Meat and Carcass Evaluation

Measuring Meat Tenderness With The Rotating Dull Knife Tenderometer

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Story in Brief

A new instrument designed to be used as a measure for meat tenderness, known as the Rotating Dull Knife Tenderometer, was compared with the Warner-Bratzler Shear instrument. Three beef muscles treated by two methods of excision at three postmortem time periods were used. The Rotating Dull Knife Tenderometer was used on both intact muscle and ground cooked meat.

The data demonstrated that intact and ground muscle measurements made by the Rotating Dull Knife instrument produced comparatively similar results as the Warner-Bratzler Shear and those of the tenderness panel. Both instruments appear to measure different properties than the human panel.

Introduction

Throughout history, meat has been accepted as an excellent source of food. The consumption of meat products as a high quality source of protein has steadily increased as the educational, social, and economic standing of the country has developed. With this development the consumer has been exposed to many new types of meat products and is keenly aware of meat tenderness. According to Weir 1960, the overall impression of tenderness to the palate includes texture and involves the initial ease of meat penetration by the teeth, the ease with which the meat breaks into fragments, and the amount of residue remaining after chewing. In today's society, tenderness is one of the most desired and critical organoleptic qualities of meat products. Lawrie 1966 stated that the consumer considers meat tenderness and texture as the major attribute of eating quality, and this preference appears to be selected at the expense of flavor or color. With the consumer's increasing perception of meat tenderness and the development of new processes of meat fabrication the need for a reliable method of measuring tenderness continues to grow.

The earliest recorded use of a mechanical device to measure tenderness of meat was published by Lehman in 1907. In the past 70 years many different mechanical devices have been devised in an attempt to objectively measure the tenderness of meat. Of all the instruments, the Warner-Bratzler shear, which was first reported by Warner 1928 and then modified and improved by Bratzler 1932, has become the most popular and widely used device for measuring meat tenderness. Despite the wide use of the Warner-Bratzler shear as a penetrometer for measuring tenderness, shortcomings for the device have been reported (Harwicz and Rischer, 1954; Wells, 1962; and Deatherage, 1951).

Researchers have continued to devise instruments which will reliably measure tenderness, have greater reproducibility, and can be accurately read. One such instrument devised as a potential source of measuring tenderness is the Rotating Dull Knife Tenderometer (RDKT). The Rotating Dull Knife Tenderometer was developed by the Feed Service Corporation, Crete, Nebraska, in an effort to provide an accurate measurement of tenderness.

The Rotating Dull Knife Tenderometer (Figure 1) was designed to integrate the parameters of penetration, and shear through both the muscle fiber and connective tissue fiber. The RDKT has a rotary circular cutter with 3 equally spaced cutting edges which are relatively dull. This dull edged cutter makes a rotary cut in the meat, the penetration of the cut being indicative of the tenderness. The cutter is attached to a vertical, constant force-biased, electronically-driven shaft. The recording mechanism includes a drum with positioning knobs for attaching the recording sheet. The drum and weight are fixed to the rotary shaft with the knife being fastened to the drive shaft. The motor is programmed by a microswitch to make one vertical revolution when the push-button power switch is pressed. The scribe is then set to engage the chart at the base line of the tenderness score sheet. When the power switch is pressed the second time, the motor rotates the drive shaft 7 times thereby cutting the sample and forming a continuous line on the recording chart. The chart is made of pressure-sensitive paper and records the full 7 revolutions. The deeper the knife penetrated the meat, the more expanded are the recorded lines on the chart and the more tender the sample (Anderson, et al., 1972). Anderson and co-workers 1972 devised a process by which the RDKT showed promise for predicting the tenderness of the entire carcass from measurements made on the heart.

