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Carcass Traits and Tenderness of Grass-fed Beef from Subtropical Pastures in Hawaii

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Introduction

The “Grass-fed beef” label indicates meat that is produced by feeding forages from start to finish without any grain supplementation (USDA-AMS 2007). 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 recent increase in the demand for grass-fed beef.

Even though beef cattle production is the third largest agricultural commodity in Hawaii, only 20-30% of weaned calves are locally raised for slaughter with the majority being shipped to the mainland USA due to the high cost of shipping concentrates feed to Hawaiian Islands. Since year-round maintenance of pasture is possible in some regions of Hawaii due to the subtropical climate, grass-fed beef production appears to be a viable alternative to shipping out weaned calves. For the development of a sustainable grass-fed beef industry, we contended that supplying consistent high quality of grass-fed beef is an important element in light of some studies reporting that palatability of grass-fed beef is inconsistent, often leading to consumer dissatisfaction with this product (Van Elswyk and McNeill 2014). Therefore, the objective of this study was to examine the carcass and meat tenderness characteristics of Hawaii grass-fed beef in an effort to improve meat quality characteristics of Hawaii grass-fed beef.

Materials and Methods

Sample collection

Three hundred fourteen ribeye steak samples from grass-fed cattle were obtained from two slaughterhouses on Hawaii Island (HI, USA) 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 in a cooler with ice packs to the Human Nutrition, Food and Animal Sciences Department’s meat lab of University of Hawaii at Manoa, USA. 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^{o}C for later measurement. Approximate animal age (based on teeth), 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.

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^{o}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, USA). The Warner-Bratzler shear force (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 Prism6 program

(Graphpad, San Diego, CA, USA).

Results and Discussion

Animal sex and age

Heifers and steers comprised 45.3% and 54.7% of cattle, respectively. 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 majority (64%) of grass-fed cattle were between 24 and 30 months of age with 17% and 19% being below 24 months and over 30 months of age, respectively.

Carcass traits

Table 1 summarizes hot carcass weight, marbling, and shear force values of the grass-fed beef. The mean carcass weight was 279.4 kg with 17.8% coefficient of variation, indicating a large variation in carcass size. The mean carcass size was much smaller than the US national mean carcass size of 372 kg (USDA, 2016). The mean marbling value was low Modest. Several studies (Davis et al. 1981, Realini et al. 2004, Van Elswyk and McNeill 2014) reported 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. In this regard, the high 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 distribution of WBSF values is shown in Fig. 1. Miller et al. (2001) reported that 86% of consumers expressed that they had had a satisfying experience when the WBSF value of their steaks 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 2011). If we apply the MTTV of "USDA Certified Tender" as a standard for tender grass-fed beef in Hawaii, about 60% of Hawaii grass-fed beef appears to fall into this category.

Shear force value within age group, sex class, carcass size, and marbling score

We examined whether WBSF value was associated with animal age, sex, carcass size, or marbling score. Animal age appears to have a significant association with WBSF value (Fig. 2A), with younger animals having 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, Fig. 2B). In contrast to the current result, our 2007 study 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 of steers.

Neither the carcass weight nor the marbling score had a significant association with WBSF value (Fig. 2C and 2D). Similarly, our previous study found no significant correlation between intramuscular fat and WBSF value (Kim et al. 2007). Fig. 3 also demonstrates that marbling is not a significant factor affecting grass-fed beef tenderness when marbling reaches more than high Slight level.

Shear force value by ranches

Variation in meat tenderness was observed among ranches (Fig. 4). Examination of animal age group, sex, carcass size and marbling score separated by ranches did not show that any of those parameteres are associted with the variation in shear force among ranches (Data not shown). Future studies, thus, need to examine how the combination of various production factors influence the tenderness of grass-fed beef.

Conclusion

In conclusion, results of this study showed that about 60% of Hawaii grass-fed beef are meeting “UDSA-Certified Tender” standards based on cooked shear force value, suggesting that cattle finished on subtropical pasture can yield quality tender beef. 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. Beyond tenderness, a taste panel study is needed to evaluate consumer acceptance and the overall palatability of grass-fed beef.

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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., kg	311	**279.3**	49.62	17.8%	178.7	572.9
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

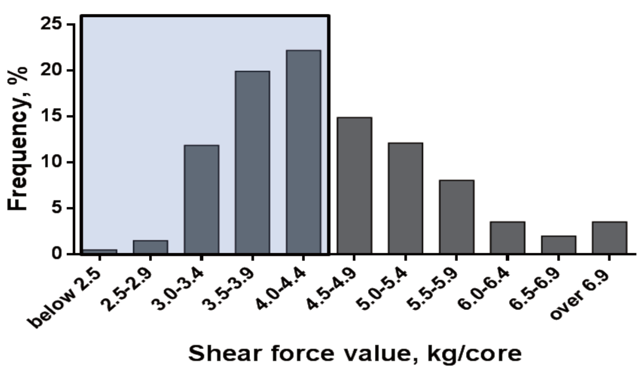

Fig. 1. Shear force value distribution of ribeye steaks from grass-fed cattle of Hawai‘i. The rectangular region indicates the area below the minimum tenderness threshold value (MTTV) required to claim “USDA Certified Tender.”

