Published February 7, 2019

Meat and Muscle Biology™

Consumer Assessment of New Zealand Forage Finished Beef Compared to US Grain Fed Beef

A. J. Garmyn[1]*, R. J. Polkinghorne[2], J. C. Brooks[1], and M. F. Miller[1]

[1]Animal and Food Sciences Department, Texas Tech University, Lubbock, TX, USA
[2]Birkenwood Pty Ltd, 46 Church St, Hawthorn, Vic 3122, Australia
*Corresponding author. Email: andrea.garmyn@ttu.edu (A. J. Garmyn)

Abstract: Consumer sensory analysis was conducted to determine differences in beef palatability between three process-verified feeding programs (New Zealand fodder beet, New Zealand grass/non-fodder beet, US grain). Beef strip loins were selected to represent low or high expected eating quality (based on eligibility for the company's branded program, which focuses on carcass attributes of marbling, ossification, pH, 12th rib fat, and HCW), resulting in 6 treatments: fodder beet low quality (FBL), fodder beet high quality (FBH), non-fodder beet low quality (NFBL), and non-fodder beet high quality (NFBH), Select (SEL) and Top Choice (TCH). Samples were aged until 21 or 35 d postmortem. Extending postmortem aging positively influenced ($P < 0.05$) New Zealand non-fodder beet samples, but largely had no effect ($P > 0.05$) on New Zealand fodder beet samples, with the exception that tenderness was improved ($P < 0.05$). Postmortem aging had a negative impact ($P < 0.05$) on SEL juiciness and TC flavor and overall liking and no impact ($P > 0.05$) on all remaining traits of US grain fed beef loin steaks. When focusing on the high eating quality samples, consumers did not discriminate between finishing systems when samples were aged 35 d, scoring TCH, FBH, and NFBH similarly ($P > 0.05$) for all palatability traits. The FBL and NFBL were normally scored similarly ($P > 0.05$) or with a slight advantage over SEL, regardless of aging period. Ultimately, finishing beef cattle using fodder beet in New Zealand can be a viable option to supply high quality beef during winter months, while maintaining the eating quality expectations associated with "grass-fed" beef according to US consumers from the Lubbock, TX area.

Keywords: cattle diet, consumer, eating quality, fodder beet
Meat and Muscle Biology 3(1):22–32 (2019) **doi:10.22175/mmb2018.10.0029**
Submitted 1 Oct. 2018 Accepted 29 Dec. 2018

Introduction

Beef production is highly sensitive to the variation in pasture growth in New Zealand (NZ). Pasture growth thrives in spring and early summer, is moderate in autumn, and low in winter (Li et al., 2011). Consequently, the slaughter pattern lags slightly behind the pasture growth curve, as slaughter numbers start to increase in November and December (late spring), reaching a peak from March to May (autumn), then decreasing in June and July, and reaching their annual low in early spring from August to October (Charteris et al., 1998). In lieu of traditional pasture, cattle commonly graze crops in the winter months. Brassicas, such as swedes/rutabaga (*brassica napobrassica*) and kale (*Brassica oleracea* var. *sabellica*), have historically been the predominant winter crops, but other brassicas, such as turnips (*brassica rapa* subsp. *rapa*) and rape seed (*brassica napus*), have also been used for winter grazing (Gibbs and Saldias, 2014). However, Gibbs and Saldias (2014) have pointed out several limitations of brassica use for winter grazing, including a short window for effective grazing, low yield per hectare [4 to 12 tons (t) dry matter (DM)/hectare (ha)], and

Research supported through partnership with Silver Fern Farms.

insufficient high energy intake [10.5 to 11 megajoules (MJ) of metabolizable energy (ME) per kg DM] for appreciable live weight gain.

Fodder beet (Beta *vulgaris* subsp. *vulgaris* L.), which is a cross between mangels/mangolds and sugar beet, has emerged as an alternative winter crop for beef cattle feeding in NZ (Oswald, 2011). Despite the potential risk for rumen acidosis when cattle are not transitioned onto the crop properly, fodder beet (FB) does offer several benefits, including high crop yields (25 to 35 tDM/ha) with low feed costs and a more competitive (or higher) ME than other available winter crops (11.8 to 12.5 MJ/kgDM; Gibbs and Saldias, 2014; Oswald, 2011).

