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Carcass Traits and Tenderness of Hawai‘i Grass-Fed Beef

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Overview

This study examined the carcass characteristics and tenderness of grass-fed beef from Hawai‘i in comparison to results from previous studies. Tenderness of current grass-fed beef has significantly improved as compared to previous results. Younger slaughter age appears to be an important factor in improving the tenderness of grass-fed beef. Marbling, beyond a certain level (probably high slight), does not appear to influence the tenderness of grass-fed beef. Current results suggest that the CTAHR grass-fed beef research program and Extension efforts to communicate research results with ranchers and other stakeholders have helped improve the tenderness of Hawai‘i grass-fed beef.

Introduction

The “Grass-Fed Beef” label indicates meat that is produced by feeding forages from start to finish without any grain supplementation. Also, “animals must have continuous access to pasture during the growing season” for a grass-fed marketing claim (USDA-AMS 2007). Year-round maintenance of pasture is possible in some regions of Hawai‘i because of the subtropical climate, providing ideal conditions for grass-fed beef production. The grass-fed beef industry has grown tremendously since the late 1990s in the US and currently accounts for 3% of total beef consumption, with a 20% annual expansion (Winrock International 2012). While very few statistics are available regarding the sale of local grass-fed beef, interest in locally produced grass-fed beef also appears to have grown among the general public, chefs, and agricultural community in Hawai‘i. This is illustrated by the enhanced marketing of grass-fed beef via online and farmers’ markets, as well as the sale of local grass-fed beef through established supermarket chains. According to a 2008 report by Leung and Loke, only 4.5% of beef consumption in Hawai‘i was from local production at that time, indicating the great potential of grass-fed beef production for improving food self-sufficiency in Hawai‘i.

Many healthful aspects of grass-fed beef have been identified, including lower total fat content and higher content of omega-3 fatty acids, conjugated linoleic acids (CLA), and antioxidants as compared to feedlot-finished beef (Razminowicz et al. 2006, Faucitano et al. 2008). The healthy nutritional profile of grass-fed beef, along with the perception that grass-finishing promotes animal well-being and environmental sustainability, has probably contributed to the increase in the demand for grass-fed beef.

Despite these positive aspects, some studies have reported that palatability of grass-fed beef is inconsistent, often leading to consumer dissatisfaction with this product (Van Elswyk and McNeill 2014). If the quality inconsistency of grass-fed beef persists, it can quickly diminish consumer demand for this product, affecting long-term economic sustainability of grass-fed beef production. For this reason, we have investigated the carcass and tenderness characteristics of grass-fed beef in Hawai‘i. Our previous studies showed that a wide variation existed in carcass characteristics (Fukumoto and Kim 2007) and meat tenderness (Kim et al. 2007) of the grass-finished beef data set collected in Hawai‘i in 1997 and 2005, respectively. Miller et al. (2001) reported that 86% of consumers expressed satisfaction with their eating experience when the Warner-Bratzler Shear Force (WBSF) value of their steaks cooked in an electric broiler with internal temperature at 70°C was less than 4.3 kg. Applying the above WBSF threshold, only 35% of the grass-fed steaks of our previous study (Kim et al. 2007) were sufficiently tender to satisfy consumers' beef-eating expectations, indicating a need for improving the tenderness of Hawai‘i grass-fed beef.

It has been eight years since the dissemination of the results of the study to stakeholders involved in grass-fed beef production. Therefore, the objective of this study was to examine the carcass and meat tenderness characteristics of Hawai‘i grass-fed beef in comparison to previous results as a part of our efforts to improve meat-quality characteristics of Hawai‘i grass-fed beef.

Procedures

Sample Collection and Processing

Three hundred fourteen ribeye steak samples from grass-fed cattle were obtained from two slaughterhouses on Hawai‘i Island between November 2013 and June 2015. The one-inch bone-in steaks were collected from the 12th rib a few days after slaughter, individually vacuum-packaged, then shipped to the Human Nutrition, Food and Animal Sciences meat lab in a cooler with ice packs. Upon arrival at the lab, the packages were removed and the boneless ribeye steaks were trimmed to less than 2 mm of subcutaneous fat and vacuum-packaged again. Vacuum-packaged samples were aged in a refrigerator for 2 weeks from the slaughter date and then were stored at -20°C for later measurement. Approximate animal age by dentition, sex, carcass weight, breed type (based on skin color), and level of marbling were evaluated during slaughter mostly by personnel at the slaughterhouses, and some evaluations were done by the research team. Marbling scores were determined by using the official USDA marbling photographs (National Cattlemen's Beef Association).

