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1993

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Wheeler, Tommy L.; Cundiff, Larry V.; and Koch, Robert M., "Effect of Marbling Degree on Palatability and Caloric Content of Beef" (1993). *Roman L. Hruska U.S. Meat Animal Research Center*. 126.  
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# Effect of Marbling Degree on Palatability and Caloric Content of Beef

Tommy L. Wheeler, Larry V. Cundiff, and Robert M. Koch<sup>1,2</sup>

## Introduction

The relationship of marbling to beef palatability has been the subject of numerous investigations and several review papers. A vast majority of the data on this subject indicate that there is a positive relationship between marbling degree (or percentage chemical fat) and tenderness, juiciness, and flavor intensity, and an inverse relationship with Warner-Bratzler shear force (a mechanical measure of tenderness). However, this relationship is weak at best. Generally, although tenderness may increase linearly as marbling increases, the increments are very small, particularly from one marbling degree to the next. A comparison of the extremes in USDA quality grade (e.g., Standard and Prime) was usually needed to find statistical differences of any practical importance. Based on available data, it appears that between 5 and 10% of the variation in tenderness can be accounted for by USDA marbling degree. Most importantly, none of the studies detected palatability differences between Slight and Small marbling degrees that could justify price differentials frequently found in the market place. The objective of this study was to determine the effect of marbling score on palatability and caloric content of meat from diverse breeds of cattle.

## Procedure

**Animals.** The data presented in this paper are from 1,337 steers and heifers from the Germplasm Evaluation (GPE) program at MARC. The breed groups represented include: Hereford, Angus, Longhorn, Salers, Galloway, Shorthorn, Piedmontese, Charolais, Gelbvieh, and Pinzgauer. These animals were born between 1986 and 1990 in March through May and weaned about October 1. After weaning, steers were fed a growing ration for 4 mo and then were allowed unrestricted access to a mixed diet of corn silage, corn and soybean meal. The cattle were slaughtered either at the MARC abattoir or at a commercial processing plant. After a 24 hr chill, the right sides of the carcasses from the commercial plant were transported to the meat laboratory at MARC at 48 hr postmortem. The loin muscle was removed and cut into 1-in thick steaks. The steaks were vacuum packaged and stored at 35°F until 7 days postmortem and then frozen at -86°F for up to 6 mo before thawing and cooking for Warner-Bratzler shear force and trained sensory evaluation.

**Shear and Sensory Evaluation.** Frozen steaks were tempered at 36°F for 24 hr then broiled to 158°F internal temperature (medium degree of doneness). The cooked steaks for shear force were chilled 24 hr at 36°F, then six .5-in diameter cores were removed parallel to the muscle fibers and sheared once each. Steaks for trained sensory evaluation were cut into .3 x .3 x 1-in samples and served warm to a trained sensory panel. Each panelist independently evaluated each sample for juiciness, tenderness, and flavor intensity on eight-point scales (1=extremely juicy or extremely tender or extremely intense; 8=extremely dry or extremely tough or extremely bland).

**Proximate Analysis.** Moisture content was determined by oven drying and chemical fat content by ether extraction on uncooked loin muscle. Protein content was calculated by difference, allowing 1% for ash content. Calories were calculated from the following equations:

- 1) Percentage protein x 4.46 x 28.4 = calories per oz protein
- 2) Percentage lipid x 9.01 x 28.4 = calories per oz fat

## Results

Warner-Bratzler shear force was not different between marbling scores ranging from Slight through Moderate (Fig. 1A). Traces marbling was not different in shear force from Slight marbling, but had a higher shear force than Small, Modest or Moderate marbling scores. In addition, the percentage of meat with shear force of greater than or equal to 13.2 lb (comparable to an overall tenderness rating of 4.5 or "slightly tough") was similar between Small, Modest and Moderate marbling scores, but slightly higher for Traces and Slight. However, more than half of the meat with Traces or Slight marbling had shear force values comparable to "slightly tender" or better sensory tenderness rating. A similar response was found for tenderness rating (Fig. 1B). Meat with Traces marbling score received slightly lower tenderness ratings than Small, Modest, and Moderate marbling scores. The percentage of tenderness ratings less than 4.5 (slightly tough) was higher for Traces and Slight compared to Modest and Moderate marbling scores.

