IDENTIFICATION OF TENDERNESS THRESHOLD FOR WARNER-BRATZLER SHEAR FORCE IN VENEZUELAN BEEF

Rodas-González A.[1], Jerez-Timaure N. [2], Huerta-Leidenz N. [2]

[1]Facultad de Ciencias Veterinarias y [2]Facultad de Agronomía, Núcleo Agropecuario, La Universidad del Zulia- Maracaibo, Venezuela.

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Background

In Venezuela, tenderness is also the most important factor influencing consumer satisfaction for beef palatability (Huerta and Rodas, 1998) and consumers demand for consistently tender meat is increasing. Regrettably, most of the beef production comes from mature cattle, particularly entire males (bulls), grass feeding, with high predominance of *Bos indicus* types. These conditions are largely responsible for the high variation observed in beef palatability in Venezuelan (Huerta *et al*., 2004) and make more difficult to target consistency in tenderness.

Years ago, it was thought that a means of segregate tender beef would be through the beef carcass grading system. Currently, Venezuelan grading systems for quality (Decree 181, 1994; Decree 1896, 1997) have not provided an accurately mean to segregate carcasses into expected palatability groups (Huerta *et al*., 1996; Malaver *et al*., 2000). Even though, in the United States with a vast experience in the grading of carcass for quality have revealed the same kind of inconsistency (Shackelford *et. al*., 1997).

Due to the deficiencies of the quality grading systems, different groups of investigators have tried to locate the separation line between tender and tough meats (Shackelford *et a*l, 1991; Tatum *et al.*, 1996; Shackelford, *et al*., 1997; Carr *et al*., 1998;) to generate more accurate classification for tenderness . The establishment of tenderness thresholds serves as quality control with more precision to guarantee tender meats and to assure consumer acceptability.

Objectives

To obtain a tenderness threshold classes by relating trained panel data to Warner Bratlzler shear force in beef.

Materials and methods

Animals: Cattle (n=738) originated from the main beef producing regions of Venezuela representing different breeds (crossbred *Bos indicus* x *Bos taurus)*, sex (bulls, steers, heifers and cows) and age (1-11 years). All cattle were slaughtered at a commercial packing plant. At 24 h *postmortem*, carcasses were ribbed and evaluated by USDA quality grade (USDA, 1989) and by Venezuelan grading system (Decree 1896,

1997). At 48 h postmortem, four steaks (2.54-cm thick) were removed from the *longissimus dorsi thoracis* muscle (ribeye) from the right side of each carcass and vacuum-packaged for sensory panel and Warner Bratlzer shear force (WBS) evaluation. These steaks were frozen at -30ºC immediately (2 d postmortem) until the date of their evaluation.

Steaks were thawed at 4 ºC for 24 h prior to sensory or shear tests. Preparation and cooking of samples for sensory and shear force evaluation were carried out following the general recommendations of the American Meat Science Association (AMSA, 1995). The steaks were cooked on an electric grill, which was preheated (approximately at 165 ºC). Steaks were turned once during broiling and removed from the grill when they reached the desired internal temperature (70 ºC).

The taste panel was comprised of eight highly trained judges (Jerez *et al*., 1994) from both sexes with different education levels, age between 25 and 45, that tasted a maximum of 12 samples (in two sessions) per day. Two or three, cubed samples taken from steaks of each animal were served warm to each judge. Judges scored the samples for muscle fiber tenderness, overall tenderness, juiciness, amount of connective tissue and flavor intensity using an 8-point structured rating scale for each attribute (where 1 = extremely tough, extremely tough, extremely dry, an abundant amount of connective tissue, extremely bland, respectively, and 8= extremely tender, extremely tender, extremely juicy, no connective tissue, extremely intense, respectively)(AMSA, 1995, Jerez *et al*., 1997).

Cooked rib steaks for shear evaluations were allowed to cool down to room temperature and four to ten core samples (1.27cm in diameter) depending on the area of the *longissimus* muscle, were removed parallel to the muscle fiber orientation, taking care not to include pieces of fat or chunks of connective tissue in the core. Each core was sheared once using a Warner-Bratzler shear machine (G-R Elec. Mfg. Co, Manhattan, KS). The four to ten Warner-Bratzler Shear force (WBS) values were recorded and averaged to obtain a single shear force value for each steak.

Simple descriptive statistics were computed for carcass traits using PROC MEANS (SAS, 1996) to characterize the animals from database. To establish the tenderness threshold, a simple lineal regression of the WBS values on the overall tenderness score of sensory panel was made using the SAS statement PROC REG (SAS, 1996).