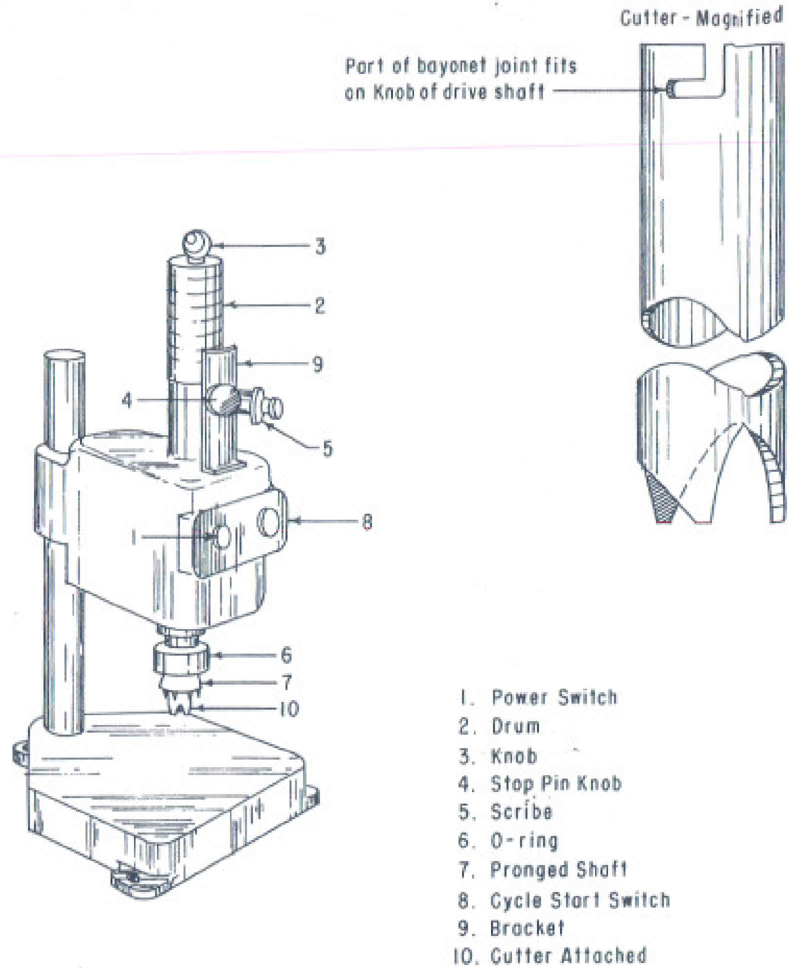

Figure 1. Rotating Dull Knife Tenderometer Parts Identification

The purpose of this investigation was to evaluate the sensitivity of e Rotating Dull Knife Tenderometer as a measure of meat tenderness comparison to the Warner-Bratzler Shear and a trained tenderness anel.

Materials and Methods

Twelve USDA Choice and Good grade black Angus steer carcasses were split and randomly designated to one of two treatments. Sides utilized for the chilled control or conventional refrigeration were held at 1.1°C for 48 hours before individual muscle systems were removed and stored in Cry-o-vac-polyethylene bags. The opposite pair sides under the non-chilled treatment were randomly designated to 3, 5, or 7 hour post-mortem conditioning periods at 16°C before removal of muscle systems (Falk, et al., 1974). Two steaks from specific areas of each muscle were removed from each treatment side for both the objective and subjective evaluation.

Muscles used for the tenderness evaluation were the longissimus dorsi (LD), the semimebranosus (SM) and the bicep femoris (BF). All steaks were cooked by deep fat method to an internal temperature of 155°F.

The RDKT was used in two separate investigations. One study involved the use of intact 5.08 centimeter cooked steaks and the depth of penetration in centimeters made by the rotating knife. The second utilized the remaining cooked meat after the steaks had been cooled and ground through a 3/16 inch plate. The 1.1°C refrigerated ground meat was pressed to 150 PSI for one minute into poleythylene cylinders (4.5 x 12.6 cm) using a Carver Press. The depth to which the Rotating Dull Knife penetrated the cooked, ground, pressed meat was once again recorded in centimeters.

Warner-Bratzler shear measurements were made on the same refrigerated steaks using ¾ inch diameter cores. Mean shear values were determined from three cores per steak and three shears per core. A six member trained tenderness panel evaluated correspondingly deep fat heated steaks from all three muscles similar to those examined in the objective portion of the study. The panel test used to determine tenderness difference between processes was the Duo-Trio Comparison Method. Panelists were presented with a reference sample which was followed by two unknown samples. Each panelist was required to indicate which of the two unknowns was like the reference sample. Three basic questions were asked of the panelists. First, was a difference in tenderness between the two processes detectable? Second, was a preference between the two processes distinguishable? And finally, on a hedonic scale was one process more acceptable than the other?

The data collected from the objective instruments and tenderness panel were interpreted after using the Analysis of Variance and F-Test to note differences. The Friedman test for ranks was also employed for the tenderness panel data.

Results and Discussion

The data from three mechanical methods of measuring tenderness, of three chilled and unchilled bovine muscles, at the 3 and 48 hour post-mortem boning periods, are shown in Table 1. Differences in penetration depth and shear force between the chilled and unchilled BF muscle was noted ($P<0.10$) for the Rotating Dull Knife Tenderometer (RDKT) intact muscle, and the Warner-Bratzler (W-B) Shear ($P<0.01$). An interaction between steaks and treatments was present for the W-B shear reading. The anterior end of the muscle was more tender than the posterior end in both the chilled and unchilled treatments. The most likely reason for this interaction can be attributed to location of muscle samples evaluated and the rate at which areas of the muscle cooled.

