Aberle (1982) observed that the thermal shrinkage temperature (T_s) of bovine intramuscular collagen was relatively high in samples from relatively old cattle. Other experiments in our laboratories showed that collagen T_s could be lowered (Judge et al., 1981) and meat tenderness improved (Salm et al., 1981; Crouse et al., 1983) by carcass electrical stimulation of steers. However, the tenderization of bull carcasses by electrical stimulation was ineffective in the research of Crouse et al. (1983) but effective when performed by Riley et al. (1983).

Regardless of whether the cited differences in collagen T_s were due to animal age or electrical stimulation, it is likely that the total number and/or number of heat-stable intermolecular cross-links in the collagen directly influence the heat stability of collagen fibrils. Consequently the observed sex differences in meat tenderness, collagen solubility and response to carcass electrical stimulation may relate to collagen cross-linking and/or T_s .

The objective of this study was to compare the T_s of intramuscular collagen of bulls and steers and to determine the influences, if any, of breed, age and carcass electrical stimulation.

Experimental Procedure

Forty bulls and 44 steers of four breeds (7/8 Charolais, 7/8 Simmental, Angus and Hereford) were used in this study. At 5 mo of age they were placed on a diet of 78% corn silage (IFN

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3-08-153), 10% corn (IFN 4-02-931) and 12% supplement. Diets varied as animals matured, with the final diet being 42.7% corn silage, 54.1% corn and 3.2% supplement.

The cattle were assigned randomly within each breed and sex to one of three groups to be slaughtered at 12, 15 or 18 mo of age. Within 1 h postmortem, the right side of each carcass was electrically stimulated. The stimulation consisted of 17 impluses at 550 V (AC), 2 to 2.5 A and 60 Hz for a 1.8-s duration with a 1.8-s pause between impluses. A single probe was inserted in the muscles between the scapula and the thoracic vertebrae and the carcasses were grounded through the rail.

Immediately after electrical stimulation, longissimus muscle samples were obtained from the second to third lumbar region of both carcass sides. The samples were frozen in liquid N₂ after removal of the epimysial connective tissue and stored at -25 C for as long as 4 wk.

The frozen samples were subjected to the connective tissue isolation procedure of McClain (1969) and the collagen T_s was determined with a thermal analyzer equipped with a differential scanning calorimeter cell (Judge et al., 1981).

Carcass grade and palatability data were collected and reported by Cross et al. (1984).

The data were subjected to the Harvey (1960) least-squares analysis. The effects of sex, breed, age, electrical stimulation, all possible two-factor interactions and specific three-factor interactions were determined.

Results and Discussion

Collagen from bull muscles shrunk (i.e., underwent endothermic transition) at higher temperatures than that of steers ($P < .01$; tables 1 and 2). The mean T_s for the steers was similar to the value reported earlier for 16-mo-old steers and heifers, but the mean for bulls was very close to that of aged cows (Judge and Aberle, 1982). Because the cross-linking of collagen is known to occur with advancing age (Goll et al., 1964), it is possible that the higher T_s of bull muscle collagen was caused by an accelerated rate of collagen maturation in bulls as compared with steers. Research reviewed by Hall (1976) suggests that the synthesis and tensile strength of collagen may be increased by anabolic steroids such as testosterone.

The breeds used in this study did not differ in T_s of intramuscular collagen nor was there a breed × sex, breed × age or breed × sex × age interaction even though both early and late maturing breeds were utilized in the study (tables 1 and 2). Assuming that T_s value partially reflects collagen solubility, these results do not support the findings of Boccard et al. (1979), which indicated that late maturing Afrikaner bulls and steers had higher muscle collagen solubility than Friesland bulls and steers at 12 to 24 mo of age.

Overall age differences in collagen T_s were noted, suggesting that the stability of the collagen was greatest at 15 mo of age ($P < .10$; tables 1 and 2). However, sex × age interaction effects indicate that only the bull muscle

TABLE 1. LEAST-SQUARES ANALYSIS OF VARIANCE FOR COLLAGEN THERMAL SHRINKAGE TEMPERATURE

Source	df	F	P
Breed ^a (B)	3	.1	.936
Sex ^b (S)	1	36.9	.000
B × S	3	.8	.478
Age ^c (A)	2	2.9	.063
B × A	6	1.0	.368
S × A	2	12.6	.000
B × S × A	6	.7	.623
Electrical stimulation (ES)	1	2.4	.13
B × ES	3	.0	.994
S × ES	1	4.3	.007
A × ES	2	1.5	.239

^a7/8 Charolais, 7/8 Simmental, Angus, Hereford.

