COMBINING WARNER-BRATZLER AND SLICE SHEAR FORCE IN ONE STEAK USING TWO DIFFERENT COOKING METHODS

C. L. Lorenzen[1], Z. D. Callahan[1], R.M. Dolazza[1], Z.T. Robertson[1], K. E. Belk[2], R. K. Miller[3], and J. B. Morgan[4]

[1]Division of Animal Sciences, University of Missouri, Columbia, Missouri USA 65203; [2]Department of Animal Sciences, Colorado State University, Fort Collins, Colorado USA 80523; [3]Department of Animal Sciences, Texas A&M University, College Station, Texas USA 77843; [4]Pfizer Animal Health, 3523 W. Bristol Road, Stillwater, Oklahoma USA 74074.

Abstract - This research was performed to determine the feasibility of measuring both Warner-Bratzler shear force (WBSF) and slice shear force (SSF) in the same steak. The objectives were to compare cooking methods commonly used in preparing steaks for WBSF and SSF procedure and compare them at different cooling times. USDA select strip loins (n=240) were aged for either 7 or 14 days to increase the variation in tenderness. Each strip loin was frozen and cut into 2.54 cm steaks. Steaks were cooked to an internal temperature of 71°C using a clamshell grill (clamshell) or an open hearth grill (open hearth). Steaks were allotted to four different cooling times to create the combinations of: WBSF 4h, SSF 0h (Trt1); WBSF 4h, SSF 4h (Trt2); WBSF 24h, SSF 0h (Trt3); WBSF 24h, SSF 24h (Trt4). Five, 1.25 cm cores were used for WBSF and one, 1x5 cm slice for SSF. Correlations for WBSF and SSF performed in the same steak ranged from 0.61 to 0.88 ($P < 0.0001$). Trt3 had the strongest relationship (0.88; $P < 0.0001$) between WBSF and SSF when using clamshell method. Trt4 had the strongest relationship (0.83; $P < 0.0001$) between WBSF and SSF when using open method.

Key Words – Beef, Shear Force, Tenderness Method

I. INTRODUCTION

Meat scientists have long used Warner-Bratzler shear force (**WBSF**) as the standard, instrumental tenderness measurement. There are, however, some limitations to WBSF (Table 1) which led to a more rapid shearing method, slice shear force (**SSF**), being developed by Shackelford [1]. During the development and validation of the SSF method a moderate correlation to WBSF was observed when the methods were performed on matched but different steaks (r = 0.65–0.87; [2]). Previous research by this team showed moderate correlations (0.53 – 0.70) between WBSF and slice shear force (**SSF**) when the measurements were taken in the same steak [3]. In the previous project the majority of the steaks were tender with only eight percent of the steaks (n = 99) used having a WBSF above 4.6 kg [3]. In order to determine the true efficacy of measuring both WBSF and SSF in the same steak the database needs to be expanded using a selected population of tender and tough meat. Additionally the cooking method used in the previous research employed a constant time which led to variation in final cooking temperatures which was a cause of concern [3]. Constant cooking endpoint temperatures may lead to higher correlations between these two tenderness methods. In the previous study, Lorenzen [3] used four cores for WBSF but Wheeler [4] reported that using five cores resulted in increased repeatability compared to four cores. Incorporating more cores may also improve the magnitude of the correlations. Therefore, the objectives of this project were to compare cooking methods commonly used in preparing steaks for Warner-Bratzler and slice shear force methods and to compare slice shear force performed hot and cooled when Warner-Bratzler shear force is performed cooled.

II. MATERIALS AND METHODS

Steak processing: Commercial USDA Select boneless beef strip loins (n = 240) were aged for either 7 or 14 days to increase variation in tenderness. The strip loins were then frozen and cut into 2.54-cm steaks on a band saw. Steaks

were allotted to one of two common research cooking methods, clamshell grill or an open hearth grill and to different cooling time combinations: WBSF 4h, SSF 0h (Trt1); WBSF 4h, SSF 4h (Trt2); WBSF 24h, SSF 0h (Trt3); WBSF 24h, SSF 24h (Trt4). Steaks were allotted so that each strip loin was represented equally in each treatment. Steaks were then vacuum packaged and remained frozen until cooking.

