

THE EFFECT OF CORING METHOD ON BEEF LONGISSIMUS
MUSCLE SHEAR FORCE VALUES

by

STEPHEN JAMES FRANCIS

B.S., Kansas State University, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

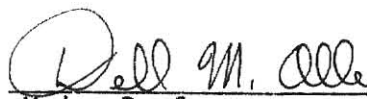
MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Approved by:


Major Professor

**THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH THE ORIGINAL
PRINTING BEING
SKEWED
DIFFERENTLY FROM
THE TOP OF THE
PAGE TO THE
BOTTOM.**

**THIS IS AS RECEIVED
FROM THE
CUSTOMER.**

Spec. Coll.
LD
2668
.T4
1980
F72
C.2

PREFACE

Originally, my master's research was to be the development of an electronic beef carcass yield and quality grading machine. However, as a result of delays in equipment procurement, analysis and reporting of the following data became my project.

Prior to working on this data analysis, I developed and taught the course "Animal Agriculture and the Consumer" for the Department of Animal Sciences and Industry. Development of this course afforded me the opportunity to delve into many areas of consumer education, product promotion and public relations, and diet-health controversies.

ACKNOWLEDGEMENTS

I wish to express sincere thanks to my major professor, Dr. Dell Allen for his support, guidance and friendship during my graduate studies. Appreciation is also expressed to Dr. Curtis Kastner and Dr. Ben Brent for their assistance on my graduate committee.

A special thanks goes to Odair O. Corte of the Instituto de Tecnologia de Alimentos for his assistance in gathering the research data.

In addition, I would like to thank the entire Animal Sciences and Industry meat group, especially Dr. Melvin Hunt, for the support and challenges put forth in the areas of consumer education and animal product promotion.

Thanks also go to the graduate students, particularly Dave Nichols, Dan Hale, and Pedro de Felicio, for their friendship and interest during my graduate tenure.

Most importantly, I would like to recognize the love and encouragement given by my mother and father, Helen and Fred Francis, as well as my brothers and their families throughout my lifetime.

TABLE OF CONTENTS

	Page
PREFACE	i
ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES AND TABLES	iv
REVIEW OF LITERATURE	1
Literature cited	5
SUMMARY	6
INTRODUCTION	7
MATERIALS AND METHODS	8
RESULTS AND DISCUSSION	11
Literature cited	15

List of Figures and Tables

Figure		Page
1	LD steak cutting methodology	8
2	Experimental design used to compare coring methods	9
Table		
1	Carcass characteristics by USDA maturity groups.	10
2	Mean shear values (kg) by days aging, USDA maturity group and coring method.	12
3	Simple correlation coefficients for hand versus machine core shear values by days aging, pooled across maturity groups and by maturity group	13
4	Spearman rank correlation coefficients for hand versus machine core shear values by days aging, pooled across maturity groups and by maturity group	14

REVIEW OF LITERATURE

Since Lehman's first attempts to develop an objective measure of muscle tenderness in 1907, numerous devices have been tested (Schultz, 1957). The Warner shear press, introduced in 1932, has grown to become the laboratory standard against which new devices are tested. The first hand operated Warner shear gave a correlation coefficient of .79 between shear values and committee tenderness evaluations (Bratzler, 1949).

L.J. Bratzler undertook the responsibility of standardizing the Warner shear machine and the procedure for its use. The final standards for the Warner-Bratzler shear included a 1.016 mm thick shearing blade with the cutting edge dulled to a .508 mm radius. A motor was added to assure a constant blade speed of 228.6 mm per minute.

Work done by Bratzler (1932) following those standardization procedures, showed a simple correlation of -.907 between cooked sample shear force values and committee tenderness scores. Bratzler (1949) gave the following precautions in experimental use of the shear device.

1. Degree of doneness: the greater the degree of doneness, the higher the shear force values.
2. Uniformity of samples: cores should be taken slowly with a twisting motion to prevent an hour glass shape.
3. Muscle fibers: sample cores should be taken parallel with the direction of the majority of the muscle fibers.
4. Connective tissue and fat deposits: these should be avoided. A 1.27 cm diameter core is valuable in that this core size makes it easier to avoid those areas than when larger diameter cores are taken.