A branded beef program was developed in NZ in the early 2010's based on predicted eating quality and is underpinned by proprietary thresholds for certain carcass traits, including marbling, ossification, pH, 12th rib fat, and HCW (Pethick et al., 2018). As demand continues to grow, the use of alternative finishing systems has been explored to supply beef cattle during winter months, when historically, cattle numbers and beef quality taper due to limited grass supply coupled with lower quality forage. Due to the growing popularity of winter maintenance of dairy heifers on FB, beef researchers (Gibbs and Saldias, 2014) have adapted and tailored this feeding system to finish beef cattle to help meet the demand for high quality beef in NZ. The purpose of this portion of the study was to determine how US consumers from the Lubbock, TX area perceived beef from cattle finished on FB directly before slaughter compared to beef from traditional NZ winter forage finished cattle and US grain finished cattle.

Materials and Methods

Animal selection

All experimental procedures were conducted in accordance with a Texas Tech University Animal Care and Use Committee protocol (Protocol #14016–04).

Seventeen beef producers in New Zealand participated in a nationwide feeding trial to finish beef steers using fodder beet (Beta *vulgaris* subsp. *vulgaris* L.) during winter months (June through September) in 2014. Each producer had a feeding plan tailored to his farm based on available FB acreage and yield of the FB crop. In general, cattle are transitioned onto the FB crop with a total diet of 8 to 10 kg DM on d 1, with only 1 kg DM FB and the remainder consisting of supplement (Gibbs and Saldias, 2014). Supplement was provided solely to add fiber to the diet, and meadow hay or cereal straw were recommended to minimize feed costs. For the next 14 d, FB is increased 1 kg DM every other day, while the supplement is decreased from 8 to 9 kg DM at d 1 to 6 kg DM at d 7 and 4 kg DM at d 14. From d 21, supplement is limited to 2.5 kg DM daily with FB fed ad libitum (Gibbs and Saldias, 2014). All steers were weighed at the start of the grazing period (d 0; average BW = 458.6 ± 45.0 kg) and at 60 d into the grazing period (average BW = 491.4 ± 48.0 kg). As a result, the ADG of those 3,567 steers was 0.5 kg from d 0 to d 60. If crop was still available to graze (dependent on farm), steers were also weighed again between 80 and 90 d of the grazing period (average BW = 522.2 ± 37.9 kg), resulting in an ADG of 1.0 kg for the 797 remaining steers. Steers enrolled in the FB feeding system and selected for eating quality assessment were on crop an average of 81 d (range 63 to 98 d) immediately prior to slaughter. Steers represented a variety of breed types including British (Angus or Hereford) purebred, Continental (Charolais, Limousin, Simmental) purebred, British crossbred, Continental crossbred, and British × Continental crossbred, but breed type was not included in the strip loin selection criteria. Carcasses from non-FB fed steers were also selected from the same processing facility as carcasses from cattle finished on FB on each collection day. Breed type, age and exact feeding program are not available for the non-FB steers.

All non-FB selected carcasses were "grass-fed" steers, but certifiably did not graze fodder beet prior to slaughter. In New Zealand, all cattle are required under federal law to be electronically identified (EID tagged) and all movements, starting at animal birth, between farms and to processing plants are recorded in the National Animal Identification & Tracing (NAIT) database. The Animal Status Declaration (ASD), as mandated under the Animal Products Act of 1999, must be completed each time animals move between properties or are consigned for processing as part of NAIT. One component of the ASD pertains to animal feeding, and producers must ensure animals have not been fed anything other than milk or pasture. To be considered pasture fed, animals must "have been raised under normal New Zealand farming conditions with year-round access to grass (e.g., hay, silage, lucerne, feed crops or other grazed or conserved forages) and other supplementary feeds (including manufacturing feeds, provided that you have a statement from the manufacturer that the feed does not contain animal protein or animal fat, other than dairy). Where animals have been fed on a feed pad or feedlot other than for short term periods (e.g., only as supplementary feed immediately prior to slaughter) then they would not be 'pasture fed' because of not having year-round access to grass" (ASD, 2016).

