Effect Of Measuring Tenderness With The Tenderometer

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Story In Brief

Ninety-nine Angus steer carcasses weighing 540 lb. were evaluated for tenderness of the longissimus dorsi muscle. Breeding, feeding, and environmental treatments of the animals were similar. All animals were slaughtered 24 hours after their arrival at the plant. The carcasses were ribbed after a 24 hour chill at zero degrees centigrade and tenderometer measurements were made on the longissimus dorsi of the wholesale rib. The influence of muscle temperature, repeated penetration, quality of fat, iodine number, fiber diameter, degree of fiber kinkiness and Warner-Bratzler shear values were evaluated.

Introduction

Tenderness is one of the most favored attributes of meat. Most of the common European cattle breeds have been selected so that fed cattle generally provide tender meat. However, in recent years, greater emphasis has been placed on cross breeding to improve various attributes of production. This change in breeding practice may introduce considerable variation in meat tenderness. The need and desire to monitor meat tenderness, in the live animal, and the carcass, has increased.

Attempts to relate objective tenderness measures of raw meat with cooked meat tenderness failed to show any significant correlation, Warner (1928), Black (1931), Mjoseth (1962), Carpenter, et al. (1965). Measured tenderness values for raw meat by the wedge tenderometer, denture tenderometer, and grinder tenderometer were reported by Carpenter, et al. (1965). They found the association with a taste panel to be small.

Various types of penetrometers have been used to measure texture, firmness, and tenderness. Pilkington, (1964) used several shaped penetrometer points to measure firmness. However, firmness did not relate highly with tenderness. Bourne, et al. (1966) reported, that the puncture force for different punches on the same food will be a function of both area and perimeter of the punch used. A problem of great concern when using the penetrometer on raw meat has been to obtain a good relationship of this measure with tenderness of cooked meat. Hinnergardt and Tuomy (1970) reported on a study which evaluated the use of a single penetration test of raw meat to predict the tenderness of cooked meat. They found that the maximum force value gave the best results.

The purpose of this work was to evaluate the Armour "tenderometer" a simple, rapid, non-destructive carcass measure of tenderness.

Procedure

The battery operated tenderometer consists of a probe assembly and a readout unit. The probe assembly includes 10 penetration needles, each 3 inches long, mounted on a manifold which is in turn attached, by cable, to an electronic strain gauge. The ten, pointed needles, made of stainless steel are mounted so as to penetrate the muscle a maximum distance of two inches. The instrument was designed to be used on the longissimus dorsi muscle at the areas of the 12th and 13th thoracic vertebrae. Readings are to be taken on muscle chilled to less than 39.20° F (4°C) and not more than 32° F (0°C). Consequently, a measurement should not be taken until at least 24 hours after slaughter.

Ninety-nine head of angus steer carcasses weighing 540 pounds were evaluated for tenderness of the longissimus dorsi muscle. Breeding, feeding, and environmental treatments of the animals were similar so as to reduce the tenderness variables. All animals were trucked 140 miles from the station feedlot to the abattoir. Feed and water were provided during the 24 hour rest period prior to slaughter. Fifty head were slaughtered 24 hours after arrival at the plant and 49 head slaughtered after 48 hours.

The carcasses were ribbed 24 hour after slaughter, between the 12th and 13th thoracic vertebrae, and a federal employee evaluated each carcass for amount of marbling and grade. Immediately after grading, tenderometer readings were made on the longissimus dorsi muscle. The internal muscle temperature was recorded using a thermometer inserted into the muscle. One-half of each carcass was divided into wholesale cuts and the wholesale rib returned to the research laboratory for further analysis. Upon arrival at the laboratory, a tenderometer measurement of each longissimus dorsi muscle, its temperature, and area tracing, were again recorded. When the temperature of the longissimus dorsi muscle had equalized to 36°F (12 hr. at 36°F), another tenderometer measurement of the longissimus dorsi muscle was made. Care was taken in the replacement of the needle to avoid previously penetrated areas of the muscle.

A two-inch slice of the penetrated longissimus dorsi muscle was removed from each wholesale rib to be used for the Warner-Bratzler shear test. An adjacent one-inch slice was removed from the longissimus dorsi muscle so as to provide tissue for histological observations and ether extract measurements.

