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Evaluation of attributes affecting tenderness differences between *Bos taurus* and *Bos indicus* cattle

Abstract

Biological tenderness differences between longissimus muscles from 3/8 and 5/8 Sahiwal (*Bos indicus*) x Hereford-Angus and from Hereford-Angus (*Bos taurus*) were evaluated. No significant breed cross effects were observed for carcass traits or rates of pH and temperature decline. Loin steaks from Hereford x Angus had lower ($P<.05$) shear-force values and higher ($P<.05$) taste panel tenderness scores at 1 and 14 d postmortem. No breed effects existed for muscle fiber sarcomere length, muscle fiber type, muscle collagen, cathepsin enzyme activity, or calcium-dependent protease-I and -II activity. However, calcium-dependent protease inhibitor activity at 24 hr postmortem was greater ($P<.01$) in Sahiwal-crosses than for Hereford-Angus. Less protein degradation, which causes tenderization during aging, occurred in Sahiwal-crosses by d 14 than in Hereford-Angus at d 1 postmortem. Therefore, mechanisms involving calcium-dependent protease and its inhibitor may be the principal factors causing tenderness differences between *Bos indicus* and *Bos taurus* breeds.

Keywords

Cattlemen's Day, 1990; Kansas Agricultural Experiment Station contribution; no. 90-361-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 592; Beef; Tenderness; *Bos indicus*; Calcium-dependent protease; Inhibitor

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K**S****EVALUATION OF ATTRIBUTES AFFECTING TENDERNESS
DIFFERENCES BETWEEN *BOS TAURUS*
AND *BOS INDICUS* CATTLE¹****U****G. Whipple², M. Koochmaraie², M. E. Dikeman,
J. D. Crouse², M. C. Hunt, and R. D. Klemm³**

Summary

Biological tenderness differences between longissimus muscles from 3/8 and 5/8 Sahiwal (*Bos indicus*) × Hereford-Angus and from Hereford-Angus (*Bos taurus*) were evaluated. No significant breed cross effects were observed for carcass traits or rates of pH and temperature decline. Loin steaks from Hereford × Angus had lower ($P < .05$) shear-force values and higher ($P < .05$) taste panel tenderness scores at 1 and 14 d postmortem. No breed effects existed for muscle fiber sarcomere length, muscle fiber type, muscle collagen, cathepsin enzyme activity, or calcium-dependent protease-I and -II activity. However, calcium-dependent protease inhibitor activity at 24 hr postmortem was greater ($P < .01$) in Sahiwal-crosses than for Hereford-Angus. Less protein degradation, which causes tenderization during aging, occurred in Sahiwal-crosses by d 14 than in Hereford-Angus at d 1 postmortem. Therefore, mechanisms involving calcium-dependent protease and its inhibitor may be the principal factors causing tenderness differences between *Bos indicus* and *Bos taurus* breeds.

(Key Words: Beef, Tenderness, *Bos indicus*, Calcium-dependent Protease, Inhibitor.)

Introduction

Bos indicus breeds are often used in crossbreeding programs, because they provide the maximum amount of hybrid vigor when crossed with *Bos taurus* breeds. However, meat from *Bos indicus* breeds is often less tender than meat from *Bos taurus* breeds. Since tenderness is a major palatability trait that determines consumer acceptability, it is important to understand what causes meat from these animals to be less tender.

Factors that influence meat tenderness may include USDA quality grade, postmortem rates of pH and temperature decline, muscle fiber sarcomere length and type, collagen content and solubility, and activity of proteases involved in postmortem tenderization (calcium-dependent proteases and cathepsins). Therefore, our objective was to examine all of these traits in an attempt to explain why meat from *Bos indicus* cattle is less tender than that from *Bos taurus*.

¹Conducted in cooperation with the USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska.

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Experimental Procedures

We utilized seven heifers and four steers that were 5/8 Sahiwal × 3/8 Hereford (H), Angus (A), or H × A, three heifers and three steers that were 3/8 Sahiwal, and five heifers and five steers that were H × A. Calves were weaned at 6 to 8 mo of age and fed an alfalfa haylage and corn silage diet for 4 mo. Cattle then were fed a corn and corn silage finishing diet until 15 to 17 mo of age. Cattle were selected randomly and slaughtered (three to four animals each week) for a 7-wk period. Within 1 hr postmortem, loin (longissimus) muscle samples were taken for early measurements of muscle pH and calcium-dependent protease (CDP)-I, CDP-II, and CDP inhibitor activities. At 24 hr and at 14 d postmortem, loin samples were taken to measure various biological traits (Table 14.1).