Strip loin selection

Strip loins were obtained from a single commercial abattoir in New Zealand located in Balclutha, NZ over a series of 9 collection days, spanning over a 28-d period in July and August to sample strip loins from as many of the participating finishers as possible (9 of 17). Geographical restrictions limited the selection from all 17 farms (i.e., cattle were located in a northern region of the South Island or on the North Island). Within each finishing system, 60 strip loins representing expected low and high eating quality (based on eligibility for the branded program, which focuses on marbling, ossification, pH, 12th rib fat, and HCW) were selected resulting in four treatments: FB low quality (FBL), FB high quality (FBH), non-FB low quality (NFBL), and non-FB high quality (NFBH). Both NZ low quality treatments would be relatively close to USDA Select based on average marbling and maturity scores; both NZ high quality treatments would be representative of USDA low Choice based on average marbling and maturity scores. Strip loins were vacuum packaged and stored on-site at 2°C until steak fabrication. In addition, 120 sides of beef [60 per USDA quality grade: Top (upper 2/3) Choice (TCH) and Select (SEL)] were selected by trained Texas Tech personnel through visual appraisal of marbling and maturity of the product at the time of selection from a commercial abattoir in Omaha, Nebraska. According to the most recent feedlot consulting nutritionist survey, corn is the primary grain used in US cattle finishing diets prior to slaughter (Samuelson et al., 2016), and so US treatments will be referred to as grain fed comparatively speaking to NZ feeding programs. Carcass data were collected in both countries by trained Texas Tech personnel using USDA standards (USDA, 1997). Traits of interest included HCW (kg), REA (cm^2), 12th rib fat thickness (mm), marbling [300 = slight00, 400 = small^{00}, 500 = modest^{00}, 600 = moderate^{00} (USDA, 1997)], ossification [100 = A00, 200 = B^{00} (USDA, 1997)], and lean color [lean maturity: 100 = A^{00}, 200 = B^{00} (USDA, 1997)]. Strip loins obtained in the U.S. were collected, vacuum packaged, shipped under refrigeration to the Gordon W. Davis Meat Science Laboratory, Lubbock, Texas, and stored at 2°C until steak fabrication.

Steak fabrication

Prior to 21 d postmortem, strip loins were fabricated in accordance with MSA protocols (Watson et al., 2008) for use in compositional analysis and consumer testing. All external fat and connective tissue were removed from strip loins prior to steak fabrication. In addition, the *gluteus medius* was removed from the strip loin leaving only the *longissimus lumborum*. Longissimus muscles were fabricated into 2.5 cm steaks and were further processed into smaller pieces measuring approximately 5 cm × 5 cm. Steak pieces were wrapped in plastic and vacuum packaged as sets of 5 based on position within the strip loin. Two sets (1 set per aging period) of 5 steak pieces were retained from each strip loin for subsequent consumer testing. Postmortem aging period (21 d or 35 d) was assigned and balanced within each treatment based on position to avoid any positional effect when examining postmortem aging. Excess pieces from each subprimal were retained for compositional analysis, vacuum packaged, held at 2 to 4°C, and frozen on d 21 postmortem. All consumer steaks were vacuum packaged and frozen at 21 or 35 d postmortem based on a predetermined postmortem aging designation.

All packages containing 5 consumer steak pieces were labeled with a unique ID code produced from MSA software prior to freezing for either 21 or 35 d postmortem. After freezing, New Zealand beef was shipped frozen to the Texas Tech University Gordon W. Davis Meat Laboratory, located in Lubbock, TX, via commercial air freight followed by frozen ground transport. Frozen samples were sorted into a predetermined cook order. After sorting, steaks remained frozen until further analysis.

Compositional analysis

Samples were analyzed using an AOAC-approved (Anderson, 2007) near infrared spectrophotometer (FoodScan, FOSS NIRsystems, Inc., Laurel, MD) to determine the percentage of fat, moisture and protein. Frozen samples were thawed at 2 to 4°C for 24 h prior to analysis. All remaining subcutaneous fat, intermuscular fat, and connective tissue were removed from each sample. Each remaining muscle sample was finely ground through a commercial food grinder (Krups 150 Watt Grinder item #402–70, Krups, Sheldon, CT) to obtain a 200-g sample.