Hurwicz and Tischer (1954) used parowax and beeswax to study the

variation in shear force values obtained from the Warner-Bratzler shear. Paro-wax and beeswax were used since homogenous samples could be obtained. The investigators tested maximum shear force, total time for failure in shear and the slope of the shear force versus the time curve in relation to taste panel evaluations. Coefficients of variation of 4.79 percent for slope of shear values versus time for failure line and 7.41 percent for maximum force, led the authors to suggest use of the slope of the line in drawing conclusions when using the Warner-Bratzler shear device.

Recognizing the need to reduce the experimental error associated with the Warner-Bratzler shear, Schultz (1957) suggested further studies be carried out to test the Kramer shear press since this machine showed promise of reducing the variation within samples. However, Henrickson et al. (1974) reported that the "Warner-Bratzler instrument is the most widely used physical method of measuring the shear force of muscle."

It has been suggested by many investigators, beginning with Bratzler (1932), that standardization of cookery method and coring procedure should aid in reduction of the sample error. Hedrick et al. (1968) showed shear force values to be significantly effected by cookery method, temperature of sample cores when sheared, core size and core location.

Correlation coefficients between Warner-Bratzler shear values and taste panel evaluations have shown the shearing device to be a simple, reliable, objective measure of muscle tenderness. Pork or beef longissimus muscle have been studied by Henry et al. (1963); Hiner et al. (1965); Rust et al. (1972); and Bereskin et al. (1978). Correlations ranging from -.498 to -.740 ($P < .01$)

for Warner-Bratzler shear force values versus taste panel evaluations were reported.

In Bratzler's original work (1932), cores were taken parallel with the majority of the muscle fibers. Steaks from the longissimus muscle are commonly used for determining muscle eating quality. They are usually cut perpendicular to the muscle's long axis. Some investigators have questioned if values obtained from cores taken without regard to fiber orientation would be valid. Hostetler and Ritchey (1964) tested that hypothesis. Using longissimus and biceps muscles, 1.27 cm hand cores were cut parallel to the majority of fibers or perpendicular to the steak cut surface. The two muscles reacted differently to coring method and final internal cooking temperature. With only one exception, shear values of the paired steaks from the same muscle with cores cut parallel to the muscle fibers were more closely related than shears of cores from within the same steak cored by both methods. Correlation coefficients between coring methods within steaks were low and non-significant. However, in comparing longissimus and biceps muscles, cores cut parallel to the muscle fibers showed a greater shear force difference for steaks cooked to 80°C than for those cooked to 61°C. Cores cut perpendicular to the steak cut surface showed the greater difference at 61°C than at 80°C.

Kastner and Henrickson (1969) devised a mechanical coring system utilizing an electric drill press which allowed for the quick, easy removal of core samples taken perpendicular to the steak cut surface. They designed an experiment to see if there was a difference between hand and machine bored cores (both taken perpendicular to the cut surface) in determining Warner-Bratzler shear values. Core sizes of 1.27, 1.9 and 2.54 cm were taken from pork

longissimus muscle.

In general, machine cores were free of the hour glass shape commonly seen in hand bored cores. In checking the variation of core size within sampling technique, mean machine core diameters from both 1.27 and 1.9 cm cores were nearer the expected diameter and had smaller standard errors than hand cores. They reported the same general trend, but no significant difference in the 2.54 cm cores.

Within chops, the difference between hand core and machine core shear values was often large. They concluded some of this variation was because the machine cores tended to be larger and more uniform in diameter. These workers also reported uniform coring was easier when chops were cooked to 72°C and chilled at 4°C for 24 hours.

Though most studies do not specify procedure used for obtaining cores for Warner-Bratzler shear tests, Lewis et al. (1977) indicated the use of the Kastner-Henrickson coring method. The longissimus, psoas, and quadriceps muscles were studied for variations in tenderness between breeds. Correlation coefficients of -.81, -.74 and -.63 ($P < .01$) were reported between taste panel tenderness scores and Warner-Bratzler shear force values for the longissimus, psoas and quadriceps muscles, respectively.