For the LD muscle a significant difference ($P<0.10$) in penetration was obtained for the RDKT intact muscle, however, an interaction between sample location and boning period was detected. The steak from the anterior portion of the muscle was more tender than a similar steak from the posterior portion, for the chilled treatment with the reverse being true for the unchilled treatment. The most plausible reason for this being the muscle area used. A difference in penetration between the chilled and unchilled excised muscle was significant ($P<0.10$) for the SM muscle measured by the RDKT intact method, but nonsignificant for the other two objective measures.

Results of the panel evaluation for tenderness as related to muscle and treatment are shown in Table 2. The tenderness panel was unable to detect a difference between the two treatments as shown by the number of right and wrong responses. Using the Duo-Trio Comparison Test no

Table 1. Mechanical measures of tenderness as influenced by treatment and muscle

Instrument		Process[3,4] Treatment	n[5]	BF[6]	LD[7]	SM[8]
RDKT[1]	cm	C (48 hr.)	24	1.60***	1.40	1.64***
Intact		U (3 hr.)	24	1.35	1.26	1.53
RDKT	cm.	C (48 hr.)	16	1.44	1.36***	1.38
Ground		U (3 hr.)	16	1.52	1.27	1.20
W-B[2]	lb.	C (48 hr.)	72	17.34*	14.14	19.60
		U (3 hr.)	72	13.72	15.19	19.28

[1] Rotating Dull Knife Tenderometer
[2] Warner-Bratzler Shear
[3,4] Chilled (C), Unchilled (U)
[5] Number Observations
[6,7,8] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
* $P<0.01$
*** $P<0.10$

Table 2. Three panel measures of tenderness as related to treatment and muscle

Duo-Trio Test

Side	n[1]	BF[2]		LD[3]		SM[4]	
		Right	Wrong	Right	Wrong	Right	Wrong
1	12	2	10	8	4	7	5
2	12	7	5	4	8	4	8
3	12	6	6	4	8	8	4
4	12	11	1*	5	7	6	6

Preference Test

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	1.58	1.56	1.56
Unchilled (3 hr.)	48	1.42	1.44	1.44

Hedonic Scale[5]

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	4.35	4.35	4.56
Unchilled (3 hr.)	48	4.25	4.29	4.38

[1] Number of Observations
[2,3,4] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
[5] A score of 1 being highly unacceptable and 6 highly acceptable.
* $P < 0.01$

significant differences in tenderness were noted for all muscle or treatments except in one case where the BF muscles was found to be different ($P<0.01$). The most likely reasons for this variation was the simple side difference probably caused by the rate of cooling. Panel data analyzed to detect a preference between the chilled and unchilled boning process showed no preference for either treatment. The difference in hedonic scale rating between chilled and unchilled process treatments was not significant for any of the three muscles studied. Even though some of the individual mechanical measures for tenderness at the 3 and 48 hour treatment periods were significant, these differences were not detectable by the panel.

The data for three mechanical methods of measuring tenderness of three chilled and unchilled bovine muscles, at the 5 and 48 hour boning periods are shown in Table 3. Muscles excised 5 hours post-mortem and then chilled were no different in tenderness when compared to those chilled on the carcass before being boned. All three mechanical instru-

Table 3. Mechanical measures of tenderness as influenced by treatment and muscle

Instrument		Process[3,4] Treatment	n[5]	BF[6]	LD[7]	SM[8]
RDKT[1]	cm	C (48 hr.)	24	1.56	1.54	1.60***
Intact		U (5 hr.)	24	1.43	1.36	1.37
RDKT	cm.	C (48 hr.)	16	1.49	1.36	1.48
Ground		U (5 hr.)	16	1.42	1.28	1.36
W-B[2]	lb.	C (48 hr.)	72	13.25	13.85	19.01
		U (5 hr.)	72	14.19	14.83	19.98

[1] Rotating Dull Knife Tenderometer
[2] Warner-Bratzler Shear
[3,4] Chilled (C), Unchilled (U)
[5] Number of Observations
[6,7,8] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
*** $P < 0.10$

ments provided general agreement. The RDKT intact, for the SM muscle was the one exception ($P<0.10$).