Consumer panels

The Texas Tech University Institutional Review Board approved procedures for use of human subjects for consumer panel evaluation of sensory attributes (#530510).

Steak samples were thawed at 2– to °C for 24 h prior to consumer evaluation. All steaks were cooked on a Silex clamshell grill (Model S-143K, Silex Grills Australia Pty Ltd., Marrickville, Australia) with a temperature set at 225°C. The Silex grill was preheated 45 min prior to the start of the panels. Ten steak pieces (unrelated to trial) were prepared on the grill before consumer samples to initiate the cooking cycle and stabilize temperatures throughout the heating elements. A strict and detailed time schedule was followed to ensure all steaks were prepared identically (Gee, 2006). Each cooking round consisted of 10 samples that were cooked at the same time on 1 grill. All steaks were cooked for 5 min and 45 s, followed by a 3-min rest period. After the rest period, each steak was cut in half into 2 equal size pieces and served to 2 separate predetermined consumer panelists.

Consumer panels were conducted in the Texas Tech University Animal and Food Sciences Building. Consumer panelists ($n = 1140$) were recruited from Lubbock, Texas and the surrounding local communities. Each consumer was monetarily compensated and were only allowed to be participate one time. Each session consisted of 20 people with 3 sessions being conducted on a given night. Each session lasted approximately 60 min.

Consumer testing was conducted according to MSA grill protocols (Watson et al., 2008). Each consumer evaluated seven samples. One steak sample was included in the cooking order as a warm-up sample for consumers and to provide linkage across all testing nights. The link samples were always served in the first position, followed by 6 test samples served in predetermined, balanced order representing the 12 treatment × aging combinations. A Latin-square design was utilized to balance the order and presentation of the 6 treatments aged either 21 or 35 d, ensuring that each product was presented an equal number of times in the 6 test positions before and after each other product. Each sample had 10 consumer observations (i.e., 5 consumer steaks all being cut in half and served to 2 individuals each). Consumers scored palatability traits tenderness, juiciness, flavor liking, and overall liking on 100-mm line scales verbally anchored at 0 (not tender, not juicy, dislike extremely) and 100 (very tender, very juicy, like extremely). The 10 individual scores for tenderness, juiciness, flavor liking, and overall liking were averaged to generate mean sensory scores for each palatability trait prior to analysis.

Each panelist was seated at a numbered booth and was provided with a ballot, plastic utensils, a toothpick, unsalted crackers, a napkin, an empty cup, a water cup, and a cup with diluted apple juice (10% apple juice and 90% water). Each ballot consisted of a demographic questionnaire, 7 sample ballots, and a post panel survey regarding beef purchasing habits. Before beginning each panel, consumers were given verbal instructions by Texas Tech personnel about the ballot and the process of testing samples. Panels were conducted in a large classroom under fluorescent lighting with tables that were divided into individual consumer booths.

Statistical analysis

All data were analyzed using the GLIMMIX procedure of SAS (Version 9.3; SAS Inst. Inc., Cary, NC). Proximate and carcass data were analyzed as a randomized complete design with treatment as the fixed effect. Consumer data were analyzed using postmortem aging, treatment, and their interaction as fixed effects. Treatment least squares means were separated with the PDIFF option of SAS using a significance level of $P \leq 0.05$. Pearson correlations were calculated using PROC CORR in SAS ($P < 0.05$). Demographic data were summarized using PROC FREQ.