Juiciness rating tended to increase as marbling score increased, but Small marbling was not different in juiciness from any other marbling score (Fig. 1C). Meat with Traces or Slight marbling scores received lower juiciness ratings than meat with Modest or Moderate marbling scores. A slightly greater percentage of meat with Traces and Slight marbling scores received juiciness ratings of less than 4.5 compared to Modest marbling score. Beef flavor intensity was not affected by marbling score (Fig. 1D).

Regression of shear force and sensory traits on marbling indicated the inability of marbling score to predict meat palatability (data not shown). Equations for shear force, tenderness and juiciness ratings were significant, but only 1 to 3% of the variation in these traits was explained by marbling score. Clearly, marbling was of little value in explaining the variation in palatability of the meat in this study.

Percentage chemical fat, fat calories and total calories increased linearly as marbling score increased in uncooked loin muscle, except Traces was not different from Slight (Table 1). Percentage protein and calories from protein did not vary as marbling score increased. Percentage of total calories from fat increased and percentage of total calories from protein decreased as marbling score increased, except Traces was not different from Slight.

Due to the USDA quality grading standards and their implied segregation of meat based on palatability, the U.S. beef industry has placed a high value on marbling in the loin muscle. The emphasis on marbling in determining carcass value is based on the slight increases in juiciness, flavor and tenderness that are obtained as marbling is increased. There are, however, several problems with the current emphasis on marbling for segregating beef carcasses based on expected meat palatability. Firstly, an abundance of research stretching over the last 30 yr indicates that mar-

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<sup>2</sup>The authors would like to acknowledge the technical and statistical assistance of Kay Theer and Darrell Light.



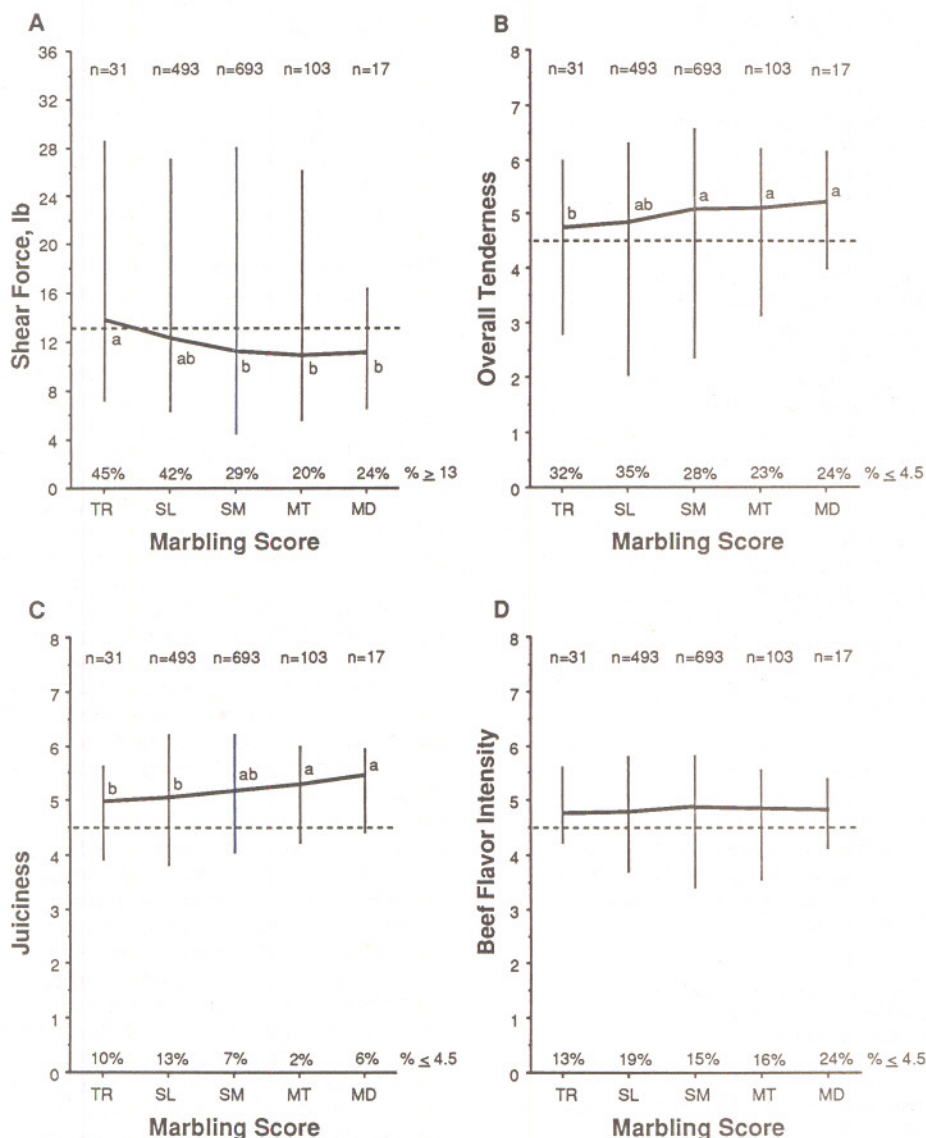
bling fat has a low relationship to palatability and explains only about 5-10% of the variation in tenderness of the loin muscle. Secondly, other research indicates that the variation in marbling in the loin muscle has little or no effect on palatability of other muscles. Thus, a visual assessment of the amount of marbling in a cross section of the loin muscle at the 12th rib may not be appropriate as a major determi-

