



Carcass Characteristics of Forage-Finished Cattle Produced in Hawai'i

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It is extremely difficult for the Hawai'i beef industry to compete against the concentrate-finished beef that dominates the U.S. beef industry because of our state's lack of grain production, lack of economy of scale, and an inefficient processing segment. Nevertheless, producers continue to keep their faith in the local and emerging niche markets, looking for opportunities for marketing Hawai'i-branded beef products.

Forage, grass, or pasture-finished beef production is a natural phenomenon because cattle, being ruminants, efficiently utilize forages for its growth. There are 614 delineated watersheds in our state providing the opportunity to produce quality forages. Thus, producing forage-finished beef by matching production requirements with our diverse environmental conditions is a real and viable option for the Hawai'i beef industry.

Recently, market awareness for locally grown and raised products has been on the rise. Programs such as CTAHR's "A Taste of the Hawaiian Range Agricultural Festival," the Hawai'i Department of Agriculture's "Island Fresh" program, activities of the Hawaiian Regional Cuisine Chef Organization, and other independent product brand labeling have contributed to the increased awareness of local products. "Buy Local" campaigns have seen a positive development and growth of niche markets within our insular island economy. For the beef industry, a movement toward target marketing of forage-finished beef has aroused the interest of several ranchers and end-users, such as restaurants and supermarkets. In the past, quality issues have plagued forage-finished beef products. Studies have shown that forage-finished beef are generally less tender, slightly darker in color, have a shorter shelf-life, and have undesirable flavor differences compared to concentrate-fin-

ished beef (Bowling et al. 1977; Kim 1995). However, it is known that forage-finished beef has positive aspects as well. For example, beef from forage-finished carcasses is leaner and has higher levels of healthy fatty acids (omega-3, conjugated linoleic acid). Therefore, it appears that pasture-finished beef produced in Hawai'i has the potential to be marketed as natural, health-promoting food, particularly for those groups of people seeking animal products raised in natural conditions without much intervention on animals' dietary intake or administration of growth-promoting agents.

Understanding the current status of carcass traits of forage-finished cattle produced in Hawai'i is important in improving carcass characteristics and meat palatability. Currently, however, no data are available, so this study was conducted to survey carcass characteristics of forage-finished cattle produced in various subtropical environments on the island of Hawai'i.

Procedures

Sample collection

A total of 386 forage-finished carcasses were evaluated over a one-year period in 1997. Carcasses were evaluated based on the U.S. Department of Agriculture beef carcass yield and quality grading system (USDA 1997, AMSA 2001). Carcass data included hot carcass weight, backfat thickness, ribeye area, marbling score, maturity score (bone ossification), and quality grade. Animal data included sex, age and estimated breed types. The animal's age was established by confirmation or estimation by the rancher and postmortem determination by teeth examination.

Data analyses

To examine the carcass traits as affected by age, three age groups were established: Group 1, less than 24 months old; Group 2, 24–30 months; Group 3, greater than 30 months old. The cattle were received from 22 different ranches or contractors, originating from all districts of the island except South Kona and Puna. With the diversity of ranch sources, cattle breeds represented in the survey varied widely. Fourteen different breeds were identified by the rancher or determined by observation at slaughter. The various breeds were categorized into four groups to examine the carcass traits by breed groups: Group 1, *Bos taurus* (Black Angus, Red Angus, Hereford, Jersey, Murray Grey, Wagyu crosses) and *Bos taurus* crosses with *Bos taurus*; Group 2, *Bos taurus* crosses with continental and/or *Bos indicus*; Group 3, continental breeds (Charolais, Gelbveih, Maine Anjou, Simmental) and crosses; Group 4, *Bos indicus* crosses and *Bos indicus* composites and crosses (Brangus, Beefmaster, Santa Gertrudis). Data analyses was performed using JMP software (SA Institute, Cary, NC). The effects of age, estimated breed types, and sex class on carcass traits were determined using the GLM procedure.