LITERATURE CITED

- Bereskin, B., D.K. Rough and R.J. Davey. 1978. Some factors affecting the evaluation of pork quality. *J. Anim. Sci.* 47:389.
- Bratzler, L.J. 1932. Measuring the tenderness of meat by means of a mechanical shear. Master Thesis. Kansas State University, Manhattan, Kansas.
- Bratzler, L.J. 1949. Determining the tenderness of meat by use of the Warner-Bratzler method. *Proc. Recip. Meat Conf.* 2:117.
- Hedrick, H.B., W.C. Stringer, R.J. Epley, M.A. Alexander and G.F. Krause. 1968. Comparison of factors affecting Warner-Bratzler shear values of beef steaks. *J. Anim. Sci.* 27:628.
- Henrickson, R.L., J.L. Marsden and R.D. Morrison. 1974. An evaluation of a method for measuring shear force for an individual muscle fiber. *J. Food Sci.* 39:15.
- Henry, W.E., L.J. Bratzler and R.W. Luecke. 1963. Physical and chemical relationships of pork carcasses. *J. Anim. Sci.* 22:613.
- Hiner, R.L., J.W. Thornton and R.H. Alsmeyer. 1965. Palatability and quantity of pork as influenced by breed and fatness. *J. Food Sci.* 30:550.
- Hostetler, R.L. and S.J. Ritchey. 1964. Effect of coring methods on shear values determined by Warner-Bratzler shear. *J. Food Sci.* 29:681.
- Hurwicz, H. and R.G. Tischer. 1954. Variation in determinations of shear force by means of the "Bratzler-Warner Shear." *Food Technol.* 8:391.
- Kastner, C.L. and R.L. Henrickson. 1969. Providing uniform meat cores for mechanical shear force measurement. *J. Food Sci.* 34:603.
- Lewis, P.K., Jr., C.J. Brown and M.C. Heck. 1977. Fiber diameter, sarcomere length and tenderness of certain muscles of crossbred beef steers. *J. Anim. Sci.* 45:254.
- Rust, R.E., D.G. Olson, G.M. Thomson and R.O. Schuler. 1972. Pork loins: The effects of selection on cut-out yields, cooked edible portion yield and organoleptic superiority. *J. Food Sci.* 37:222.
- Schultz, H.W. 1957. Mechanical methods of measuring tenderness of meat. *Proc. Recip. Meat Conf.* 10:17.

SUMMARY

Thirty Zebu steer carcasses were selected based on A,C or E USDA beef carcass maturity standards. The shortloin portion of the longissimus muscle was excised 7 days postmortem. Upon removal of 2.54 cm steak for Warner-Bratzler shear evaluation, the remaining portion of the longissimus muscle was vacuum packaged an additional 14 days. At that time, an additional 2.54 cm steak was removed for Warner-Bratzler shear evaluation. Upon cooking, hand cores were taken parallel to the orientation of the majority of the muscle fibers and another set of cores from the same steak were taken by machine perpendicular to the steak's cut surface without regard to muscle fiber orientation.

Analysis of variance for each aging treatment revealed no difference ($P>.10$) in shear force values across maturity groups regardless of coring method.

Simple correlation coefficients of .81 and .80 ($P<.001$) were calculated between coring methods across maturity groups for steaks cut 7 and 21 days aging, respectively.

Spearman rank correlation coefficients were .84 and .75 ($P<.001$) between coring methods across maturity groups for 7 and 21 days aging, respectively.

These data suggest longissimus muscle cores for use in Warner-Bratzler shear tests obtained by either coring method results in the same relative data interpretation.

INTRODUCTION

Steaks from the longissimus muscle are commonly used for determining muscle eating quality and are usually cut perpendicular to the muscle's long axis. Since Bratzler (1932) specified that cores for Warner-Bratzler shear evaluation should be taken parallel to the predominate fiber orientation, some investigators have questioned if values obtained from cores taken without regard to fiber orientation perpendicular to the steak's cut surface give valid results. The American Meat Science Association (1978) recognizes both coring techniques (parallel and perpendicular) as acceptable methods for obtaining cores for shear test evaluation.

If cores could be taken without regard to fiber orientation, time and effort could be reduced by employing the procedure outlined by Kastner and Henrickson (1969) which allows for the mechanical removal of cores perpendicular to the steak's cut surface.

