PE4.56 A Comparison between the US and the Norwegian Method for Assessment of Warner-Bratzler Shear Force 196.00

Rune Rødbotten (1, 2) rune.rodbotten@umb.no, Jan Berg(1), Josefine Skaret 2, Kjell Ivar Hildrum 2 Jens Petter Wold 2 Dalton Dwain Johnson 3
(1)Norwegian University of Life Sciences
(2)Nofima Mat AS
(3)University of Florida

Abstract **Warner-Bratzer (WB) shear force and sensory tenderness have been measured on *Longissimus dorsi* (LD) and *Triceps brachii* (TB) obtained from both US and Norwegian cattle. Shear force was measured with both the US and Norwegian WB methods. The two methods were highly correlated. Lower WB values were obtained when samples were measured with the US method than the Norwegian. The Norwegian WB method was able to distinguish between the three design parameters "Age of animal", "Country of origin" and "Muscle", while "Age of animal" was the only significant parameter when the US method was applied. However, the US method obtained higher correlation coefficient between WB and sensory tenderness than the Norwegian method.**

1) Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway.
2) Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway
3) Department of Animal Sciences, University of Florida, Gainesville 32611, USA

Key words: **beef, collagen, sensory tenderness, Warner-Bratzler**

I. INTRODUCTION

Warner-Bratzler (WB) shear force is the most commonly used method for assessment of tenderness today [1]. Although WB is talked-about as one method different laboratories around the world have unlike protocoles for performance of their WB measurements. For example in Norway, as the rest of Europe, it is common to cook the meat samples in a waterbath, while grilling is the standardized method in USA. Although the heat treatment is stoped when the center temperature reach 70ºC in both countries these two approches give unequal temperature gradients in the meat samples. Other differences between the two protocoles are 1) the cross-head speed of the knife during the shear force measurement, 2) the shape and cross-sectional area of the cores (parallelles) from each steak and 3) the number of parallelles from each steak. All these factors may influence the final result.

Sometimes it is claimed that US beef is more tender than European beef. However, to be able to compare and discuss results it is absolutely necessary to know how the values relate to each other. Therefore, the purpose of this study was to compare the US and Norwegian WB shear force methods. This was done by analyzing samples from the same muscles in both countries with their respective protocol. In addition, the WB results were compared with sensory analyses since this was considered to be the "gold-standard".

II. MATERIALS AND METHODS

A. Animals and sample preparation

Longissimus dorsi (LD) and *Triceps brachii* (TB) muscles were collected from 24 different carcasses. 12 of these carcasses were harvested in a commercial slaughterplant in Norway, while the other 12 were harvested in the slaughterplant at the University of Florida. Carcasses were selected so they spanned a wide range in age and gender. From both countries 6 young and 6 elder carcasses were selected. All the young Norwegian samples were collected from bulls (age 19 – 24 months). The elder Norwegian samples were cows (age 4 – 8 years). Also, the old US samples were collected from cows of the same age as the Norwegian. The group of young US samples were collected from 3 steers and 3 heifers (all 6 approximately 18 months).

After slaughter all 24 carcasses were chilled at 4°C for 48 hours before the LD and TB muscles were excised. These muscles were vacuum packed in plastic bags and further aged for 12 days at 2°C, then frozen at -40°C. A frozen part of each Norwegian muscle was sent to the Univeristy of Florida, and equally a part of each US muscle was sent to Nofima Mat in Norway. All muscles were keept frozen on dry-ice during the shipment.

B. Norwegian method for preparation and measurements

The frozen muscles were cut into 3.5 cm thick slices across the longitudinal direction of the muscle and thawed overnight at 4ºC. The next day the slices were repacked in vacuum bags and heated in waterbath at 70.5ºC for 50 minutes, which gave an internal

temperature of 70ºC, then chilled in ice-water for 50 minutes. The samples were conditioned at room temperature for at least 2 hours before rectangular pieces of 1x1x3 cm were cut along the fibre direction. These pieces were used for either WB or sensory analysis.

Warner-Bratzler shear force – Norwegian method.

Ten pieces of each muscle sample were sheared perpendicular to the fibre direction with a WB shear force device attached to an Instron Materials Testing Machine (Model 4202, Instron Engineering Corporation, High Wycombe, UK). The cross-head speed was 100 mm/min. The mean value of each sample was used in the data analysis.

Sensory descriptive analysis – Norwegian samples.