Cooking and Shear Force Measurement

Shear force measurements were carried out periodically when about 70 samples had been collected. Steak samples were thawed overnight in a refrigerator. The thawed, vacuum-packaged steaks were cooked in a water bath at 70°C for one hour, cooled at room temperature for one hour, and chilled overnight in a refrigerator, as described in a protocol by the USDA-ARS Meat Animal Research Center (Wheeler et al. 2005). The pouches were unwrapped, and cooled steaks were gently dried with paper towels. For a shear force measurement, 6 core samples (1.3 cm diameter) were taken parallel to the longitudinal orientation of muscle fibers of each of the cooled steaks. The force required to cut the cores was measured by a Warner-Bratzler machine (G-R Manufacturing, Manhattan, KS). The WBSF value was the mean of the maximum forces required to shear each set of core samples.

Data Analyses

To examine the WBSF value as affected by age, three age groups were established: Group 1, less than 24 months old; Group 2, 24 to 30 months; and Group 3, greater than 30 months old. The effects of age, sex class, carcass weight, and marbling on shear force value were determined by ANOVA procedure using the Prism6 program (Graphpad, San Diego, CA).

Results and Discussion

Carcass Traits

Figure 1 shows the distribution of heifers and steers slaughtered for grass-fed beef production. Heifers and steers comprised 45.3% and 54.7% of cattle, respectively.

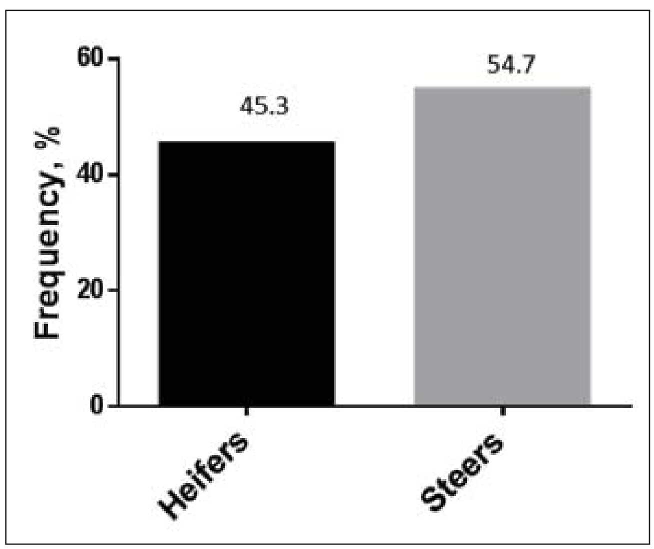

Figure 1. Distribution of sex class of grass-fed cattle in Hawai‘i (n=311)

In our 1997 study, heifers and steers comprised 42% and 58% of the cattle slaughtered for grass-fed beef production (Fukumoto and Kim 2007). Considering that some heifers are retained as cow replacements, it is to be expected that the proportion of heifers for grass-finishing would be lower than that of steers.

The distribution of animal age at slaughter is presented in Figure 2. Similar to previous results (Fukumoto and Kim 2007), the majority (64%) of grass-fed cattle were slaughtered between 24 and 30 months of age. As compared to Fukumoto and Kim's study (2007), the proportion of younger cattle less than 24 months increased (17% vs 10%), and there was also a slight increase in the proportion of older cattle greater than 30 months of age (19% vs 16%).

Table 1 summarizes hot carcass weight, marbling, and shear force values of the grass-fed beef sampled. Mean carcass weight was 615.8 lbs., about 5 lbs. lower than mean carcass weight of our previous study (Fukumoto and Kim 2007). As is shown in Figure 3, the proportion of carcasses smaller than 550 lbs. has increased almost three-fold (24.2% vs. 9.1%), while the proportion of carcasses between 550 and 750 lbs. has decreased (62.4% vs. 82.4%) as compared to Fukumoto and Kim's study (2007).