Results and discussion

Assessment of carcass traits

Figure 1 presents the distributions of sex classes, age and estimated breed types of forage-finished cattle slaughtered in Hawai'i. Steers and heifers composed

58% and 42% of the total number of cattle processed. *Bos taurus* and *Bos taurus* crosses with other breeds comprised most (94%) of the forage-finished cattle produced in Hawai'i. The majority (74%) of the forage-finished cattle were slaughtered between 24 and 30 months of age, with 10.1% being slaughtered below 24 months of age and 15.9% being slaughtered above 30 months of age.

Figures 2 and 3 and Table 1 summarize carcass traits of forage-finished cattle in Hawai'i, and Table 2 shows the national average carcass traits surveyed during the National Beef Quality Audit 2000 (McKenna et al. 2002). Mean carcass weight, ribeye area, and backfat thickness of Hawai'i cattle were 620.9 lb, 11.5 in², and 0.27 inch, respectively. Compared with the national average, Hawai'i cattle had lighter carcass size (166 lb less), smaller ribeye area (1.6 in² smaller) and thinner backfat (0.2 inch thinner) than those of the national mean. Average marbling score and maturity of forage-finished carcasses of Hawai'i were Slight⁺ and A maturity. National average marbling score was Small⁰ (Table 2). Average USDA quality grade of forage-finished carcasses of Hawai'i was Select, while the national average was close to low Choice.

The distribution of USDA quality grades of forage-finished carcasses of Hawai'i were 12.6% for Standard, 50.4% for Select, 29.7% for low Choice, 6.0% for average Choice, and 1.3% for above average Choice (Figure 3). As expected, Hawai'i carcasses had a higher proportion of Standard and Select grades and a lower pro-

Figure 1. Distribution of sex class, age, and breed type of forage-finished cattle slaughtered in Hawai'i.

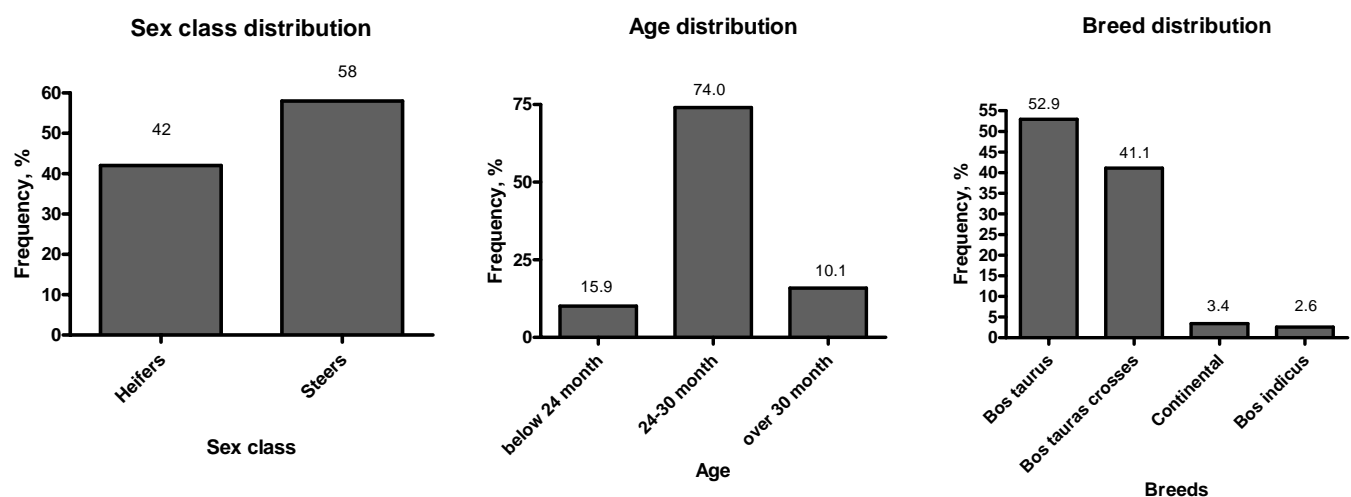


Figure 2. Distribution of carcass weight, ribeye area, and backfat thickness of forage-finished cattle slaughtered in Hawai'i.