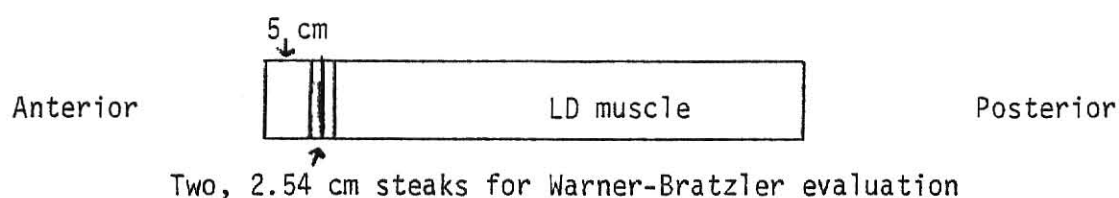
Still, since the introduction of the mechanical coring method, some investigators have questioned its validity since it disregards muscle fiber orientation.

MATERIALS AND METHODS

Thirty carcasses from Zebu steers were selected in a Sao Paulo, Brazil commercial slaughter facility based on A, C and E USDA beef carcasses maturity standards with ten carcasses in each group. Carcasses were chilled for approximately 20 hr and shipped to the Instituto de Tecnologia de Alimentos (ITAL) in Campinas, Sao Paulo where they were stored in a 2°C cooler.

Longissimus muscles were excised from one side of each carcass from the thirteenth rib to the last lumbar vertebrae (shortloin). Seven days postmortem, one 2.54 cm steak was cut 5.0 cm from the anterior end of each LD. The remainder of the LD was vacuum packaged and stored at approximately 2°C for an additional 14 days before removal of an additional, adjacent steak. The 7 and 21 day aged steaks were wrapped, frozen and stored (-40°C) on the respective days of cutting for subsequent Warner-Bratzler shear evaluation. The LD steak cutting methodology is presented in figure 1.

Figure 1. LD STEAK CUTTING METHODOLOGY



Upon thawing (2°C for 24 hr), all steaks were cooked to a final endpoint temperature of 70°C in a 170°C oven (American Meat Science Association, 1978). Thermocouples were used to monitor steak and oven temperature. After steaks were allowed to cool for approximately two hr at room temperature,

sample cores for Warner-Bratzler shear tests were taken. Six 1.27 cm cores were first taken by hand (hand cores) from each steak parallel to the predominate muscle fiber orientation. Six 1.27 cm cores were taken by machine (machine cores) from that portion of the steak left after hand coring and were cut perpendicular to the steak cut surface (Kastner and Henrickson, 1969), without regard to muscle fiber orientation. The experimental design is presented in figure 2.

Figure 2. EXPERIMENTAL DESIGN USED TO COMPARE CORING METHODS^a

<u>Aging treatment, days postmortem</u>	<u>USDA maturity group</u>	<u>Number of steaks per maturity group</u>
7	A	10
	C	10
	E	10
21	A	10
	C	10
	E	10

^a Six hand and six machine cores were cut from each steak. Hand cores were taken parallel to the predominate muscle fiber orientation. Machine cores were cut perpendicular to the steak cut surface, without regard to muscle fiber orientation.

Shear values from each steak were averaged within each aging treatment, USDA maturity group and coring method to give one value per steak for statistical analysis. Analysis of variance was calculated to determine if both coring methods detected the same relative differences among maturity groups

and days aging treatment. In addition, simple and Spearman rank correlation coefficients were calculated between coring method (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Carcass composition and quality indicators based on USDA quality and yield grade criteria are presented in table 1. As selected, mean maturity scores for each group were A⁷¹, C²² and E²⁶.

Table 1. CARCASS CHARACTERISTICS BY USDA MATURITY GROUPS

Carcass characteristic	USDA maturity groups		
	A	C	E
Hot carcass weight (kg)	251.5	275.1	281.7
Twelfth rib loin eye area (cm ²)	65.2	70.1	62.7
Twelfth rib fat thickness (mm)	4.3	6.8	8.4
Percent kidney fat	1.3	1.6	1.35
USDA yield grade	2.0	2.3	2.8
Bone maturity ^a	A ⁷¹	C ²²	E ²⁶
Marbling ^b	SI ⁴⁰	Sm ³¹	Sm ⁰⁸

^a Bone maturity based on 0-100 percent within each of A, B, C, D or E USDA bone maturity standards.

^b Marbling based on 0-100 percent within each respective USDA marbling degree.

No significant ($P>.10$) mean shear value differences were detected by analysis of variance for each coring method and aging treatment among the three maturity groups (table 2). This in general agreement with Romans *et al.* (1965) and Reagan *et al.* (1976) who showed no significant shear value

differences with advancing maturity, but unlike this study, a trend toward lower shear values in younger carcasses did appear in the previous work.