Table 1. Mean, Standard Deviation and Range for Carcass and Tissue Variable of Tested Animals.

	Mean	S. Dev.	Range
Carcass wt. lb.	541.0	57.6	405-666
L. Dorsi area sq. in.	10.2	1.1	8.1-12.9
Fiber Diameter u.	64.2	6.4	75.4-81.4
Carcass grade score[1]	10.4	1.2	8.0-13.0
Marbling score[2]	5.2	1.1	3.0-8.0
Ether Extract %	5.8	1.9	2.3-11.3

[1] Carcass score ranged from 8 (average good) to 14 (top prime).
[2] Marbling score ranged from 3 (traces) to 9 (abundant).

Three one-half inch diameter cores were removed from the dorsal, central, and ventral areas of the one-inch thick muscle sample and placed in 10 percent formalin. The remainder of the muscle was made into a composite paste and analyzed for its fat content.

The formalin fixed tissue provided fibers to be evaluated for their degree of rigor mortis. To harvest the fibers, a single fascicula was placed in a mechanical mixer and stirred at a slow speed. When the fibers were dislodged, they were placed in a petri dish to be evaluated for degree of rigor and diameter measurement at 100x.

Results and Discussion

Animals used in the investigation were generally homogeneous in so far as production factors were concerned. Carcass weight ranged from 406 to 666 pounds with a mean of 541 pounds. The carcasses were generally muscular as reflected by the mean L. dorsi area of 10.2± 1.1 sq. in. with a range of 8.1 to 12.9 sq. in. The fat content of the L. dorsi muscle, as evidenced by the ether extract value, was 5.8± 1.9 percent (range 2.3 to 11.3 percent). The designated average federal grade was choice with the numerical score being 10.4± 1.2. A highly significant difference due to animal variation and tenderometer reading was noted (Table 2).

The multi-point penetrometer was easy to use in the cooler while working a rail of carcasses. A measurement can be rapidly made without

Table 2. Analysis of Variance

Source	dF	MS	F
Animal	98	15.506	5.79
Tenderometer	3	263.364	98.39
Error	294	2.677	
Total	395		

damage to the carcass or description of the daily normal cooler operation. The in-plant tendrometer reading, made on the rib L. dorsi muscle was greater than any of the three measurements made on the wholesale rib after it was returned to the laboratory (Table 3). Penetration force variance may be attributed to the difference in product temperature and/or the degree of fiber rigor. Since the same muscle area was penetrated a second time, this too may have affected the reading. No repeatability measurements were made to varify this potential variable. When the muscle temperature and cooler temperature (36°F) were permitted to equilibrate, (48 hr.) tenderometer readings were not different from those recorded at 30 hr. post-mortem (Table 3). Fat firmness and quantity would likely have an effect on the tenderometer reading. Firm fat would require more force to insert the needles. The fat in turn would be beneficial as the muscle was heated. Thus, the tenderometer reading would be inversely related to the quantity of fat located within the muscle.

The kind of fat as reflected by the iodine number, within the L. dorsi muscle was not found to vary in these carcasses regardless of fat quantity (Table 4). Muscle with 3.4 percent fat possessed an iodine number of 44.5, while muscle with 9.2 percent fat was 43.3.

Fiber size and compactness was considered a factor which would likely influence the penetration force. Fiber diameter in this group of bovine muscles ranged from 75.5 to 81.4 microns. It was assumed that this 6 micron difference would not greatly infiuence the tenderometer reading (Table 1).

Fiber rigor is a factor which could be a very influential factor. The quantity of rigor fibers ranged from 14 to 83.4 percent (Table 3). This measurement was made on the tissue 48 hours after death. This time period elapse would likely be sufficient for some resolution to take place. Therefore, tenderometer readings taken 24 hours after death would like-

Table 3. Mean Shear Force, Degree Rigor Fibers and Tenderometer Values for Bovine L. Dorsi Muscle.