^bBulls, steers.

^c12, 15, 18 mo.

TABLE 2. COLLAGEN THERMAL SHRINKAGE TEMPERATURE (C)

Group	No.	Mean	SE ^a
Sex**			
Bulls	40	70.2	.12
Steers	44	69.0	.11
Breed			
7/8 Charolais	17	69.7	.18
7/8 Simmental	24	69.6	.15
Angus	21	69.6	.16
Hereford	22	69.6	.16
Electrical stimulation			
ES	84	69.5	.11
Control	84	69.7	.11
Age*			
12 mo	28	69.4	.14
15 mo	28	69.9	.14
18 mo	28	69.5	.14
Sex X age**			
Bulls - 12 mo	14	69.6	.20
Bulls - 15 mo	13	71.2	.21
Bulls - 18 mo	13	69.8	.21
Steers - 12 mo	14	69.2	.20
Steers - 15 mo	15	68.7	.19
Steers - 18 mo	15	69.2	.19
Sex X ES**			
Bulls - ES	40	69.9	.17
Bulls - control	40	70.4	.17
Steers - ES	44	69.1	.16
Steers - control	44	69.0	.16

^aStandard error of least-squares mean.

*P<.10.

**P<.01.

collagen underwent an increase followed by a decrease in T_s ($P<.01$). The decrease in collagen T_s from 15 to 18 mo of age might be interpreted to reflect an accelerated synthesis of new collagen, but no supporting evidence could be found for such synthesis in muscle from 15- to 18-mo-old bulls.

Carcass electrical stimulation did not affect collagen T_s in steer muscle and it only slightly reduced T_s in that of bulls ($P<.01$; tables 1 and 2). These results are in general agreement with previously reported research, which showed that collagen T_s is not affected by electrical stimulation of steer carcasses if they come from cattle fed high energy diets (Judge et al., 1981). The tendency for bull muscle collagen to shrink at a slightly lowered temperature after electrical stimulation suggests the need for further research on carcass electrical stimulation and muscle collagen of bulls. Information is needed on the role of androgenic hormones in maturation

of collagen and the consequences to meat tenderness.

Literature Cited

- Boccard, R. L., R. T. Naude, D. E. Cronje, M. C. Smith, H. J. Venter and E. J. Rossow. 1979. The influence of age, sex and breed of cattle on their muscle characteristics. *Meat Sci.* 3:261.
- Cross, H. R., J. D. Crouse and M. D. MacNeil. 1984. Influence of breed, sex, age and electrical stimulation on carcass and palatability traits of three bovine muscles. *J. Anim. Sci.* 58:1358.
- Crouse, J. D., S. C. Seideman and H. R. Cross. 1983. The effects of carcass electrical stimulation and cooler temperature on the quality and palatability of bull and steer beef. *J. Anim. Sci.* 56:81.
- Goll, D. E., W. G. Hoekstra and R. W. Bray. 1964. Age-associated changes in bovine muscle connective tissue. II. Exposure to increasing temperature. *J. Food Sci.* 29:615.
- Hall, D. A. 1976. *The Ageing of Connective Tissue*. Academic Press, New York.
- Harvey, W. R. 1960. Least-squares analysis of data

- with unequal subclass numbers. USDA, ARS 20:8.
- Judge, M. D. and E. D. Aberle. 1982. Effects of chronological age and postmortem aging on thermal shrinkage temperature of bovine intramuscular collagen. *J. Anim. Sci.* 54:68.
- Judge, M. D., E. S. Reeves and E. D. Aberle. 1981. Effect of electrical stimulation on thermal shrinkage temperature of bovine muscle collagen. *J. Anim. Sci.* 52:530.
- McClain, P. E. 1969. Isolation of intramuscular connective tissue. *Nature* 221:181.
- Riley, R. R., J. W. Savell, C. E. Murphey, G. C. Smith, D. M. Stiffler and H. R. Cross. 1983. Effects of electrical stimulation, subcutaneous fat thickness and masculinity traits on palatability of beef from young bull carcasses. *J. Anim. Sci.* 56:584.
- Salm, C. P., E. W. Mills, E. S. Reeves, M. D. Judge and E. D. Aberle. 1981. Effect of electrical stimulation on muscle characteristics of beef cattle fed a high energy diet for varying lengths of time. *J. Food Sci.* 46:1284.
- Seideman, S. C., H. R. Cross, R. R. Oltjen and B. D. Schanbacher. 1982. Utilization of the intact male for red meat production: A review. *J. Anim. Sci.* 55:826.