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Meat Tenderness and the Calpain Enzyme System in Young Bulls and Steers

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Introduction

Comparisons of meat palatability between bulls and steers have indicated that meat from young bulls is more variable in tenderness. In addition, meat from bulls is usually numerically less tender, although the difference is frequently not statistically significant. This indicates that meat from bulls is only slightly, but consistently less tender than meat from steers.

Numerous studies have attempted to link bull meat toughness to higher amounts and decreased solubility of connective tissue. However, it has been reported that this change in bull meat does not occur until 12 to 16 mo of age. It has been shown conclusively, using different species and a variety of conditions, that the calpain enzyme system (which occurs naturally in muscle) is responsible for a majority of the tenderization that occurs during aging of meat. The possible contribution of the calpain system to differences in postmortem tenderization of muscle from bulls and steers has not been reported. This study was conducted to examine the effect of castration on palatability traits and 24-hr postmortem activities of μ-calpain, m-calpain and calpastatin in loin muscle of cattle.

Procedure

Six each, MARC III composite (1/4 Red Poll, 1/4 Pinzgauer, 1/4 Hereford, and 1/4 Angus) bulls and steers weighing approximately 397 lb were given unrestricted access to a growing/finishing diet. Animals were fed until 16 mo of age and slaughtered according to standard humane procedures. Carcasses were chilled for 24 hr at 34°F in the holding cooler.

At 24 hr postmortem, the loin muscle was cut into 1-in thick steaks and vacuum packaged. Steaks to be used for shear force (a mechanical measure of tenderness), Myofibril Fragmentation Index (a measure of tenderness), and trained sensory panel evaluation were assigned to 1, 7, or 14 days postmortem aging at 35°F. The steaks were stored at -50°F for 2 to 4 wk until they were thawed and cooked. Also at 24 hr postmortem, a sample of loin muscle was taken from each carcass for determinations of μ-calpain, m-calpain, and calpastatin activities.

Results

Conflicting reports exist concerning differences in tenderness of meat from carcasses of intact and castrated animals. Some researchers have reported that meat from bull carcasses is tougher and less palatable than meat from steer carcasses, while others have been unable to detect significant differences in tenderness of meat from young bulls and steers slaughtered at comparable ages. Our data indicate that regardless of postmortem aging time, bull loin muscle steaks had higher shear force values (i.e., less tender meat) than muscle from steer carcasses (Table 1). Steaks from steer carcasses had approximately a 30% decrease in shear force values between 1 and 14 days of aging. However, shear force values for bull loin steaks decreased only 20% after 14 days of aging. Loin tenderness is highly and positively correlated with Myofibril Fragmentation Index (MFI). Loin muscle from steers had higher MFI values than bull muscle at 1 day and 7 days postmortem, but not at 14 days (Table 1), indicating a greater amount of tenderization had occurred earlier postmortem in muscle from steers.

Sensory panel ratings indicated that as postmortem aging time increased, loin muscle samples became more tender with less detectable connective tissue (Table 1). It was anticipated that since shear force values indicated that meat from bull carcasses was tougher than meat from steer carcasses, differences in sensory tenderness ratings would be detected. However, gender had little effect on sensory panel myofibrillar or overall tenderness ratings (Table 1). In several previous reports involving assessment of palatability between bull and steer loin samples, meat from bull carcasses was tougher as indicated by increased shear force values; however, in most cases, the difference was small and more than likely would not result in consumer objection. Additionally, juiciness and flavor intensity were not affected by gender or time postmortem (Table 1).

A convincing body of literature indicates that the calpain enzyme system plays a major role in postmortem tenderization. The muscle proteins degraded by calpain enzymes closely mimic changes in muscle observed under normal postmortem aging. Our study showed there were no differences due to gender in 24-hr μ-calpain or m-calpain activities (Table 2). These data are consistent with previous findings indicating no differences in 24-hr calpain activities between *Bos taurus* and *Bos indicus* breeds of cattle. Previous research has indicated that under typical postmortem conditions, m-calpain is very stable, whereas there is a decline in the activity of μ-calpain and calpastatin (calpain inhibitor).

Calpastatin activity was 45% greater in loin muscle from bulls at 24-hr postmortem (Table 2). These data agree with the results of several recent experiments that indicate calpastatin is probably a primary regulator of m-calpain in postmortem muscle. Furthermore, the postmortem activity of calpastatin is highly related to the rate and extent of postmortem tenderization in meat from *Bos indicus* breeds of cattle, in meat from animals fed a β-agonist and in meat from different species. In the present study, calpastatin activity of meat from bulls at 24 hr postmortem (2.41 units of activity) was similar to the 0 hr calpastatin values for steers (2.24 units of activity; data not shown). The greater calpastatin activity in bull loin muscle could have decreased the amount of muscle protein proteolysis by μ-calpain, resulting in less tender meat.

Collectively, available evidence indicates that bulls are slightly, but consistently, less tender than steers, although the difference is frequently not statistically significant. Our data indicate that the rate of tenderization was greater in steers, implying that tenderness differences due to castration may depend on the time postmortem of measurement. Thus, this tenderness difference may not be of practical importance. We slaughtered our animals at 12 mo, thus, collagen solubility would not explain the tenderness differ-

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ences we found. Furthermore, our data are consistent with the current hypothesis that higher calpastatin activity results in less tender meat due to decreased proteolysis by μ-calpain.

As previously reported, in tougher meat from *Bos indicus* breeds of cattle and animals fed β-agonists, the slightly tougher bull meat had higher calpastatin activity than meat from steers. These results support the theory that meat tenderness is inversely related to calpastatin activity. Calpastatin may regulate the activity of μ-calpain and in turn prevent muscle protein proteolysis and reduce ultimate meat tenderness. Research regarding meat tenderness and lean beef production systems should involve methods of manipulating the activity of the calpain inhibitor, calpastatin.

Table 1—Effects of postmortem aging time and gender on meat palatability traits

	1 day		7 days		14 days	
Trait	Bull	Steer	Bull	Steer	Bull	Steer
Shear force, lb	12.1[a]	11.2[b]	11.0[a]	9.3[b]	9.3[a]	7.5[b]
MFI[c]	22.0[b]	35.2[a]	53.5[b]	62.0[a]	72.6	73.2
Tenderness	4.0[b]	4.6[a]	4.7[b]	5.4[a]	6.2[b]	6.6[a]
Juiciness	5.2	5.1	5.1	4.9	5.1	5.2
Flavor intensity	4.6[b]	5.7[a]	5.4	5.7	5.8	5.9

[a b] Means in a row within aging time lacking a common superscript differ.

[c] Myofibril Fragmentation Index.

Table 2—Effect of gender on 24-hr calpain and calpastatin activities in loin muscle

Item	Bulls	Steers
μ-Calpain[a]	.29	.21
m-Calpain[b]	.80	.90
Calpastatin[c]	2.41[d]	1.33[e]

[a] Low calcium-requiring calpain.

[b] High calcium-requiring calpain.

[c] Inhibition of m-calpain.

[d e] Means within a row lacking a common superscript letter differ ($P < .05$).