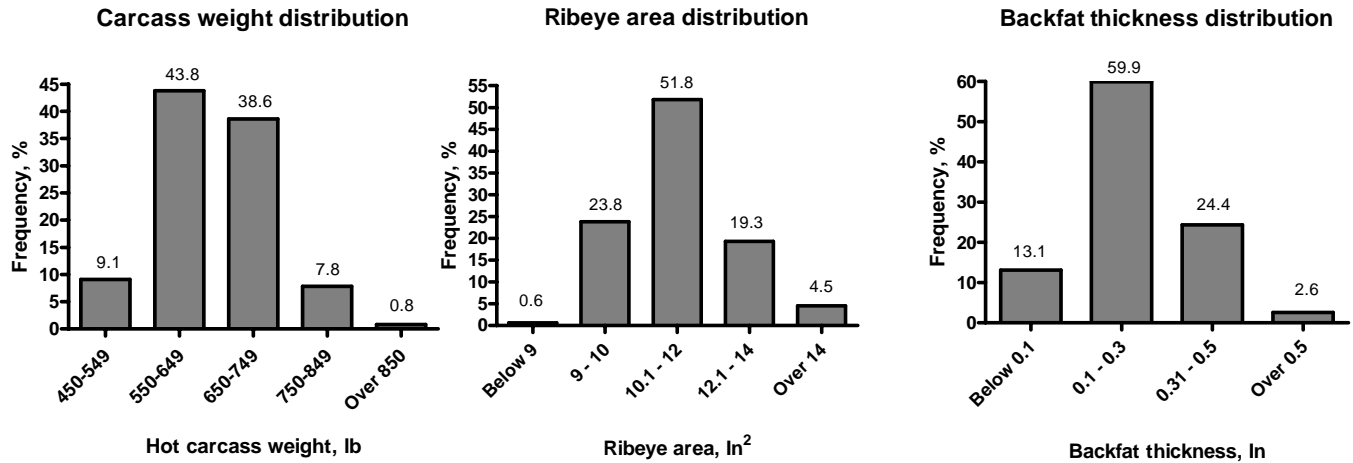


Figure 3. Distribution of maturity, marbling score and USDA quality grade of forage-finished cattle slaughtered in Hawai'i.

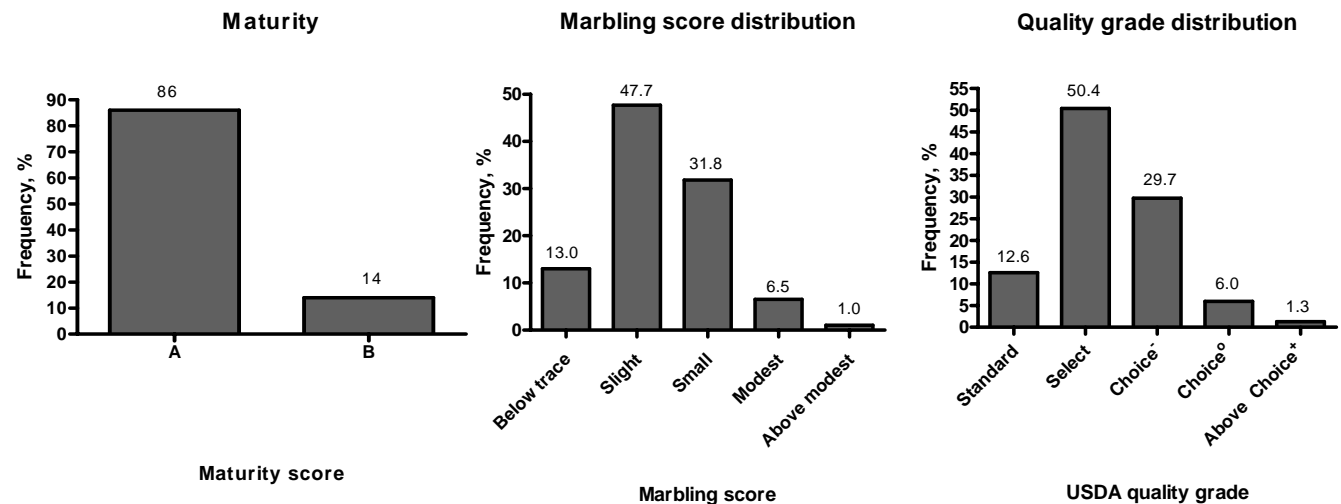


Table 1. Carcass traits of forage-finished cattle produced in Hawai'i.