Results and Discussion

Carcass data

Treatment influenced ($P < 0.01$) all carcass traits, including HCW, REA, 12th rib fat thickness, marbling, ossification, and lean color (Table 1). Top choice carcasses were heavier than all other treatments ($P < 0.05$), followed by SEL carcasses. There was no difference in HCW of the four NZ treatments ($P > 0.05$), and all were lighter than TCH or SEL ($P < 0.05$). Top choice and SEL had similar REA ($P > 0.05$), but both had larger ($P < 0.05$) average REA than all four of the NZ treatments, which did not differ ($P > 0.05$). Top choice carcasses had the most fat at the 12th rib, followed by SEL, which had more fat than any of the NZ carcasses ($P < 0.05$). Within the FB carcasses, there were no differences in fat thickness between the carcasses selected to represent low compared to those selected to represent high eating quality ($P > 0.05$). A similar trend was observed for fat thickness within the non-FB carcasses. As expected, TCH had greater marbling than any other treatment ($P < 0.05$), followed by FBH and NFBH, which were similar. Select carcasses had intermediate marbling compared to the two high NZ treatments and the two low NZ treatments. Fodder beet low and NFBL had less ($P < 0.05$) marbling than any other treatment but did not differ from each other ($P > 0.05$). Both NZ low treatments would be relatively close to USDA Select based on average marbling and maturity scores; both NZ high treatments would be representative of USDA low Choice based on average marbling and maturity scores. Select carcasses had lower ($P < 0.05$) ossification scores than any other treatment; however, all carcasses were “A”

Table 1. The LS means for carcass data of selected cattle according to treatment (n = 60/treatment)

Treatment[1]	HCW, kg	REA, cm^2	12th rib fat thickness, mm	Marbling[2]	Ossification[3]	Lean color[4]
Fodder Beet Low	280.7^c	71.0^b	4.9^{cd}	308^d	151^a	185^{ab}
Fodder Beet High	278.4^c	69.5^b	5.7^c	415^b	151^a	175^b
Non-Fodder Beet Low	283.2^c	72.0^b	3.9^d	299^d	152^a	195^a
Non-Fodder Beet High	280.7^c	71.6^b	5.0^{cd}	404^b	149^a	175^b
Select	428.7^b	99.5^a	13.3^b	350^c	142^b	149^c
Top Choice	451.8^a	99.0^a	17.2^a	565^a	150^a	147^c
SEM[5]	4.9	1.1	0.6	7	2	4
P-value (Treatment)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

$^{a\text{-}d}$Within a column, LS means without a common superscript differ ($P < 0.05$).

[1]Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Non-Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Non-Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; high predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Select = USDA Select.

Top Choice = USDA top (upper 2/3) Choice.

[2]Marbling: 300 = slight^{00}, 400 = small^{00}, 500 = modest^{00}, 600 = moderate^{00} (USDA, 1997).

[3]Ossification: 100 = A^{00}, 200 = B^{00} (USDA, 1997).

[4]Lean color: 100 = A^{00}, 200 = B^{00} (USDA, 1997).

[5]SEM (largest) of the least square means.

skeletal maturity, so a ten-degree difference in ossification would unlikely have any practical relevance. Non-fodder beet low had a greater ($P < 0.05$) average lean color score, indicating a darker ribeye color, than all other treatments except FBL. Fodder beet high and NFBH were intermediate; however, neither were different from FBL. The 2 US treatments had the lowest ($P < 0.05$) lean color scores, indicating SEL and TCH had more youthful red lean color than any of the NZ treatments. However, the average lean color scores for all treatments would be considered “A” lean maturity, despite any statistical differences between treatments.

As expected due to the variation in finishing systems between the US and NZ, US carcasses were considerably heavier than NZ carcasses with larger ribeyes and more back fat. Our US carcasses, however, were heavier and had larger ribeyes than average US beef carcasses as reported by Boykin et al. (2017) in the 2016 National Beef Quality Audit. The NZ carcass weights were slightly below the average weight reported by Sepulveda et al. (2018), which is to be expected given this trial was conducted in the winter when carcass weights would lessen due to the seasonality of the NZ cattle finishing system. Ribeye area and fat thickness of NZ carcasses aligned with values reported by Sepulveda et al. (2018) in a NZ carcass trait benchmarking study.

Composition

Proximate composition of longissimus muscle representing the six treatments can be found in Table 2. In alignment with marbling score, TCH had greater ($P < 0.05$) percentage intramuscular fat (IMF) than any other treatment, followed by FBH, NFBH and SEL, which were similar ($P > 0.05$). However, IMF for SEL was similar to FBL, but greater than NFBL. Otherwise, FBL and NFBL had less ($P < 0.05$) IMF than any other treatment but did not differ from each other ($P > 0.05$). Due to the inverse relationship between fat and moisture, FBL and NFBL had the greatest moisture percentage, followed by FBH and NFBH, which were similar, then SEL, and TCH had less moisture than any other treatment ($P < 0.05$). Select had greater protein percentage than any other treatment. Non-FB low had greater ($P < 0.05$) protein percentage than all remaining treatments, except NFBH, but no other differences were observed in protein percentage ($P > 0.05$). The range in protein percentage was less than one percent between the 6 treatments and would likely not translate to practical differences despite statistical differences in protein between certain treatments.