		Mean	S. Dev.	Range
Shear Force	lb.	18.29	4.3	9.9-18.3
Degree Rigor	%	36.37	15.3	14.0-83.4
Tenderometer	A lb.	17.10	2.6	12.0-23.4
	B lb.	14.72	2.5	9.0-20.0
	C lb.	14.96	2.3	9.7-20.5
	D lb.	13.12	2.2	8.4-18.4

A. Muscle temperature 37.3°F, 24 hours post-mortem, in plant measurement.
B. Muscle 42°F, 30 hours post-mortem, in lab measurement.
C. Muscle 36°F, 48 hours p st-mortem, in lab measurement.
D. A two inch slice was removed and penetration was made into the new muscle surface, 36°F, 48 hours post-mortem.

Table 4. Iodine Values of Fat from the Bovine L. Dorsi Muscle

Fat %	Range	Iodine Value
3.4	3.1- 3.8	44.5
9.2	8.2-11.3	43.5

[1] Twelve muscle samples were used at each fat level. Each measure was made in duplicate.

ly be greater and more varied than a similar reading registered after 30 to 48 hours.

Connective tissue within the muscle would also be a factor influencing the tenderometer reading. Not only would the amount of connective tissue be an important variable, but its composition would also be influential. Connective tissue with large quantities of elastin would likely provide more resistance to penetration than tissue composed only of the protein collagen. This variable was not evaluated but will be considered as the work is continued.

Correlation coefficients indicated that the Warner-Bratzler shear force machine and the tenderometer were not related (Table 5). Both units measure an element of tenderness. However, in the case of the tenderometer one measures the force necessary to separate the individual raw muscle fibers. While the Warner-Bratzler shear measures the force required to cut the cooked fibers at right angle to their long axis. The degree of fiber rigor, fiber diameter, fat level, or muscle area were not significantly correlated with the tenderometer force.

Summary

The Armour Tenderometer is easy to use in the cooler. Readings may be taken using the L. Dorsi muscle 24 hours after slaughter. Force required to insert the manifold of needles varied greatly within a homogenous group of carcasses, reflecting that some tissue difference does exist. Tenderometer measurements made in the plant using the carcass were larger than those made in the laboratory using the wholesale rib. Force required to insert the penetrometer into the L. dorsi muscle 48 hours after death, was significantly less than at 24 or 30 hours. Even though the degree of rigor was not shown to be a major factor in the use of this instrument, it may well be an important attribute and should receive further investigation.

The quantity of fat as reflected by marbling and ether extract influenced the tenderometer reading. Fat firmness as reflected by iodine number was not a factor in this group of carcasses. In general, correlations between the Warner-Bratzler shear machine and the tenderometer were low.

Table 5. Correlations Among Factors Which Tend to Influence the Tenderometer[1]

		Marbling	E. Extract	L.D. Area	Fiber Diam.	Deg. Rigor	Tenderometer A	B	C	D	Sheai
Marbling		1.00	0.32	—0.21	—0.04	0.14	0.23	0.24	0.37	0.44	—0.29
Ether Extract		0.32	1.00	—0.21	0.01	0.04	0.05	0.12	0.12	0.12	—0.31
L. Dorsi area		—0.21	—0.21	1.00	0.08	—0.28	—0.38	—0.34	—0.33	—0.39	0.08
Fiber diameter		—0.04	0.01	0.08	1.00	—0.03	—0.12	—0.23	—0.06	—0.07	0.04
Degree Rigor		0.14	0.04	—0.28	—0.03	1.00	—0.07	—0.02	0.04	0.05	0.22
Tendermeter	A	0.23	0.05	—0.38	—0.12	—0.07	1.00	0.65	0.56	0.57	—0.15
	B	0.23	0.12	—0.34	—0.23	—0.02	0.65	1.00	0.58	0.43	—0.14
	B	0.24	0.12	—0.34	—0.23	0.04	0.56	0.58	1.00	0.48	0.02
	D	0.44	0.12	—0.37	—0.06	0.05	0.57	0.43	0.48	1.00	—0.01
Shear Force		—0.29	—0.30	—0.08	0.34	0.22	—0.15	—0.14	0.02	—0.01	1.00

[1] Animals used (99) were thirteen months of age and of uniform breeding.

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