Trait	N	Mean	SD	Minimum	Maximum
Hot carcass weight, lb	386	620.9	75.14	477	871
Ribeye area, in ²	311	11.5	1.50	6.5	16.8
Backfat thickness, in	374	0.27	0.141	0.05	1.2
Marbling score ^a	384	8.8	2.25	1	19
Maturity ^b	386	7.9	0.35	7	9
USDA quality grade ^c	381	5.4	1.73	1	10

^a Practically devoid (-, 0, +) = 1, 2, 3; Trace (-, 0, +) = 4, 5, 6; Slight (-, 0, +) = 7, 8, 9; Small (-, 0, +) = 10, 11, 12; Modest (-, 0, +) = 13, 14, 15; Moderate (-, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

^b A⁰-A⁵⁰ = 9; A⁵¹-A¹⁰⁰ = 8; B⁰-B⁵⁰ = 7; B⁵¹-B¹⁰⁰ = 6; C⁰-C¹⁰⁰ = 5; C⁵¹-C¹⁰⁰ = 4; D⁰-D⁵⁰ = 3; D⁵¹-D¹⁰⁰ = 2; E⁰-E¹⁰⁰ = 1

^c Standard (-, 0, +) = 1, 2, 3; Select (-, 0, +) = 4, 5, 6; Choice (-, 0, +) = 7, 8 and 9; Prime (-, 0, +) = 10, 11, 12

Note: low = -, average = 0, and high = +

Table 2. Carcass traits of U.S.-fed steers and heifers.

Trait	Mean	SD	Minimum	Maximum
Hot carcass weight, lb	786.8	94.1	417.8	1191.8
Ribeye area, in ²	13.1	1.7	7.8	23.2
Backfat thickness, in	0.47	0.20	0.0	1.73
Marbling score ^a	10.7	3.0	3.1	21
USDA quality grade ^b	6.6	-	-	12

^a Practically devoid (-, 0, +) = 1, 2, 3; Trace (-, 0, +) = 4, 5, 6; Slight (-, 0, +) = 7, 8, 9; Small (-, 0, +) = 10, 11, 12; Modest (-, 0, +) = 13, 14, 15; Moderate (-, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

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Note: low = -, average = 0, and high = +

The data are from McKenna et al. (2002).

portion of Choice grade than mainland carcasses. The 2000 National Beef Quality Audit reported 2.0% Prime, 42.1% Choice, 42.2% Select, and 6.6% below Standard (McKenna et al. 2002).

Carcass traits within sex classes

Table 3 presents carcass trait means within sex classes. Mean slaughter age was not different between heifers and steers. Steers had a significantly heavier mean carcass weight (643 vs. 583 lb), lower backfat thickness (0.24 vs. 0.30 inch), and lower marbling score (8.20 vs. 9.46) than heifers, but no difference was observed in ribeye area and maturity between the two sex classes. There was a significant difference in the quality grade between heifers and steers. As was expected from the higher marbling score of heifers, heifers produced a higher USDA quality grade carcass compared to steers. The mean quality grade of heifers was high Select (5.96) while that of steers was average Select (5.05).

Similar to our results, in concentrate-finished cattle Choat et al (2006) reported that steers had smaller ribeye area, less backfat thickness, and lower marbling score and USDA quality grade score than heifers.

Carcass traits within age groups

Carcass trait means within age groups are summarized in Table 4. As was expected, with the increase of animal age, carcass weight became heavier, ribeye area became larger, backfat thickness increased, marbling score increased, and maturity score decreased. The mean USDA quality grade of carcasses was affected by the age groups. Mean USDA quality grade of age group below 24 month was in between low Select to average Select (4.6), while

Table 3. Means and standard errors (in parentheses) for carcass traits within sex class.