Tenderness panel data as related to muscle and treatment are shown in Table 4. The human panel was unable to detect a difference between the two methods of beef fabrication. The differences determined by the Duo-Trio Comparison between chilled and unchilled processes were nonsignificant for all muscles except in one sample where one of the LD muscles was found to be different ($P<0.01$). Here, as in the previous study, the most likely reason for this difference was due to carcass side variation. The preference test for the chilled and unchilled processes revealed no significant differences for the BF and LD muscles. Differences of statistical importance ($P<0.10$) was obtained for the SM muscle. Looking at the hedonic scale rating one may note significance (P<0.[illegible]) for the SM muscle but the reverse for the BF and LD muscles. Mechanical measurements at the 5 and 48 hour investigation revealed measures for tenderness were nonsignificant. These findings were also in agreement with panel evaluation.

Table 5 provides data for the 7 and 48 hour treatment period. The mechanical measures for chilled and unchilled treatments were nonsignificant for all BF readings. On the other hand, the W-B shear was significant ($P<0.10$) for the LD muscle with the remaining observations having no difference. For the SM muscle significance was shown by the RDKT whole ($P<0.10$) and W-B shear ($P<0.05$) readings.

Results of the panel evaluation for tenderness as related to muscle and treatment are shown in Table 6. The tenderness panel was unable to detect a difference between the two treatments for all muscles studied.

Table 4. Three panel measurements of tenderness as related to treatment and muscle

Duo-Trio Test

Side	n[1]	BF[2]		LD[3]		SM[4]	
		Right	Wrong	Right	Wrong	Right	Wrong
5	12	4	8	2	10	4	8
6	12	8	4	5	7	6	6
7	12	8	4	9	3*	3	9
8	12	4	8	4	8	5	7

Preference Test

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	1.60	1.54	1.62***
Unchilled (5 hr.)	48	1.40	1.46	1.38

Hedonic Scale Rating[5]

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	4.35	4.46	4.40***
Unchilled (5 hr.)	48	4.00	4.38	4.08

[1] Number of Observations
[2,3,4] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
[5] A score of 1 being highly unacceptable and 6 highly acceptable.
*** $P < 0.10$
* $P < 0.01$

Table 5. Mechanical measures of tenderness as influenced by treatmen and muscle

Instrument		Process[3,4] Treatment	n[5]	BF[6]	LD[7]	SM[8]
RDKT[1]	cm.	C (48 hr.)	24	1.36	1.53	1.39**
Intact		U (7 hr.)	24	1.52	1.65	1.48
RDKT	cm.	C (48 hr.)	16	1.52	1.34	1.26
Ground		U (7 hr.)	16	1.45	1.38	1.22
W-B[2]	lb.	C (48 hr.)	72	15.77	13.61***	19.83**
		U (7 hr.)	72	14.39	11.96	21.62

[1] Rotating Dull Knife Tenderometer
[2] Warner-Bratzler Shear
[3,4] Chilled (C), Unchilled (U)
[5] Number Observations
[6,7,8] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
** $P < 0.05$
*** $P < 0.10$

Table 6. Three panel measurements of tenderness as related to treatment and muscle

Duo-Trio Test

Side	n[1]	BF[2]		LD[3]		SM[4]	
		Right	Wrong	Right	Wrong	Right	Wrong
9	12	8	4	7	5	5	7
10	12	7	5	7	5	5	7
11	12	5	7	7	5	8	4
12	12	8	4	8	4	6	6

Preference Test

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	1.58	1.38***	[illegible]
Unchilled (7 hr.)	48	1.42	1.62	[illegible]

Hedonic Scale Rating[5]

Process Treatment	n	BF	LD	SM
Chilled (48 hr.)	48	4.42**	4.52	[illegible]
Unchilled (7 hr.)	48	4.10	4.81	[illegible]

[1] Number Observations
[2,3,4] Biceps femoris (BF), Longissimus dorsi (LD), Semimembranosus (SM)
[5] A score of 1 being highly unacceptable and 6 highly acceptable.
** $P < 0.05$
*** $P < 0.10$

Preference ratings for chilled and unchilled treatments showed significance ($P<0.10$). The differences in hedonic rating between treatments was nonsignificant for the LD and SM muscles while the BF muscle show significance ($P<0.05$) in the 7 and 48 hour study. Some individual objective measures for tenderness were different, however, these differences were not detectable by the tenderness panel.

Conclusions

These results demonstrated that the intact and ground muscle measurements made by the Rotating Dull Knife Tenderometer produced comparatively similar results as that of the Warner-Bratzler Shear and those of the tenderness panel. It further appeared that both forms of RDKT usage measured different properties than those of the Warner-Bratzler shear or the human panel. In addition, mechanical measurements led to the conclusion that no major differences existed between beef fabricated by the chilled and unchilled treatments. Finally, Duo-Trio Test, preference and hedonic scale ratings supported the findings of the mechanical instruments that the boning of beef muscle before it has been chilled provides beef of satisfactory tenderness.

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