Table 1. Comparison of Warner-Bratzler and slice shear force methods[a]

Component of Method	WBSF	SSF
Preferred cooking time	No preference	Rapid (conveyor)
Final internal temperature	71 ^{o}C	71 ^{o}C
Cooling time	Range from 4 hr to 24 hr	No cooling time
Number of cores/slices	4 to 6	1
Cross head speed	200 – 250 mm/min	500 mm/min
Numeric force for slightly tender	4.6 kg	25.0 kg

[a]Adapted from AMSA, 1995 and Shackelford et al., 1999a.

Cooking: All steaks were thawed for 48 h at approximately 2^{o}C prior to cooking. Prior to cooking, a raw weight was obtained for each steak. Steaks were cooked on either a clamshell grill (George Foreman Healthy Living Grand Champ^{TM}; **clamshell**) or a on a grated, non-stick electric grill (Hamilton Beach^{TM} Indoor/Outdoor Grill; **open hearth**) to achieve a final internal temperature of 71^{o}C. During cooking steak internal temperature was monitored using a hand held thermometer with a copper-constantan Type-T wire thermocouple (HH-21, Omega Engineering, Stamford, CT 06907 USA). After cooking, a cooked weight was obtained. Cook yield was determined as (cooked weight/raw weight) x 100. WBSF steaks were cooled at either room temperature, approximately 21^{o}C, for a minimum of 4 h or at refrigerated temperature, approximately 2^{o}C, for 24 h. SSF steaks were either not cooled (0 h), cooled at room temperature for 4 h, or cooled at refrigerated temperature for 24 h.

Shearing: For each steak five 1.27-cm cores were removed parallel to the muscle fibers for WBSF and a 1 cm x 5 cm slice removed from the lateral end of the steak parallel to the muscle fiber for SSF. All shear forces were performed on the United STM Smart-1 Test System SSTM-500 (United Calibration Corp., Huntington Beach, CA). Settings for WBSF test speed was 250 mm/min and SSF test speed was 500 mm/min.

Statistics: Means and correlation coefficients among steaks and cooking methods were calculated using SAS version 9.2 (SAS Inst., Cary, NC USA). In addition, PROC GLM was used to determine differences in shear values and cook yields; a *P* value of 0.05 was used.

III. RESULTS AND DISCUSSION

While the clamshell method of cooking was faster it produced tougher steaks as evidenced by WBSF and reduced cook yield (Table 2). Interestingly, neither cooking method affected ($P > 0.05$) SSF values. Callahan [5] produced similar means for WBSF and SSF in the same steak when using a convection conveyor oven or oven broiling. However, the means reported by Lorenzen [3] were much lower, 35.3 N for WBSF and 196.0 N for SSF, for steaks cooked in a conveyor convection oven indicating that we were able to achieve our goal of increasing the range of tenderness in the current study. Wheeler [6] found that a conveyor grill produced tougher steaks and lower cook losses than an open hearth grill. While Lawrence [7] reported lower shear force values for steaks cooked with forced-air convection oven and electric broiler compared to a conveyor grill but no differences in cooking loss. This also demonstrates that shear force means can be manipulated by cooking method.

Conducting SSF at 0 h while the steak was still warm produced higher values than steaks sheared after 4 h of cooling ($P > 0.05$; Table 3). WBSF values were not influenced by cooling time ($P = 0.5052$) which is not surprising since both cooling times are endorsed by the AMSA research guidelines for instrumental tenderness measurement [8].

