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Palatability of Meat from Bull and Steer Carcasses

Castration of bulls has long been a traditional practice in the United States. Historically, castration has produced an animal more manageable and desirable for marketing. At present, production of intact males has gained attention because of consumer demands for lean meat. Generally, bulls grow more rapidly, have better feed efficiency, and produce higher-yielding carcasses with less fat and more muscle than steers. Major disadvantages with bull production include management problems due to temperament and lower U.S. Department of Agriculture (USDA) quality grade due to less marbling. Meat from bulls has also been observed to be darker in color and less tender. If these problems are resolved, the use of bulls for meat production may be adopted by the meat industry.

BACKGROUND

Consumption trends and consumer preference studies indicate current desires for a reduced level of fatness in animal products (1,2). Munro (3) observed that meat is a significant source of nutrients but that it would be more nutritious if the proportion of saturated fatty acids could be reduced. High levels of dietary fat have been associated with increased risks of some types of cancer (4) and cardiovascular disease (5). Fat is a concentrated source of caloric energy. However, in the present highly mechanized and relatively sedentary society of the developed countries, the need for calories to fuel daily activities is reduced from earlier periods when manual labor was more the norm (6). Thus, the reduction of fat in meat has received considerable attention. It is a major goal in the genetic improvement of livestock (7,8) and development of livestock production systems. The historical practice of castrating male calves that remains common in North America is apparently counter to this goal.

There have been several comprehensive reviews of the effect of castration on meat production in sheep, cattle, and pig, beginning in 1962 (9) up to (10,11) a few years ago (12). This survey reviews the advantages and disadvantages of utilizing young intact male cattle (bulls) for meat production, with emphasis on their carcass characteristics compared with castrates (steers). For further information, readers are referred to Northern Central Regional Research Publication 309 (13), which deals with recommendations for producing young bulls for meat production.

CURRENT STATUS

Carcass and Growth Characteristics

Carcasses of bulls have less intramuscular fat (marbling), less subcutaneous fat, and less fat surrounding the kidney and contain more protein per unit of weight than do carcasses of steers (14–23). However, steers have more subcutaneous fat at the twelfth rib than do bulls (14.3 mm versus 9.3 mm, respectively) (11). Field (11), citing 15 references, concluded that carcasses of bulls and steers represent a similar percentage of live weight (59.7% versus 59.6%, respectively).

Lower marbling scores associated with bull carcasses result in a lower USDA quality grade for these carcasses. This reduction in quality grade has resulted in strong resistance to bulls by packers because of existing price discrimination based on USDA quality grade. However, the greater protein content of bull carcasses translates into a greater yield of closely trimmed retail products than is obtained from steers (17,19,20). Jacobs et al. (17) further indicated that bull carcasses were worth approximately 15% more to the retailer than were steer carcasses.

It has been consistently reported that bulls are superior to steers for economically important traits. On average, bulls grow 17% faster and are 13% more efficient in converting feed to live weight than are steers. It is also clearly documented that bulls produce carcasses that contain less fat (approximately 35% less) and more muscle per unit of weight than carcasses from steers. The recent increased awareness by consumers regarding health implications of fat in their diets gives added impetus to developing production systems using the natural advantages of the bull in producing lean beef.

Meat Quality

Meat from bull carcasses may be tougher than meat from steer carcasses (11,12,24,25). However, in most cases, this difference is very small and more than likely would not result in consumer objection (Table 1). Numerous researchers have been unable to detect significant differences between the tenderness of meat from young bulls and that of meat from steers slaughtered at comparable ages (18,21,22,26–31; Table 1). The mechanism causing differences in tenderness between meat from bulls and steers is not well defined. Riley et al. (28) suggested that differences in the fatness could explain the differences in the tenderness. Differences in the connective tissue associated with differences in tenderness have also been suggested (32,33). As might be expected, the commonly used bull versus steer model often yields equivocal results. Studies attempting to relate collagen to the tenderness differences in bulls and steers are not consistent. In the majority of the studies, lean meat from bulls tends to have a higher quantity of collagen than does meat from steers (21,22,24,25,30; Table 2).

According to Bailey (34), it is the solubility of collagen that is important in meat tenderness rather than the absolute amount. However, again there is disagreement in the literature (Table 2). Some researchers report that lean muscle from bull meat has significantly lower collagen solubility (24,33), while others have not been able to detect any differences (21,23,25,30; Table 2).

Marsh (35) hypothesized that collagen and/or the myofibrillar apparatus determines meat tenderness. Numerous studies have attempted to link the differences in meat tenderness between bull and steer carcasses to collagen. However, very little (if any) work has been done in determining the possible contribution of the myofibrillar apparatus to this difference. Assuming that tenderness is a major consumer concern regarding consumption of meat from bull carcasses, it appears that the problem can be solved. Proteolysis of myofibrillar proteins is probably the major reason for postmortem tenderization of meat (36,37). Additionally, it has been demonstrated that calcium-dependent proteases are most likely responsible for proteolysis of those myofibrillar proteins that are degraded during postmortem storage to yield the resultant increase in bovine and ovine meat tenderness (38–42). Indeed, Koohmaraie et al. (40–42) have demonstrated that when calcium-dependent proteases are activated during the early postmortem period, the tenderization process in ovine carcasses was completed within 24 h of postmortem storage. Since the mechanism of postmortem tenderization is believed to be the same in bovine and ovine carcasses, we should be

Table 1 Comparison of palatability characteristics of bulls (B) and steers (S)