Traits	Sex class	
	Heifer	Steer
Age, months	27.6 (0.32)	27.3 (0.28)
Hot carcass weight, lb	583.1 (5.92)	643.0* (5.04)
Ribeye area, in ²	11.6 (0.14)	11.3 (0.11)
Backfat thickness, in	0.30 (0.012)	0.24* (0.010)
Marbling score ^a	9.46 (0.218)	8.20* (0.185)
Maturity ^b	7.95 (0.023)	7.94 (0.020)
USDA quality grade ^c	5.96 (0.141)	5.05* (0.113)

^a Practically devoid (-, 0, +) = 1, 2, 3; Trace (-, 0, +) = 4, 5, 6; Slight (-, 0, +) = 7, 8, 9; Small (-, 0, +) = 10, 11, 12; Modest (-, 0, +) = 13, 14, 15; Moderate (-, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

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Note: low = -, average = 0 and high = +

* P<0.05

the mean USDA quality grade of 24–30 month age and over 30 month age group was high Select (5.65 and 5.70).

Table 4. Mean and standard errors (in parentheses) for carcass traits within age groups.

Trait	Age group (months)		
	Below 24	24–30	Over 30
Hot carcass weight, lb	580.6 ^d (12.23)	615.9 ^e (4.51)	653.5 ^f (9.72)
Ribeye area, in ²	11.1 ^d (0.26)	11.4 ^d (0.10)	12.1 ^e (0.24)
Backfat thickness, in	0.20 ^d (0.023)	0.28 ^e (0.009)	0.30 ^e (0.019)
Marbling score ^a	7.47 ^d (0.415)	9.03 ^e (0.154)	9.12 ^e (0.330)
Maturity ^b	8.08 ^d (0.052)	7.93 ^e (0.019)	7.61 ^f (0.041)
USDA quality grade ^c	4.50 ^d (0.282)	5.65 ^e (0.105)	5.70 ^e (0.224)

^aPractically devoid (–, 0, +) = 1, 2, 3; Trace (–, 0, +) = 4, 5, 6; Slight (–, 0, +) = 7, 8, 9; Small (–, 0, +) = 10, 11, 12; Modest (–, 0, +) = 13, 14, 15; Moderate (–, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

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Note: low = –, average = 0 and high = +

^{d,e,f} Means within a row not sharing common superscript differ ($P < 0.05$). Mean difference was analyzed by Tukey honestly significant difference (HSD) test.

Carcass traits within estimated breed types

Table 5 summarizes carcass trait means within estimated breed types. Continental breed type carcasses had heavier carcass weight, larger ribeye area, lower backfat thickness, and lower marbling score than other breed type carcasses. USDA quality grade of continental breed types tended to be lower (low Select) than other breed types (average Select or high Select). These results are in general agreement with results observed in grain-finished cattle carcasses (Binder et al. 2002, Wheeler et al. 2005). Considering that the proportion of continental and *Bos indicus* breed types were much lower (3.4 and 2.6%) than *Bos taurus* and *Bos taurus* crosses breed types (52.9 and 41.1%) and the breed type classification was based on approximate assessments, the results on mean carcass traits within breed type need to be interpreted with caution.

Correlation between backfat thickness and marbling score

Figure 4 shows the relationship between marbling score and backfat thickness of forage-finished cattle slaughtered in Hawai'i. The following equation predicts marbling score from backfat thickness: marbling score = $6.85 + 7.299 \times$ backfat thickness (in inches). The correlation was 0.15, indicating that backfat thickness does not have high predictive value for marbling score. The correlation (0.15) observed in this study is lower than that observed in other studies with concentrate-finished cattle. Gregory et al. (1995) reported a 0.44 correlation between marbling score and backfat thickness, while Klopfenstein et al. (2000) reported a correlation ranging from 0.48 to 0.64.