Table 2. Means for Warner-Bratzler Shear and slice shear force by cooking method (n = 240/cooking method)

	Clamshell	Open Hearth	*P* value
WBSF (N)	57.8[a]	46.1[b]	<.0001
SSF (N)	268.5	260.7	0.3564
Cook yield (%)	79.2[a]	81.9[b]	<.0001
Cook time (min)	7.2[b]	15.2[a]	<.0001

[a,b]Means within a row lacking a common superscript differ.

Table 3. Means for slice shear force by cooling time

Time	SSF (N)
O h (n=240)	276.4[a]
4 h (n = 120)	246.0[b]
24 h (n = 120)	260.7[ab]

[a,b]Means within a column lacking a common superscript differ ($P < 0.05$).

Correlations between WBSF and SSF within the same steak are presented in Table 4 and ranged from 0.61 to 0.88. These correlations are stronger than the correlations reported by Lorenzen [3] and Callahan [5] using a convection conveyor oven or an oven broiling method for cooking steaks. The increase in the number of cores used to determine WBSF, consistent endpoint temperature, and changes in cooling times may explain the increase in correlation values between Lorenzen [3] and the current study.

Table 4. Correlations between Warner-Bratzler Shear force (WBSF) and slice shear force (SSF) at the varying cooling times within the same steak (n = 60/WBSF-SSF combination).

Treatment	Clamshell	Open Hearth
1 (WBSF 4 hr/ SSF 0 hr)	0.77 (<.0001)	0.71 (<.0001)
2 (WBSF 4 hr/SSF 4 hr)	0.82 (<.0001)	0.61 (<.0001)
3 (WBSF 24 hr/ SSF 0 hr)	0.88 (<.0001)	0.70 (<.0001)
4 (WBSF 24 hr/ SSF 24 hr)	0.76 (<.0001)	0.83 (<.0001)

IV. CONCLUSION

The clamshell cooking methods offers decreased cooking times and the strongest correlations between WBSF and SSF in the same steak. Traditional open hearth cooking methods lead to more tender steaks according to WBSF and strong correlations. This research confirms that WBSF and SSF can successfully be accomplished in the same steak.

ACKNOWLEDGEMENTS

This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board by the Missouri Beef Industry Council.

REFERENCES

1. Shackelford, S.D., Wheeler, T.L., & Koohmaraie, M. 1999a. Tenderness classification of beef II: design and analysis of a system to measure beef longissimus shear force under commercial processing conditions. J. Anim. Sci. 77:1474-1481.
2. Shackelford, S.D., Wheeler, T.L. & Koohmaraie, M. 1999b. Evaluation of slice shear force as an objective method of assessing beef longissimus tenderness. J. Anim. Sci. 77:2693–2699.
3. Lorenzen, C.L., Calkins, C.R., Green, M.D., Miller, R.K., Morgan, J.B., & Wasser, B.E.. 2010. Efficacy of performing Warner-Bratzler and slice shear force on the same beef steak following rapid cooking. Meat Sci. 85:792-794.
4. Wheeler, T.L., Shackelford, S. D., & Koohmaraie, M. 1996. Sampling, cooking, and coring effects on Warner-Bratzler shear force values in beef. J. Anim. Sci. 74:1553-1562.
5. Callahan, Z.D., Dolazza, R.M., Robertson, Z.T., Callahan, E.M., Belk, K.E., Miller, R.K., Morgan, J.B., & Lorenzen, C.L. 2012. Combining two proven mechanical tenderness measurements in one steak using two different common cooking methods. J. Anim. Sci. (Accepted Abstract)
6. Wheeler, T.L., Shackelford, S. D., & Koohmaraie, M. 1998. Cooking and palatability traits of beef longissimus steaks cooked with a belt grill or an open hearth electric broiler. J. Anim. Sci. 67:2805-2810.
7. Lawrence, T.E., King, D.A., Obuz, E., Yancey, E.J., & Dikeman, M.E. 2001. Evaluation of electric belt grill, forced-air convection oven, and electric broiler cookery methods for beef tenderness research. Meat Sci. 58:239-246.
8. AMSA. 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Chicago, IL. American Meat Science Association.