	Warner-Bratzler shear (kg/1.27 cm)		Panel scores*					
			Tenderness		Juiciness		Flavor	
Reference	B	S	B	S	B	S	B	S
Calkins et al. (21)	2.31	2.16	—	—	—	—	—	—
Vanderwert et al. (22)	4.48	4.08	5.56	5.70	5.61	5.50	—	—
Burson et al. (24)	4.00	2.80	—	—	—	—	—	—
Dikeman et al. (25)	—	—	6.59	7.72	6.75	7.39	3.21	3.26
Riley et al. (28)	3.20	2.90	5.60	6.20	5.30	5.20	—	—
Jones et al. (31)	6.69	5.60	—	—	—	—	—	—
Fortin et al. (51)	—	—	8.74	8.78	8.46	8.51	8.11	8.29
Griffin et al. (53)	—	—	6.00	6.30	5.90	5.10	3.80	3.90
Hopkins and Dikeman (54)	4.40	4.00	—	—	—	—	—	—
Miller and Cross (55)	4.50	4.30	5.20	5.30	5.30	5.30	5.50	5.50
Stiffler et al. (56)	4.20	3.60	5.80	6.50	5.50	5.60	—	—
Crouse et al. (57)	4.49	3.66	5.30	6.32	5.79	5.89	5.39	5.60
Crouse et al. (58)	4.67	4.02	5.09	5.32	5.27	5.34	5.47	5.50

* Taste panel ratings are on the scale of 1 to 8 for all studies except Dikeman et al. (1 to 10) and Fortin et al. (1.5 to 13.5). In all cases, least number (e.g., 1.0 or 1.5) indicates tough, dry, and bland, and high number (8 or 10) indicates tender, juicy, and intense for tenderness, juiciness, and flavor, respectively.

Table 2 Comparison of collagen characteristics of lean meat from bull (B) and steers (S)

	Total collagen (mg/ml)		Soluble collagen (%)		Panel score* (connective tissue)	
Reference	B	S	B	S	B	S
Calkins et al. (21)	9.56	8.12	41.89	37.84	11.28	11.88
Gerrard et al. (23) (9 months of age)	5.65	5.40	26.00	22.50	—	—
Gerrard et al. (23) (12 months of age)	5.35	5.15	20.50	20.00	—	—
Gerrard et al. (23) (15 months of age)	5.35	4.50	17.50	15.50	—	—
Gerrard et al. (23) (18 months of age)	5.65	4.75	10.50	13.00	—	—
Burson et al. (24)	5.34	5.91	13.90	24.20	—	—
Crouse et al. (30)	4.76	4.25	18.80	19.20	4.93	5.19
Cross et al. (33)	5.75	5.05	15.92	14.76	—	—
Crouse et al. (57)	—	—	—	—	5.08	6.07

* Taste panel ratings are on the scale of 1 to 8 for Crouse et al. 1984 and 1985 and 1 to 15 for Calkins et al. 1986. In both cases, 1 = abundant connective tissue, and 8 and 15 = no connective tissue.

able to achieve the same result in bovine and, specifically, bull carcasses.

It is often reported that bull meat is darker in color and coarser in texture than steer meat (12). This difference in the color of meat from bulls and steers is not due to their myoglobin content (32,43,44). Postmortem muscle color is directly associated with the antemortem muscle glycogen content, which determines the ultimate muscle pH (45). Antemortem muscle glycogen is affected by live animal physiological stress (46–49). Owing to their temperament (50,51), bulls are much more susceptible to antemortem stress than steers (12). This susceptibility to stress results in a condition called dark-cutting beef (DCB). Mismanagement of cattle before slaughter, resulting in physiological stress and exhaustion, is the most frequently suggested cause of DCB (52). According to a survey conducted by Tarrant (52), bulls are universally considered to be the group of cattle most susceptible to dark cutting. In addition to the objectionable appearance, meat from DCB is much more receptive to spoilage than normal meat, because of the high ultimate pH. The economic losses due to DCB are approximately 10% compared with normal meat (52).

Although tenderness is reported to be the major problem with bull meat, perhaps dark cutting is an even more serious problem. There are methods available to alleviate the toughness problem, and research on tenderness is much more active than that on dark cutting. Suitable procedures for utilizing DCB should be developed while research progresses toward resolving the DCB phenomenon. Attempts to market DCB as normal beef should be discouraged in the long-term interest of the industry. Although antemortem mishandling is the most frequent cause of DCB, climate and other seasonal factors are reported to be important in the etiology of DCB (52). The seasonal factors may be more difficult to resolve than problems associated with antemortem mishandling.

FUTURE DIRECTIONS

It is now evident that consumers do not accept meat with excessive visible fat and fat cover. Packers, in response, have begun to trim excess fat. If this consumer demand continues, the industry will be forced to produce lean animals. An advantage is the economy gained by avoiding the costs of fattening and of trimming fat in the packing houses. Since bulls produce meat with much less fat than steers, it appears that bulls will meet consumer demands for lean meat. However, significant difficulties with producing bulls must be solved before bulls are fully incorporated in the production systems. Two major problems are associated with the acceptance of bull meat. First is the toughness of the meat, and second, and perhaps more important, is the DCB phenomenon. The tenderness problem is being actively investigated, and it is not unrealistic to predict that this problem will be solved. The remaining problem is the DCB phenomenon. DCB has darker color, coarser texture, and drier lean muscle and therefore presents a major consumer acceptance problem. Unless these two problems are addressed and solved, the utilization of bulls as meat-producing animals will never reach its potential.

KEY CONTRIBUTORS

The short list below concentrates on individuals involved in the use of bulls as meat-producing animals, with emphasis on carcass characteristics and the palatability of bull meat. For further information, the reader is referred to members of North Central Regional (NCR-132) Research Committee (Project title: The Use of Noncastrated Meat Animal for Food). Most of the listed individuals are members of this committee.

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