Mean marbling value was low Modest (Table 1), an improvement as compared to the previous mean marbling value of high Small (Fukumoto and Kim 2007). As is shown in Figure 4, about 60% of carcasses scored better than Small marbling, while only about 8% of carcasses scored better than Small marbling in the 2007 study (Fukumoto and Kim 2007). Many studies generally report that intramuscular fat content of grass-fed beef is much lower than that of feedlot-finished beef, with a marbling from Slight to Small range (Oltjen et al. 1971, Purchas and Davies 1974, Davis et al. 1981, Realini et al. 2004, Van Elswyk and McNeill 2014). In this regard, the dramatic improvement in marbling score is somewhat unexpected, and further studies are needed to examine underlying factors leading to the high marbling of current grass-fed beef samples.

Shear Force Value

The mean WBSF value was 4.43 kg, with values ranging from 1.95 to 11.37 kg (Table 1). The mean WBSF value is about 15% lower than the mean WBSF value (5.21 kg) of our previous study (Kim et al. 2007). The distribution of WBSF values of the current study was compared with that of 2007 (Figure 5). The result shows that the proportion of steaks with WBSF value lower than 5.0 kg is much greater than that of the 2007 study (74.2% vs 48.9%), indicating a significant improvement in the tenderness of Hawai‘i grass-fed beef. Miller et al.

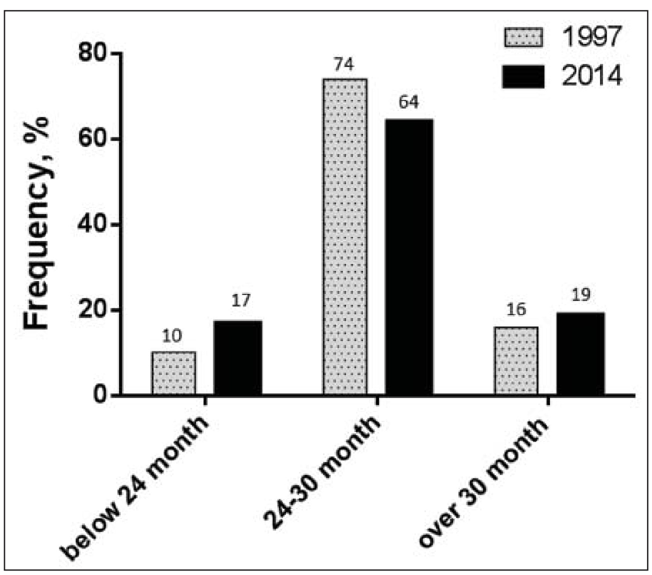

Figure 2. Distribution of age group of grass-fed cattle in Hawai‘i (n=307)

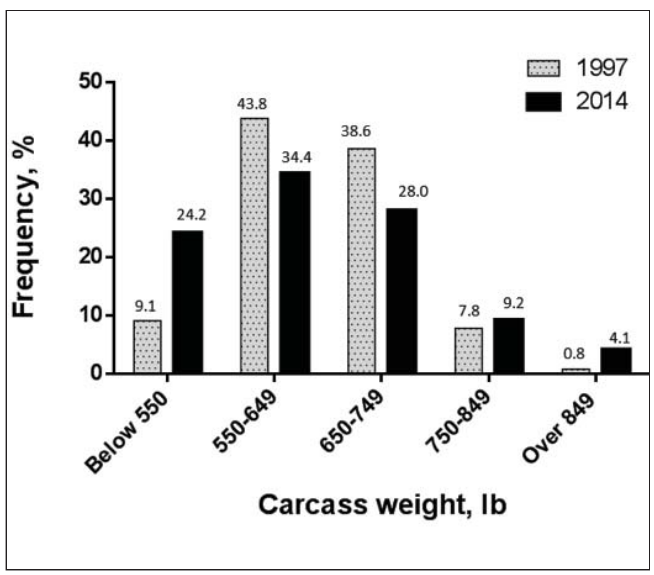

Figure 3. Distribution of carcass weight of grass-fed cattle in Hawai‘i (n=314).