Table 14.1. Loin Muscle Traits Evaluated and Times of Measurement

Traits	Times of measurement, postmortem
Temperature and pH	0, 3, 6, 9, 12, and 24 hr
Warner-Bratzler shear force	1 and 14 d
Taste panel evaluation	1 and 14 d
Calcium dependent protease-I and -II and CDP inhibitor activities	0 and 24 hr
Cathepsin B and B+L activities	1 and 14 d
Muscle fiber sarcomere length	24 hr
Type and area of muscle fibers	24 hr
Soluble and total collagen	1 and 14 d
Free-water-soluble calcium	24 hr
Extent of protein degradation (gel electrophoresis)	0, 1, and 14 d

Results and Discussion

All breed crosses had similar ($P > .10$) USDA quality and yield grades, with averages of high Select and 3.2, respectively. Also, breed crosses had similar ($P > .05$) lean color; lean firmness; lean texture; maturity scores; dressing percentages; marbling scores; fat thicknesses; and percentages of kidney, pelvic, and heart fat. In our study, no marbling score differences were found among breed-crosses, although *Bos indicus* cattle typically have lower marbling scores. Our marbling scores were confirmed by chemical analysis of intramuscular fat.

Significant loin steak tenderness differences were found among breed-crosses (Table 14.2). H × A were more tender ($P < .05$) at both d 1 and d 14 than 5/8 and 3/8 Sahiwals, as revealed by Warner-Bratzler shear-force values. In addition, trained taste panelists scored H × A as being more tender ($P < .05$).

Of all biological traits measured, CDP inhibitor activity at 24 hr was the only trait to differ among breed-crosses (Table 14.2). The 5/8 and 3/8 Sahiwals had more CDP inhibitor activity at 24 hr postmortem than Hereford × Angus. Less protein degradation occurred during aging in Sahiwal-crosses than in H × A. Thus, the response to aging must be somehow related to the activity of CDP inhibitor. Because CDP is known to degrade muscle proteins, the mechanism for its effectiveness during aging must be different between breeds, whether it be

CDP inhibitor or other unknown protease(s). However, these results emphasize the importance of CDP and CDP inhibitor in relation to beef loin tenderness and show that further studies must be conducted to enhance our understanding of the mechanism(s) involved.

Table 14.2. Muscle Trait Least-squares Means by Breed-cross

Traits	Breed-cross		
	Hereford × Angus	3/8 Sahiwal	5/8 Sahiwal
Warner-Bratzler shear force, kg			
d 1	7.0 ^b	9.3 ^c	9.6 ^c
d 14	4.7 ^b	6.4 ^c	7.7 ^d
Taste-panel tenderness scores ^a			
d 1	4.6 ^b	3.6 ^c	3.6 ^d
d 14	5.9 ^b	5.0 ^c	4.4 ^d
Muscle fiber sarcomere length, μm	1.83	1.76	1.75
Free-water-soluble calcium content, $\mu\text{g/g}$	10.8	8.6	9.5
Soluble collagen, %			
d 1	13.6	14.1	14.2
d 14	16.7	14.1	16.5
Total collagen, mg/g			
d 1	2.9	2.6	2.8
d 2	3.1	2.7	3.0
Cathepsin B activity, pmole/g/min			
d 1	32.4	27.9	34.3
d 14	30.5	29.0	34.7
Cathepsin B+L activity, pmole/g/min			
d 1	41.7	38.3	44.4
d 14	41.5	41.0	46.6
Calcium-dependent protease-I activity/100 g muscle ^e			
0 hr	113	109	101
24 hr	35	45	35
Calcium-dependent protease-II activity/100 g muscle ^e			
0 hr	106	92	98
24 hr	109	116	110
Calcium-dependent protease inhibitor activity/ 100 g muscle ^f			
0 hr	398	351	366
24 hr	136 ^b	196 ^c	209 ^c

^aA score of 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough.

^{bcd}Numbers in a row with different superscripts differ ($P < .05$).

^eDefined as the units of enzyme catalyzing an increase of 1.0 absorbance unit.

^fDefined as the amount that inhibited 1.0 unit of purified CDP-II activity.