These findings disagree with those of King *et al.* (1958); Breidenstein *et al.* (1968); and Tuma *et al.* (1971) who reported a significant increase in shear values with advancing carcass maturities. However, steaks used in this study were obtained from animals of exclusive Zebu origin which had been grass fattened and not grain fed. In addition, there may have been a complicating effect of cold induced toughening due to differences in fat cover among maturity groups. There was a progressive increase in fat cover with increasing maturity (table 1) which could have masked differences due to maturity groups (Marsh, 1977).

Table 2. MEAN SHEAR VALUES (KG) BY DAYS AGING, USDA MATURITY GROUP AND CORING METHOD

Coring method ^a	USDA maturity groups			F statistic
	A	C	E	
	<u>7 days aging</u>			
Hand	5.74+ <u>1.67</u>	5.16+ <u>1.25</u>	5.34+ <u>1.38</u>	.43 ^{NS}
Machine	5.00+ <u>1.27</u>	4.70+ <u>1.04</u>	5.11+ <u>.95</u>	.38 ^{NS}
	<u>21 days aging</u>			
Hand	4.61+ <u>1.29</u>	4.57+ <u>.68</u>	4.49+ <u>.84</u>	.04 ^{NS}
Machine	4.48+ <u>1.03</u>	4.56+ <u>.85</u>	4.34+ <u>.80</u>	.06 ^{NS}

^aHand cores taken parallel to predominate muscle fiber orientation; Machine cores taken perpendicular to steak's cut surface without regard to fiber orientation.

^{NS}Non-significant ($P>.10$) differences among maturity group means within coring method and days aging.

The absence of any statistical difference between maturity groups allowed pooling of data to calculate correlation coefficients between hand and machine coring methods.

Simple correlation coefficients were calculated to determine the relative agreement between coring methods. Coefficients of .81 and .80 were ($P < .001$) from pooled data among all maturity groups for steaks cut 7 and 21 days post-mortem, respectively (table 3).

Table 3. SIMPLE CORRELATION COEFFICIENTS FOR HAND VERSUS MACHINE CORE SHEAR VALUES BY DAYS AGING, POOLED ACROSS MATURITY GROUPS AND BY MATURITY GROUP

USDA maturity	7 days aging	21 days aging
Pooled	.81***	.80***
A	.92***	.91***
C	.67*	.79**
E	.81**	.64*

*** ($P < .001$); ** ($P < .01$); * ($P < .05$).

To determine the ability of the machine coring method to rank steaks from most to least tender in the same order as hand cored steaks, Spearman rank correlation coefficients were calculated. Pooled maturity group coefficients were .84 and .75 ($P < .001$) for 7 and 21 days aging, respectively. Within maturity groups, all coefficients were ($P < .01$) and above with the exception of maturity groups C and E, 21 days aging. These were .73 ($P < .02$) and .56 ($P < .10$) (table 4). The lower correlation coefficients in these

two groups may be a result of less variation in shear values within these groups (table 2).

Table 4. SPEARMAN RANK CORRELATION COEFFICIENTS FOR HAND VERSUS MACHINE CORE SHEAR VALUES BY DAYS AGING, POOLED ACROSS MATURITY GROUPS AND BY MATURITY GROUP

USDA maturity	7 days aging	21 days aging
Pooled	.84***	.75***
A	.90***	.92***
C	.84**	.73 ¹
E	.85**	.56 ⁺

*** (P<.001); ** (P<.01); ¹ (P<.02); + (P<.10).

When using machine coring, every precaution should be taken to cut longissimus muscle steaks exactly perpendicular to the long axis of the muscle in an effort to standardize sampling. In addition, core location, cookery method, steak location within the longissimus muscle and core location within the steak should be standardized as much as possible.

The comparison of absolute shear values to other researchers' results is extremely difficult due to many factors that can contribute to differences. Among these are: coring method and size, cookery method, initial and final temperature, steak location in the muscle, machine differences, and animal differences, etc. However, if one wishes to make absolute comparisons he would want to control coring method. But, if relative differences are of primary interest, results of this study indicate that machine and hand coring procedures give comparable results.