Table 1. Carcass weight (lbs.), marbling, and shear force value (kg) of grass-fed beef (2013–2015)

Trait	N	Mean	SD	CV	Minimum	Maximum
Carcass wt., lbs.	311	**615.8**	109.4	17.8%	394	1263
Marbling*	308	**13.3**	3.36	25.3%	4	20
Shear force, kg	314	**4.43**	1.12	25.2%	1.95	11.37

***Practically devoid (-, o, and +): 1, 2, and 3; Trace (-, o, and +): 4, 5, and 6; Slight (-, o, and +): 7, 8, and 9; Small (-, o, and +): 10, 11, and 12; Modest (-, o, and +): 13, 14, and 15; Moderate (-, o, and +): 16, 17, and 18; Slightly abundant: 19; Moderately abundant: 20; Abundant: 21**

(2001) reported that 86% of consumers expressed that they had had a satisfying experience when the WBSF value of their steaks—cooked in an electric broiler to an internal temperature at 70°C—was less than 4.3 kg. In 2013, USDA launched a program certifying beef tenderness, under which eligible beef products can carry "USDA Certified Tender" or "USDA Certified Very Tender" labels. The minimum tenderness threshold values (MTTV) to claim "USDA Certified Tender" and "USDA Certified Very Tender" are 4.4 kg and 3.9 kg WBSF value, respectively (American Society for Testing and Materials International publication F2925-11). If we apply the MTTV of "USDA Certified Tender" as a standard for tender grass-fed beef in Hawaiʻi, about 60% of current Hawaiʻi grass-fed beef appears to fall into this category, while only 35% would have fallen into it in the study by Kim et al. (2007).

Shear Force Value Within Age Group, Sex Class, Carcass Size, and Marbling Score

We examined whether WBSF value is associated with animal age, sex, carcass size, or marbling score. Animal age appears to have a significant association with WBSF value (Figure 6), with younger animals having

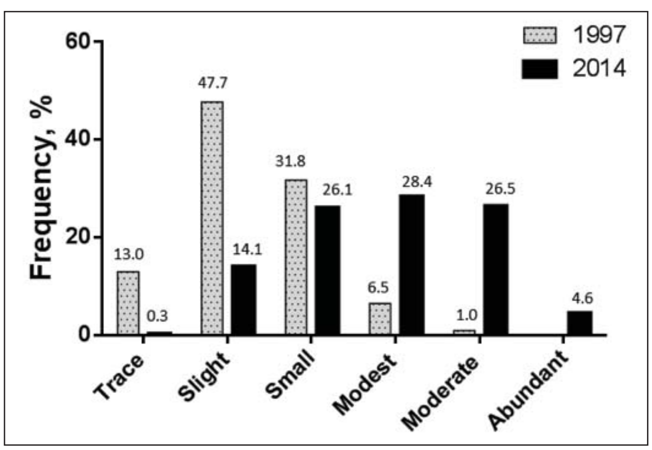

Figure 4. Distribution of marbling of grass-fed cattle in Hawaiʻi (n=308).

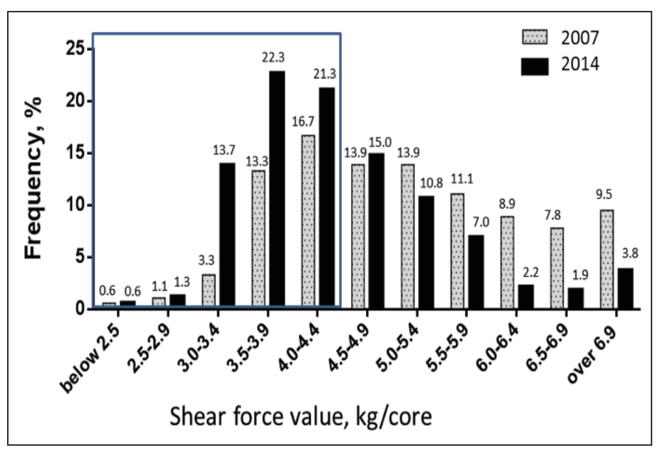

Figure 5. Shear force value distribution of ribeye steaks from grass-fed cattle of Hawaiʻi. The rectangular region indicates the area below the minimum tenderness threshold value (MTTV) required to claim "USDA Certified Tender."

lower values than older animals. In our previous study (Kim et al. 2007), it was also observed that steaks from cattle more than 36 months had significantly higher WBSF values.