Results and Discussion

Means, standard deviations (SD), and minimum/maximum values for carcass characteristics and WBS values are presented in Table 1. Since the carcass sampled were representative of the Venezuelan beef herds, a wide range in each of the carcass traits were observed. The chronological age revealed a high variation (12 to 132 mo.) corresponding to the high variation observed in skeletal and lean maturity indicators (A to D). Furthermore, fat external finish showed a high variation (very abundant to devoid), but such variation does not correspond to marbling score, that ranged between “small” and “practically devoid”. According to the Venezuelan grading criteria (Decree 1896, 1997) 60.11% of the carcasses was graded in the “A” category (also named “Excelent”) followed by the “B” category (29.64 %, or “Select”). According to USDA grading system, (USDA, 1989) 88.65% of the carcasses were categorized as “Standard”.

Lineal regression analysis of WBS on overall tenderness ratings (with trained panel) in our laboratory indicates that a sample rated “slightly tender” correspond to the WBS value 3.86 kg. A sample was classified as “tender” if its shear value was less than 3.86 kg. The following procedure was to separate the group of “tough” meats in some of “intermediate” meat (which tenderness rating and acceptance could be improved with ageing) and other frankly “tough” ones (showing off their doubtful acceptance, being even ageing). The separation line between “intermediate” and “tough” meat, correspond to the sensory panel description of "slightly tough" with WBS values greater than 4.98 kg. Therefore, the interval of meat with “intermediate” toughness was set between 3.86 and 4.98 kg, so a sample was classified as “tough” if its shear value was higher than 4.98 kg.

There are several thresholds reported in the literature. They defined meat as “tender” when they have less than 6 kg. (Shackelford et al., 1997), 4.6 kg. (Shackelford et al., 1995), 3.85 kg. (Tatum et al., 1996) or 3.0 kg. (Huffman et. al., 1996; Wheeler et al., 1997) of WBS. These differences among research centers in the tenderness threshold may be due to differences in the sensory panel training procedures, differences in shear force assessment, or both (Wheeler et al., 1997). However, our threshold is similar to the one reported by Tatum et al. (1996). Some researcher have reported (Shackelford et al., 1991; Miller et al., 1995; Huffman et al., 1996) that consumer are able to distinguish differences in beef tenderness that have been classify based on Warner-Bratlzler shear force; consequently, in necessary evaluate our tenderness threshold by Venezuelan consumer.

Conclusions

The tenderness threshold obtained in this study allows the definition of three categories: WBS values <3.86 kg. for tender meats, >3.86 <4.98 kg. for intermediate meats and >4.98 kg. for tough meats. This threshold was obtained based on trained sensory panel, and it lacks of the final consumer's opinion. Further studies that include consumer acceptability are necessary to establish the true value of tenderness.

The generation of these thresholds will be useful in the formulation of programs to generate commercial marks that allow the certification of quality beef in the market of demanding consumers.

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TABLE 1.
STATISTICS FOR CARCASS TRAITS AND SHEAR FORCE.

Trait	Mean	SD	Min.	Max.
Leg muscle profile[a]	3.09	0.79	1.00	5.00
Fat external finish[b]	3.39	0.71	1.00	5.00
Back fat thickness, mm[c]	2.59	2.24	0.00	19.00
Marbling score [d]	4.95	0.23	3	5
Ribeye area, cm^2	73.66	12.70	36.12	121.93
Bone maturity [e]	B^{19}	53.96	A^{30}	D^{50}
Lean maturity [e]	B^{04}	49.88	A^{20}	D^{00}
Adipose maturity [f]	2.70	0.49	2.00	4.00
Final maturity [g]	B^{11}	44.32	A^{47}	D^{30}
Carcass weight, kg	268.90	37.28	149.00	465.00
Chronological age, mo.	36.45	10.64	12.00	132.00
Venezuelan grade, % [h]	AA: 2.49			
	A: 60.11			
	B: 29.64			
	C: 7.76			
USDA quality grade, %	Choice: 0.27			
	Select: 1.50			
	Standard: 88.65			
	Utility: 9.30			
	Cutter 0.27			
Shear force at 2 d postmortem, kg.	5.17	1.89	1.87	11.88

SD: standard deviation

[a] According to Presidential Decree No. 1896 (1997): where 1 = very convex, 2 = convex, 3 = straight, 4 = concave and 5 = very concave.

[b] According to Presidential Decree No. 1896 (1997): where 1 = very abundant, 2 = abundant, 3 = moderate, 4 = slight and 5 = devoid.

[c] Measured at the $12^{th}/13^{th}$ rib interface.

[d] Marbling scores according to Presidential Decree No. 181 (1997): where 3 = Small; 4= Slight; 5=traces and Practically devoid.

[e] Maturity scores according to USDA (1989). Where A= younger maturity; D=older maturity; degrees 0-99.

[f] Adipose tissue maturity based on fat color, according to Presidential Decree No. 1896 (1997); where 1 = ivory white, 2= creamy white, 3 = yellowish, 4 = yellow, and 5 = orange.

[g] According to Presidential Decree No. 1896 (1997).

[h] Carcass grade according to Presidential Decree No. 1896 (1997); where A=Excellent; B=Select.