LITERATURE CITED

- American Meat Science Assn. 1978. Guidelines for Cookery and Sensory Evaluation of Meat. Amer. Meat Sci. Assn., Chicago, IL.
- Bratzler, L.J. 1932. Measuring the tenderness of meat by means of a mechanical shear. Master Thesis. Kansas State University, Manhattan, Kansas.
- Breidenstein, B.B., C.C. Cooper, R.G. Cassens, G. Evans and R.W. Bray. 1968. Influence of marbling and maturity on the palatability of beef muscle. I. Chemical and organoleptic considerations. J. Anim. Sci. 27:1532.
- Kastner, C.L. and R.L. Henrickson. 1969. Providing uniform meat cores for mechanical shear force measurement. J. Food Sci. 34:603.
- King, G.T., O.D. Butler and R.L. Sims. 1958. Beef acceptability as rated by a panel of families and the Warner-Bratzler shear, using loin steaks and chuck roasts from cattle of known history. J. Anim. Sci. 17:1152 (Abstr.).
- Marsh, B.B.. 1977. The basis of tenderness in muscle foods. J. Food Sci. 42:295.
- Reagan, J.O., Z.L. Carpenter and G.C. Smith. 1976. Age-related traits affecting the tenderness of the bovine longissimus muscle. J. Anim. Sci. 43:1198.
- Romans, J.R., H.J. Tuma and W.L. Tucker. 1965. Influence of carcass maturity and marbling on the physical and chemical characteristics of beef. I. Palatability, fiber diameter and proximate analysis. J. Anim. Sci. 24:681.
- Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods (6th Ed.). Iowa State College Press, Ames.
- Tuma, H.J., R.L. Henrickson and D.F. Stephens. 1971. Influence of marbling and animal age on factors associated with beef quality. J. Anim. Sci. 20:921 (Abstr.).

THE EFFECT OF CORING METHOD ON BEEF LONGISSIMUS
MUSCLE SHEAR FORCE VALUES

by

STEPHEN JAMES FRANCIS

B.S., Kansas State University, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Thirty Zebu steer carcasses were selected from a Sao Paulo, Brazil commercial slaughter facility with ten carcasses in each of three groups based on A, C and E USDA beef carcass maturity standards. Seven days postmortem, the longissimus muscle was excised from one side of each carcass from the thirteenth rib to the last lumbar vertebrae. A 2.54 cm steak was cut 5.0 cm from the anterior end of the muscle, the remaining muscle was vacuum packaged and aged (2°C) an additional 14 days before removal of an additional steak. Both steaks were wrapped, frozen and stored (-40°C) on the respective days of cutting for subsequent evaluation. Steaks for Warner-Bratzler shear force evaluation for each muscle and aging treatment were cut adjacent to one another.

Using thermocouples, steaks were cooked to an internal temperature of 70°C in a 170°C oven according to the guidelines of the American Meat Science Association (1978). Cores were taken by hand (hand cores) parallel to the orientation of the majority of muscle fibers. Using the same steaks, cores were taken by machine (machine cores) perpendicular to the steak's cut surface without regard to muscle fiber orientation. Twelve, 1.27 cm cores (six hand and six machine cores) were taken from each steak.

Analysis of variance for each aging treatment revealed no difference ($P>.10$) in shear values among maturity groups in steaks aged either 7 or 21 days regardless of coring method. Data were thus pooled for calculation of simple and Spearman rank correlation coefficients between coring methods by days aging, across maturity groups and by maturity groups.

Simple correlation coefficients of .81 and .80 ($P<.001$) were calculated between coring methods across maturity groups for steaks cut 7 and 21 days

postmortem. On a within age group basis, the simple correlation coefficients ranged from .64 to .92 and were significant at ($P < .05$) and above. To determine the ability of the machine coring method to rank steaks from least to most tender in the same order as hand cored steaks, Spearman rank correlation coefficients were calculated. When maturity groups were pooled, the Spearman rank coefficients were .84 and .75 ($P < .001$) between coring methods across maturity groups for 7 and 21 days of aging, respectively. Within maturity groups, coefficients ranged from .73 to .92 and were ($P < .02$) and above for all but E maturity, 21 days aging .56, ($P < .1$) .

The results of this study suggest longissimus muscle cores for use in Warner-Bratzler shear tests obtained by either coring method results in the same relative data interpretation.