Steers had significantly greater mean WBSF value, with more variation, than heifers (4.60 vs 4.28, Figure 7). In contrast to the current results, our previous study (Kim et al. 2007) showed that steers had a lower WBSF value (4.96 vs 5.52). With regard to the effect of sex on beef tenderness, results of various studies are not consistent (Gracia et al. 1970, Prost et al. 1975, Choat et al. 2006, Wulf et al. 1996), suggesting that some factors other than inherent sex-related factors, such as animal age and marbling, come into play together to influence meat tenderness. In the current study, more than 30% of steers were in the age group greater than 30 months, while only 3.5% of heifers were in this age group (data not shown). Also, steers had in general a lower marbling score (data not shown). It is thus speculated that the older age of steers compared to heifers contributed to higher WBSF values for the steers.

Neither the carcass weight nor the marbling score had a significant association with WBSF value (Figure 8 and 9). Similarly, our previous study found no significant correlation between intramuscular fat and WBSF value (Kim et al. 2007). Figure 10 also demonstrates that marbling is not a significant factor affecting grass-fed beef tenderness when marbling reaches more than high Slight level.

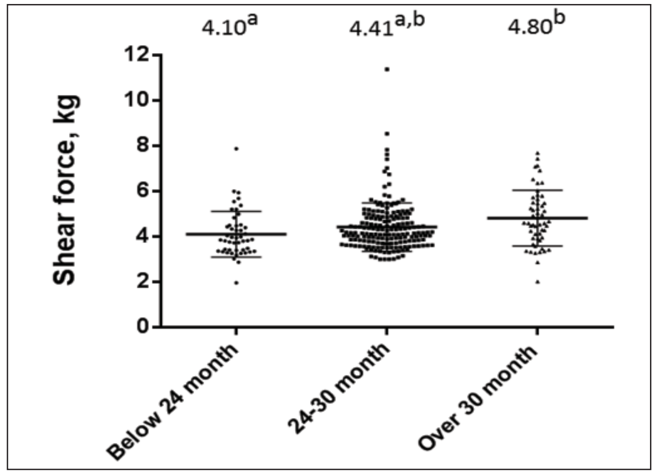

Figure 6. Shear force values by age group (mean ± SD). Means not sharing the same superscript differ at P<0.05.

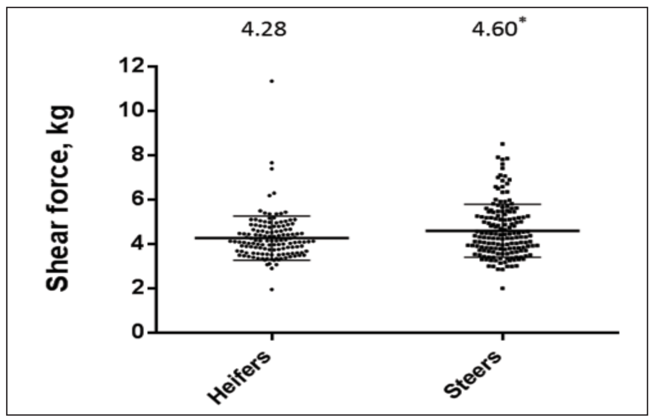

Figure 7. Shear force values by sex class (mean ± SD). +, P<0.05.

