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Evaluation of the Tenderness, Size, and Marbling of Kaua'i Ribeye Steaks

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The objective of this study is to establish a baseline of beef-quality data from ribeye steaks available at the retail meat counter in Kaua'i to help guide production and marketing efforts of local beef. We evaluated the shear force value, marbling, and ribeye area of steaks purchased from various retail markets across the island. Samples were grilled to reach an internal temperature of 71°C (160°F), and 1.3-cm core samples were cut with a Warner-Bratzler blade to determine shear force value. We evaluated marbling score and ribeye area according to standard USDA methods. Shear force values of Kaua'i ribeye steaks ranged from 2.8 kg to 11.0 kg across the 35 samples tested, with a mean of 4.4 kg and standard error of 0.26 kg. More than half of these samples would not meet the majority of consumers' satisfaction. Most Kaua'i steak shear force values ranged from 2.8 to 5.5 kg, with about 10% of the steaks separated from this group with much higher values. Marbling score ranged from 310 (slight) to 740 (slightly abundant), with an average of 450 (small) and standard deviation of 85. Ribeye area ranged from 7.3 in^2 to 15.9 in^2, with an average of 10.2 in^2 and standard deviation of 1.9 in^2, which is slightly smaller than the national average. Kaua'i ribeye steak sample quality grades compared favorably with data published from the Big Island and national studies. When comparing with Mainland data, which includes grain-finished cattle, of note is the fact that Kaua'i and Big Island data are entirely forage-finished cattle. As with other studies, we found no appreciable correlation between quality grade and tenderness. Kaua'i beef processors may benefit from mechanical tenderness improvement technology as well as maintaining strict quality control to limit off flavors.

Introduction

Many factors influence consumers' acceptance of higher-value beef products such as steaks. All factors being equal, tenderness issues overshadow other eating qualities such as flavor or juiciness, and consumers are willing to pay more for steaks guaranteed to be tender (Smith et al. 2008; Miller et al. 2001). To date there has not been a systematic island-wide tenderness assessment of the Kaua'i-produced beef available at the retail market. All commercial beef cattle in Kaua'i are raised entirely on forage, or in other words are "grass-fed" or "grass-finished" as opposed to being fed concentrates. Ranchers supplying the local retail market rely primarily on Guinea grass (*Panicum maximum*), pangola grass (*Digitaria eriantha*), California grass (*Brachiaria mutica*), and several *Desmodium* species to produce finished cattle.

The primary purpose of this store-shelf beef survey is to establish a baseline of tenderness data using a shear force evaluation to help guide Kaua'i ranchers' production and marketing efforts. Based on this information, specific factors known to influence beef tenderness in Hawai'i (Kim et al. 2007b) will be further tested using Kaua'i beef.

Methods

Sample Collection. For nearly four months between March and June 2010, we collected 70 ribeye steak samples from retail outlets across Kaua'i carrying local beef. These samples were vacuum sealed, frozen, and shipped to the Department of Human Nutrition, Food and Animal Sciences, UH-Mānoa campus, for analysis (Figure 1).

Ribeye Area and Marbling. After thawing and trim-

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Figure 1. Kaua‘i-produced ribeye steak samples ready for analysis.

Figure 2. Ribeye steaks were grilled to reach a final internal temperature of 71°C (160°F) before being tested for shear force values.

ming off excess fat, we measured the ribeye area (REA) of steak samples using an industry-standard plastic measurement grid (ISU 1989). We gave each sample a marbling score for grading purposes using the official USDA standard method (USDA 1997). Marbling scores were converted to a 10-point-increment scale ranging from slight (300), through small (400), modest (500), and moderate (600), to slightly abundant (700; Platter et al. 2003). For grading, we assumed beef cattle were slaughtered at less than 30 months of age, based on common practices in Kaua‘i.

Cooking Methods. A subsample of 35 steak samples were grilled on both sides simultaneously at 218°C (425°F) until internal temperatures reached around 65°C (150°F) using a temperature-controlled clamshell-type George Foreman Grill® model #GRP99 series 708 (George Foreman Cooking, Macon, MO). Steaks were then removed to reach a final temperature of 71°C (160°F). Internal temperatures were measured with a Comark DT33 (Comark, Hitchin, UK) digital probe thermometer inserted in the center of the steak and left in during the grilling process (Figure 2).

Shear Force Testing. Five 1.3-cm (0.5-in)-diameter cores were drilled from each of the 35 steak samples parallel to the muscle grain. Cores were cut at a speed of 180 mm/min using a Warner-Bratzler blade attached to a TA.XT2 Texture Analyzer (Texture Technologies Group, Scarsdale, NY). The shear force value assigned to each steak sample was the average of the maximum forces in kilograms required to cut each set of cores (Figure 3).