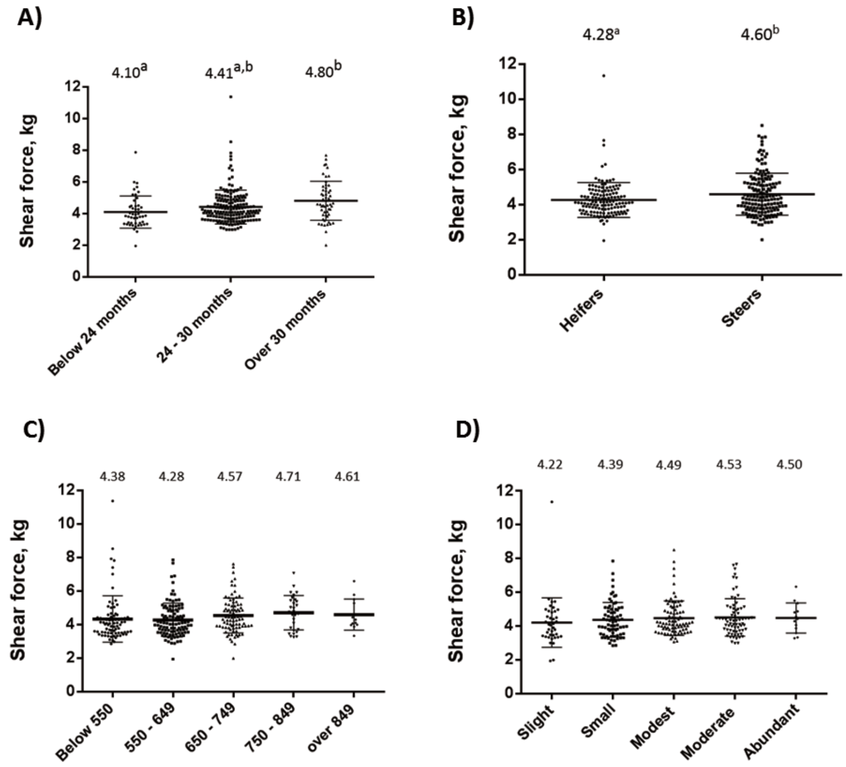

Fig. 2. Shear force value by age group (A), sex (B), carcass size (C) and marbling (D). Means not sharing the same superscript differ at P<0.05.

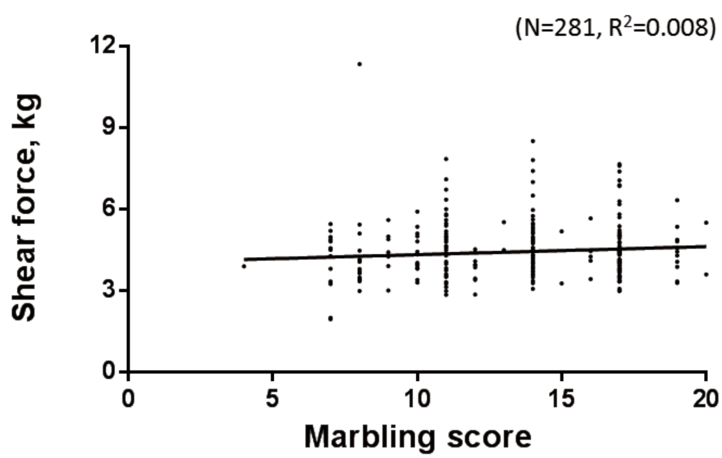

Fig. 3. Relationship between shear force and marbling score. The description of numerical marbling score is the same as in Table 1.

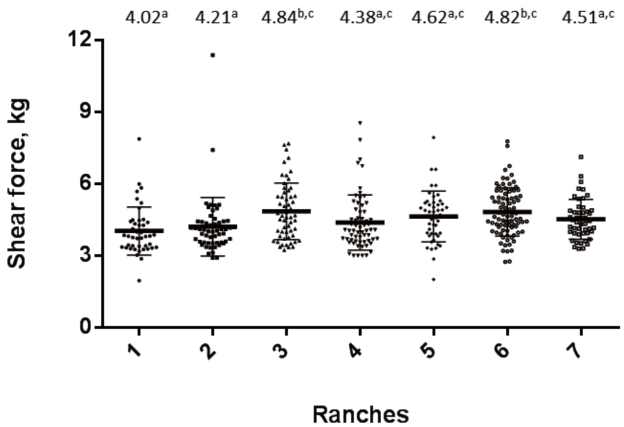

Fig. 4. Shear force value by ranches. Means not sharing the same superscript differ at P<0.05.

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