nant of the value of the entire carcass. Our data support previous research indicating that marbling has little association with meat palatability. The emphasis on marbling in beef promotes excess fat production in cattle and does little to ensure desirable eating quality of the meat. Clearly, a more accurate method to predict meat palatability is needed.

**Table 1—Composition and caloric content of 3.5 oz uncooked loin muscle with different marbling scores**

Marbling	Chemical fat			Protein		Total calories	Calories from fat, %	Calories from protein, %
	N	%	Calories	%	Calories			
Traces	23	3.3 <sup>d</sup>	30.3 <sup>d</sup>	21.7	97.0	127.4 <sup>d</sup>	23.3 <sup>d</sup>	76.6 <sup>a</sup>
Slight	456	3.5 <sup>d</sup>	31.7 <sup>d</sup>	21.9	97.6	129.3 <sup>d</sup>	24.0 <sup>d</sup>	76.0 <sup>a</sup>
Small	661	4.7 <sup>c</sup>	42.5 <sup>c</sup>	21.6	96.2	138.7 <sup>c</sup>	30.2 <sup>c</sup>	69.8 <sup>b</sup>
Modest	93	6.2 <sup>b</sup>	55.9 <sup>b</sup>	21.3	95.0	150.9 <sup>b</sup>	36.8 <sup>b</sup>	63.2 <sup>c</sup>
Moderate	14	7.3 <sup>a</sup>	65.5 <sup>a</sup>	21.2	94.4	160.0 <sup>a</sup>	40.5 <sup>a</sup>	59.5 <sup>d</sup>

<sup>a b c d</sup> Means in a column lacking a common superscript are different ( $P < .05$ ).



**Figure 1** — Shear force and sensory traits as affected by marbling score. The darker, horizontal line passes through the mean values. The vertical lines represent the full range of values. The number of observations for each marbling score is given at the top. The percentage of samples that received unacceptable scores is given at the bottom. The broken line is the boundary between acceptable and unacceptable values. TR = Traces, SL = Slight, SM = Small, MT = Modest, MD = Moderate.