Figure 3. TA.XT2 texture analyzer fitted with a Warner-Bratzler blade used to measure shear force values of steak samples.

Data analysis. We conducted all data analyses using JMP® 8.0.2 software (SAS Institute Inc., Cary, NC).

Results and Discussion

Shear Force Values. Shear force values of Kaua‘i ribeye steaks ranged from 2.8 kg to 11.0 kg across the 35 samples tested, with a mean of 4.4 kg and standard error of 0.26 kg (Figure 4, Table 1, Table 2). The standard error is a measure of variability among samples. The coefficient of variation (CV) allows for comparison of variability among data sets where a higher CV indicates greater variation among samples. The mean shear value of Kaua‘i ribeye steaks was higher than the mean shear value (4.1 kg) of Big Island ribeye steaks, which

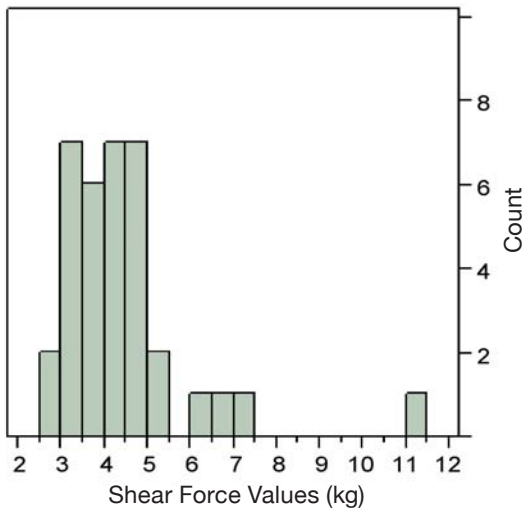

Figure 4. Distribution of shear force values of steak samples.

was obtained from a study in 2007 (Table 1). It also appeared that shear values of Kaua‘i ribeye steaks were more variable than those of Big Island steaks (Table 1).

A previous study reported that 99%, 94%, 86%, and 25% of U.S. consumers expressed satisfaction with the tenderness of their steaks when shear force values were lower than 3.4 kg, lower than 4.0 kg, lower than 4.3 kg, and greater than 4.9 kg respectively (Miller et al. 2001). Our results show that 43% of Kaua‘i steaks had shear force values lower than 4.0 kg (Table 2), suggesting that more than half of Kaua‘i steaks would not meet the majority of consumers’ satisfaction. While shear force values of most Kaua‘i steaks ranged from 2.8 to 5.5 kg, about 10% of the steaks were separated from this group with much higher shear values. Differences in ranch management or in the age at slaughter of the animals supplied to this source probably account for this variation. Trials conducted in Hawai‘i have shown that low-voltage electrical stimulation and mechanical blade tenderizers can lower shear force values by 10% and 20% respectively (Fukumoto and Kim 2007a; Kim et al. 2007b). Beef processors and marketers on Kaua‘i may improve the overall consistency of the tenderness of their products by using these technologies.

Rib Eye Area and Grading. REA ranged from 7.3 in^2 to 15.9 in^2, with an average of 10.2 in^2 and standard deviation of 1.9 in^2 (Figure 5a). Standard deviation is a measure of variability among individual values. Marbling score ranged from 310 (slight = low Select

Table 1. Average shear force value (SFV) and coefficient of variation (CV) of Kaua‘i rib steak samples compared to samples from a study on the Big Island (Fukumoto and Kim 2007b). Big Island values were adjusted to allow for differences in cooking methods.

Source	Avg. SFV (kg)	CV	Range (kg)	Number of samples
Kaua‘i	4.4	35	2.8–11.0	35
Big Island	4.1	25	2.1–7.1	191

Table 2. Summary of samples below or over thresholds of consumer acceptance where 99%, 94%, 86%, and 25% of steaks are acceptable when below 3.4kg, below 4.0kg, below 4.3 kg, and over 4.9 kg respectively (Miller et al. 2001).

Threshold	<= 3.4 kg	<= 4.0 kg	<= 4.3 kg	>= 4.9 kg
Number of samples	7	15	21	6
Percent of total	20	43	60	17

grade) to 740 (slightly abundant = mid-Prime grade), with an average of 450 (small = low Choice grade) and standard deviation of 85 (Figure 5b). Table 3 summarizes REA and grade data for all Kaua‘i rib steak samples as compared to data reported from the Big Island (Fukumoto and Kim 2007b) and national data (Garcia et al. 2008). Some variation in REA of Kaua‘i beef compared to other studies may be explained by the fact that this was a store-shelf survey as opposed to a standard REA measurement at the 12th rib.