Conclusion

The results of this survey provide the forage-finished segment of the Hawai'i beef industry with baseline information from which future research activities can be initiated to help the beef industry measure progress in carcass traits. The results show that high quality carcasses can be produced on 100% forage-based production systems in Hawai'i. However, improvements targeted at heavier carcass weights, larger rib-eye area, and lower days to harvest are key areas which merit future research efforts. In addition, because the current survey did not include the meat quality characteristics, it is recommended that meat tenderness characteristics of forage-finished cattle in Hawai'i be surveyed in order to establish a benchmark for future improvement in the tenderness of forage-finished beef.

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Table 5. Mean and standard errors (in parentheses) for carcass traits within estimated breed types.

Trait	Breed type			
	<i>Bos taurus</i>	<i>Bos taurus</i> crosses	Continental	<i>Bos indicus</i> crosses
Age, months	28.9 ^d (0.28)	26.9 ^e (0.30)	26.2 ^{d,e} (1.04)	25.1 ^e (1.25)
Hot carcass weight, lb	618.7 (5.31)	621.5 (6.03)	645.3 (20.82)	611.7 (23.74)
Ribeye area, in ²	11.4 ^d (0.12)	11.4 ^d (0.13)	13.6 ^e (0.42)	11.2 ^d (0.48)
Backfat thickness, in	0.28 ^d (0.010)	0.27 ^d (0.011)	0.15 ^e (0.150)	0.27 ^{d,e} (0.270)
Marbling score ^a	9.14 ^d (0.173)	8.68 ^{d,e} (0.197)	7.23 ^e (0.679)	8.40 ^{d,e} (0.775)
Maturity ^b	7.80 ^d (0.025)	7.96 ^e (0.028)	8.00 ^{d,e} (0.097)	8.00 ^{d,e} (0.110)
USDA quality grade ^c	5.79 ^d (0.118)	5.35 ^{d,e} (0.134)	4.17 ^e (0.479)	5.30 ^{d,e} (0.525)

^a Practically devoid (–, 0, +) = 1, 2, 3; Trace (–, 0, +) = 4, 5, 6; Slight (–, 0, +) = 7, 8, 9; Small (–, 0, +) = 10, 11, 12; Modest (–, 0, +) = 13, 14, 15; Moderate (–, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

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^{d,e} Means within a row not sharing common superscript differ (P<0.05). Mean difference was analyzed by Tukey honestly significant difference (HSD) test.

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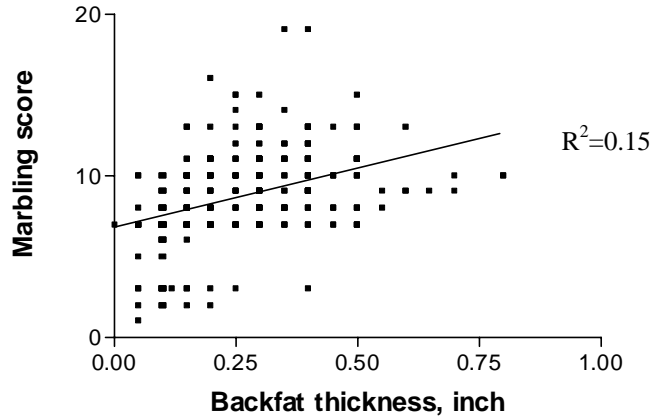
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Figure 4. Correlation between backfat thickness and marbling score.



^aPractically devoid (-, 0, +) = 1, 2, 3; Trace (-, 0, +) = 4, 5, 6; Slight (-, 0, +) = 7, 8, 9; Small (-, 0, +) = 10, 11, 12; Modest (-, 0, +) = 13, 14, 15; Moderate (-, 0, +) = 16, 17, 18; Slightly abundant = 19; Moderately abundant = 20; Abundant = 21

A group of forage-finished steers being tamed down using the highly palatable leucaena variety Kx2. Developing low-stress animal handling techniques is a key factor in forage-finished production systems.



Example of a highly marbled rib eye muscle produced on forage. This particular steer was harvested at 21.3 months of age from the UH-CTAHR Mealani Research Station.