A trained tase panel of 10 persons used Descriptive Sensory Analysis (ISO-6564-1985- Methodology-Flavor Profile) to assess the samples. The meat samples were served at 20ºC. Fifteen attributes were assesed and registrated in a computer registration system (CSA, Compusens, Canada). The results were converted to numbers between 1 (low intensity) and 9 (high intensity), and the mean value of each parameter was used in the data analysis.

C. US method for preparation and measurements.

The frozen muscles were cut into 2.5 cm thick slices across the longitudinal direction of the muscle and thawed overnight at 4ºC. The next day the slices were cooked to an internal temperature of 71ºC on a Hamilton Beach Indoor-Outdoor Grill, Model 31605 AH. The steaks were covered with plastic film and chilled over-night. The following day cores of 1.27 mm in diameter were taken from the steaks and used for WB analysis. Sensory samples were cut while warm into 1.27 mm cubes and two cubes from each sample was served to panelist.

Warner-Bratzler shear force – US method.

Six cores of each muscle sample were sheared perpendicular to the fibre direction with a WB shear device on an Instron Testing Machine (Model 1011, Instron Corporation, Canton MA, USA). The cross-head speed was 200 mm/min. The mean value of each sample was used in the data analysis.

Sensory descriptive analysis – US samples.

A panel of 10 persons, trained according to AMSA sensory evaluation guidelines (AMSA, 1995) evaluated the samples for 5 attributes. Juiciness, Beef Flavor Intensity and Overall Tenderness were evaluated on a scale from 1 (low intensity) to 8 (high intensity). The scale was opposite for Connective Tissue, 1=high intensity and 8=low intensity. Off Flavor was evaluated on a scale from 1 (extreme off-flavor) to 6 (no off-flavor). The mean value of each sample was used in the data analysis.

D. Collagen and fat measurements

A slice of aproximately 1.5 cm was cut across each muscle and finely homogenized. From a 5g subsample soluble and insoluble collagen content were determined as described by Von Seggern et. al. [2]. Intramuscular fat content was assessed from another subsample of approximately 5g according to the AOAC procedure 24.003 and 24.005.

E. Statistical analysis

Statistical analyses were performed in MINITAB, version 15. The data were analysed using the GLM procedure with the factors muscle (M), age of the animal (A) and country (C). The 2-factor interactions were also included in the model.

III. RESULTS AND DISCUSSION

The animals used in this study were selected to span a wide range in age, which was expected to influence tenderness and other meat quality parameters. Several studies have shown differences in quality parameters between bulls and steers [3]. Since the male cattle from USA were steers while the Norwegian male samples were bulls gender was not included as a factor in the analysis of variance.

As shown in Table 1 there was a tendency ($p=0.076$) for higher collagen content in the Norwegian samples compared to the US samples. There was no difference in total collagen content between muscles from young or old carcasses. However, samples from young animals had significantly higher ($p<0.05$) content of soluble collagen than samples from elder carcasses. As expected, there was found higher content of total collagen in TB compared to LD muscles. This is in agreement with previous studies [4], [5]. There was a tendency ($p=0.055$) for higher fat content in the US compared to the Norwegian samples. Fat content was correlated ($p<0.05$) to WB shear force and sensory tenderness. Neither total nor soluble collagen content was correlated to WB shear force.

All 48 muscle samples from Norway and USA were analyzed with both WB shear force methods. Since the results from these two methods usually are expressed in different units, “kg” for the US- and “Newton” (N) for the Norwegian method, and the cross-sectional area of the samples were different all values were adjusted to the same unit “kg/cm^2” for comparison. The adjusted values are plotted against each other in Figure 1. As expected these methods were highly correlated ($r=0.69$,

$p<0.001$). Higher ($p<0.001$) WB values were obtained when samples were measured with the Norwegian compared with the US method. This discrepancy was probably related to cooking method, which was different between methods. Although the steaks were cooked to an internal temperature of 70ºC with both methods a water-bath was used in the Norwegian method, while the samples were grilled in the US method. This resulted in a longer heating time for the Norwegian method. Cross-head speed of the shear force instruments was another factor which most likely affected the difference in WB-values between methods too. The cross-head speed was 200 mm/min for the US method, while 100 mm/min was used in the Norwegian method. Wheeler et. al. [6] compared different cross-head speeds and obtained a WB value of 4.4 kg at 100 mm/min and 3.8 kg when the speed was increased to 200 mm/min. However, in the present study an adjusted value of 4.0 kg obtained with the US metod would correspond to an adjusted value of 7.2 kg for the Norwegian method (Figure 1).