On the national level, research indicates a trend toward consumer demand for loin steaks with a REA greater than 11 sq. in. (Sweeter et al. 2005, Savell 2007). The majority of Kaua‘i steaks available at retail were below this level (Table 3). However, trends in local market consumption have not been assessed and may differ from national trends. Other factors such as the perceived health benefits of forage-finished beef, a preference for locally produced beef, or others may outweigh REA and grade as important influences

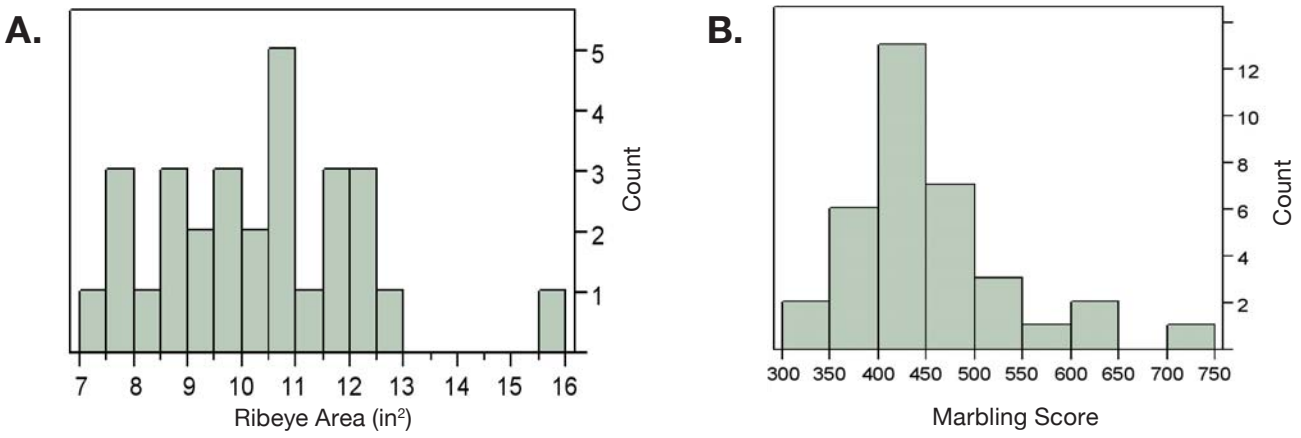

Figure 5. Distribution of ribeye area (a) and marbling score (b) values.

Table 3. Summary of ribeye area (REA) and grade data from Kaua‘i, Big Island (Fukumoto and Kim 2007b), and national studies (Garcia et al. 2008).

Source	Avg. REA (in²)	CV	Range	Percent*					
				S	C-	C	C+	P	N
Kaua‘i	10.2	18.4	7.3–15.9	21	57	3	16	3	69
Big Island	11.5	13.0	6.5–16.8	50	30	6	<2	<2	381
U.S.	13.4	13.7	7.0–24.6	38	-	55	-	3	9173

* S = Select, C- = Low Choice, C = Choice, C+ = High Choice, P = Prime, N = Number of samples.

of consumer retail choices in Kaua‘i. Considerable anecdotal evidence from consumer feedback and food festivals suggests these are very influential factors in Hawai‘i, and these specific topics remain to be further quantified at the state and county level.

USDA quality grades are a semi-quantitative assessment of beef marbling and age of the animal at slaughter. While retailers on Kaua‘i do not have access to USDA graders for marketing purposes, assessing sample quality grades is important as an indicator of how local beef on the shelf compares with beef imported from the Mainland. Furthermore, USDA grade is an indirect measure of juiciness and flavor, as some flavor characteristics are associated with the amount of intramuscular fat or marbling. Kaua‘i ribeye steak sample quality grades compared favorably with samples from the Big Island and nationally (Garcia et al. 2008, Fukumoto and Kim 2007b). When comparing to Mainland data, which includes grain-finished cattle, of note is the fact that Kaua‘i and Big Island data are for entirely forage-finished cattle. As with other studies, we found no appreciable correlation between quality grade and tenderness (Wheeler et al. 1994).

Other Factors. Outside of the variables we measured directly for this study, we also noted differences in color between Kaua‘i samples and Mainland steaks at retail. Kaua‘i samples were somewhat darker than Mainland steaks. Color may be an issue where local steaks are sold next to imported steaks. However, as with REA and quality grades, further research needs to determine local consumer preference on color as a purchasing factor.

We noted some rib steak samples had a somewhat off odor and a sticky residue on the surface compared to other samples. Length of aging can improve beef tenderness, but an increased length of time also allows

for increased bacterial growth, contributing to off odors or flavors. While the steaks are safe to eat, these appearance factors may confound efforts to market tender beef. Aging in vacuum-sealed packages and limiting handling of carcasses and cuts will help reduce exposure to bacteria and subsequent negative effects.

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