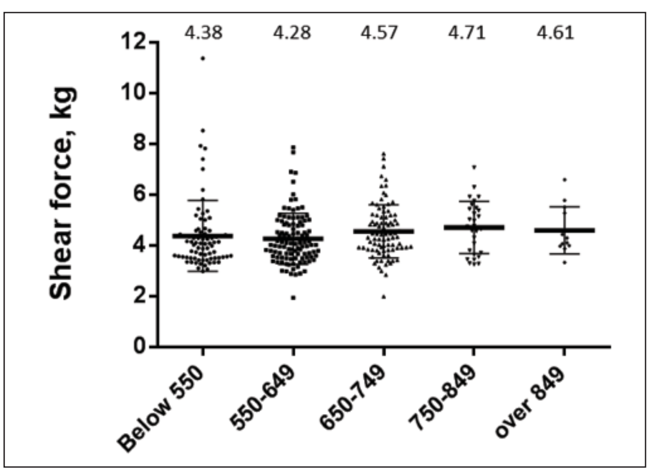

Figure 8. Shear force values by carcass weight (mean ± SD).

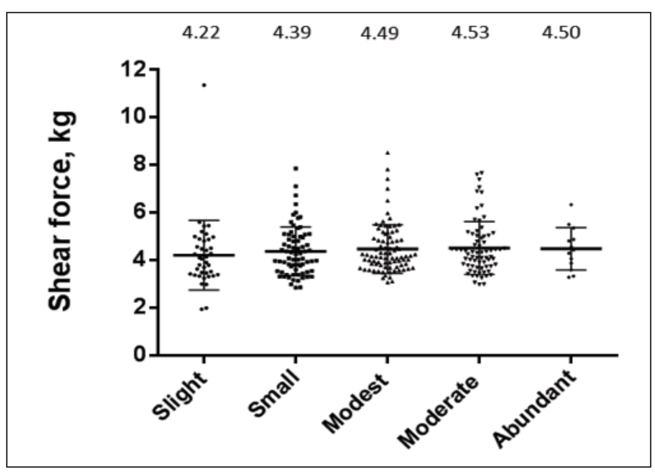

Figure 9. Shear force by marbling (mean ± SD).

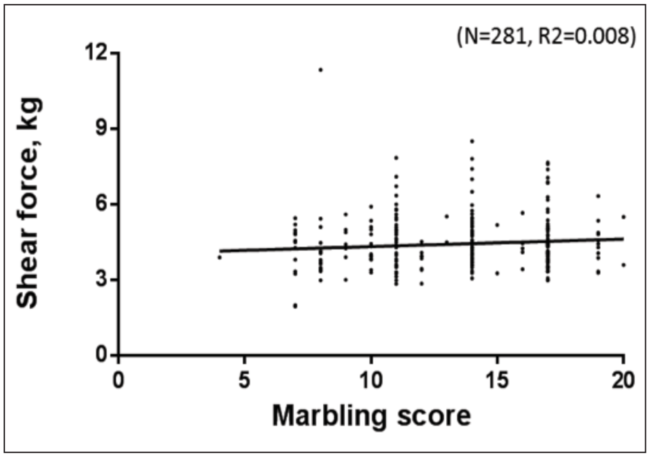

Figure 10. Relationship between shear force and marbling score.

Conclusion

Results of this study show that tenderness of recently produced grass-fed beef in Hawai‘i has significantly improved during the last 10 years, with about 60% of grass-fed samples meeting "UDSA-Certified Tender" standards based on cooked shear force value. CTAHR's grass-fed beef research program and Extension efforts to communicate research results with ranchers and other stakeholders appears to have helped improve the tenderness of Hawai‘i grass-fed beef.

Younger slaughter age appears to be an important factor in improving the tenderness of grass-fed beef. Significant improvement in marbling score was also noted, but it appears that marbling, beyond a certain level (probably high Slight), is not an important factor influencing the tenderness of grass-fed beef.

Beyond tenderness, a taste panel study is needed to evaluate consumer acceptance and the overall palatability of grass-fed beef produced in Hawai‘i. Based on the significant improvement in tenderness of Hawai‘i grass-fed beef during the last decade, arguments can be made for the superior eating quality of Hawai‘i grass-fed beef. If the industry desires to expand the grass-fed beef market in- or out-of-state, the industry probably needs to develop a program certifying its eating quality. Suggested certification criteria may include shear force, marbling score, and age verification to improve eating satisfaction of grass-fed beef. The certified beef probably can demand a premium price, and the certification program would serve as an effective marketing tool, bringing involved market segments, including distributors, restaurants, and chefs, together for the promotion of Hawai‘i grass-fed beef.

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