According to Shackelford et. al. [7] most consumers will rate steaks with a WB value of 3.9 kg or less as "tender" when evaluated by the US method. The threshold value for "slightly tender" was set at 4.6 kg in that study. Based upon the results of the present study a corresponding value for the Norwegian method (expressed in original units) would be approximately 47.3 and 61.6N for respectively "tender" and "slightly tender".

As shown in Table 2 both the US and Norwegian methods were able to distinguish between samples from young and old carcasses. However, no difference was found between LD and TB samples, or US and Norwegian samples when the US WB method was applied. When the Norwegian method was applied significant differences ($p<0.05$) was seen for "country" and "muscle" also. The LD muscles had higher WB shear force than the TB muscles which may be a paradox since the retail price in the Norwegian market for LD is almost twice compared with TB. The interaction between Age and Country was significant ($p<0.05$) in both ANOVA's where WB was the respons variable. Figure 2 shows that almost identical WB values were obtained for samples from old animal, while the young animals from Norway had considerably higher shear force than the young animals from USA. The observed difference for the young samples could be related to the gender of the samples. All young Norwegian samples were bulls, while the US samples were steers and heifers.

Although the design variables were better differenciated by the Norwegian WB method the best evaluation criterion for the methods was comparison with sensory tenderness. However, neither the Norwegian nor the US authorities gave permission for sensory analysis of beef samples from foreign countries. Therefore the sample set had to be split into a US- and a Norwegian part for the comparison between WB and sensory results. The overall correlation coefficient for both LD and TB muscles was -0.51 for the Norwegian samples, while the corresponding value for the US samples was -0.76. In Figure 3 and 4 the two tenderness methods are plotted against each other for US and Norwegian samples, respectively. As shown, the correlation coefficients for the two sub-sets of LD muscles were of the same size. The US TB samples obtained a relatively high correlation coefficent ($r = -0.87$) while the Norwegian TB samples obtained a more moderate correlation value. It is difficult to draw confident conclusions about the methods since the sample sets were small and not all samples could be evaluated against the same "gold standard" of sensory analysis. However, the obtained results seem to indicate that the US method gives a higher correlation coefficient between WB and sensory tenderness.

ACKNOWLEDGEMENT

The project ProSafeBeef in the EU 6th framework research program and the Norwegian Research Council are acknowledged for financial support. The assistance from colleagues at Nofima Mat AS and University of Florida is much appreciated.

REFERENCES

[1] Destefanis, G. et al. (2008). Relationship between beef consumer tenderness perception and Warner-Bratzler shear force. Meat Science 78: 153-156
.

[2] Von Seggern, D.D. et. al.. (2005). Muscle profiling: Characterizing the muscles of the beef chuck and round. Meat Science 71: 39-51.

[3] Cross, H. R. et. al.. (1984). Sex, age and breed related changes in bovine testosterone and intramuscular collagen. Meat Science 10: 187-195.

[4] McKeith, F. K. et. al. (1985). Chemical and sensory properties of 13 major beef muscles. Journal of Food Science 50: 869-872.

[5] Rhee, M. S. et. al. (2004). Variation in palatability and biochemical traits within and among eleven beef muscles. Journal of Animal Science 82: 534-550.

[6] Wheeler, T. L. et al. (1997). A comparison of Warner-Bratzler shear force assessment within and among institutions. Journal of Animal Science 75: 2423-2432.

[7] Shackelford, S. D. et. al. (1991). Identification of threshold levels for Warner-Bratzler shear force in beef top loin steaks. Journal of Muscle Foods 2: 289-296.

Table 1. Mean values for collagen and fat content in the beef samples.

	TB	LD	Sign.	Young	Old	Sign.	USA	NOR	Sign.
Tot. coll (mg/g)	6.62	4.50	**	5.28	5.84	NS	4.76	6.35	(-)
Sol. coll (mg/g)	0.525	0.297	**	0.501	0.311	*	0.369	0.440	NS
Fat (%)	2.81	3.12	NS	2.91	3.02	NS	3.40	2.53	(-)

NS =p>0.1 (-) = p<0.1 *= p<0.05 ** = p<0.01 *** = p<0.001

Table 2. Warner-Bratzler mean values obtained with the US- and Norwegian methods.

	TB	LD	Sign.	Young	Old	Sign.	USA	NOR	Sign.
USA-WB (kg)	4.65	4.85	NS	4.24	5.27	***	4.70	4.85	NS
NOR-WB (N)	60.4	68.6	*	57.3	71.6	***	59.9	69.1	*

NS =p>0.1 (-) = p<0.1 *= p<0.05 ** = p<0.01 *** = p<0.001

Figure 1. WB values for the Norwegian and US methods expressed in comparable units (kg/cm^2).