Top Choice and SEL had fat percentages within the range of previously reported values by authors comparing top loin specifically from those 2 quality grades, where SEL has ranged from 3.0– 4.7%

Table 2. The S means for proximate composition of selected strip loins according to treatment (n = 60/treatment)

Treatment[1]	Fat, %	Moisture, %	Protein, %
Fodder Beet Low	3.1^{cd}	72.2^{a}	23.3^{c}
Fodder Beet High	4.1^{b}	71.4^{b}	23.3^{c}
Non-Fodder Beet Low	2.9^{d}	71.9^{a}	23.6^{b}
Non-Fodder Beet High	4.0^{b}	71.3^{b}	23.4^{bc}
Select	3.6^{bc}	70.8^{c}	24.2^{a}
Top Choice	7.2^{a}	68.4^{d}	23.3^{c}
SEM[2]	0.2	0.2	0.1
P-value (Treatment)	< 0.01	< 0.01	< 0.01

$^{a-d}$Within a column, LS means without a common superscript differ ($P < 0.05$).

[1]Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Non-Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Non-Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; high predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Select = USDA Select. Top Choice = USDA top (upper 2/3) Choice.

[2]SEM (largest) of the least square means.

fat and TCH has ranged from 6.9 to 9.2% fat (Bueso et al., 2018, Gomez et al., 2018; Hunt et al., 2014). Crownover et al. (2017) reported fat percentage of 4.0% for longissimus lumborum from grass fed NZ carcasses with marbling scores ranging from 200 to 400 (traces^{00}-small^{00}), which aligns with FBH and NFBH. This percentage is also similar to the lipid concentration (4.1%) of the longissimus thoracis of pasture-fed NZ beef reported by Daly et al. (1999). However, all NZ muscles had lower fat percentage than the 7% value published for separable lean of strip loin in the New Zealand Food Composition Database (NZFCD, 2018).

Table 3. Demographic characteristics consumers who participated in consumer sensory panels in Lubbock, TX (n = 1,140)

Trait	Percentage, %
Age	
< 20 y	8.4
20-29 y	24.7
30-39 y	21.3
40-49 y	16.9
50-59 y	14.6
≥ 60 y	14.1
Gender	
Male	49.5
Female	50.5
Occupation	
Tradeperson	12.7
Professional	32.0
Administration	14.6
Sales & Service	12.6
Laborer	6.0
Homemaker	2.8
Student	11.8
Currently Not Employed	7.6
How often do you eat beef?	
Daily	12.9
4-5 times/wk	27.7
2-3 times/wk	35.4
Weekly	17.0
Biweekly	4.6
Monthly	2.3
Never	0.1
Household Size (Adults)	
1	10.7
2	58.0
3	21.1
4	8.0
5	1.6
6	0.5
7	0.2
Household Size (Children)	
0	51.7
1	14.9
2	19.9
3	9.0
4	3.5
5	0.9
6	0.2

(continued)

Demographics

A summary of demographic characteristics of participating untrained panelists is shown in Table 3. Age was evenly distributed among all categories from less than 20 y to greater than 60 y, but the largest proportion of consumers (46.0%) were aged 20 to 39 y. Participants were evenly split between male and female. The most popular occupation was 'Professional', with nearly twice the proportion as any other occupation. A majority of consumers (93.0%) ate beef at least once per wk. Nearly two-thirds of participants (63.9%) preferred their

Table 3. (cont.)

Trait	Percentage, %
Preferred cooking level	
Rare	2.4
Medium Rare	33.7
Medium	30.2
Medium Well Done	23.2
Well Done	10.5
Income Level	
< $20,000/yr	11.9
$20,000-50,000/yr	25.9
$50,001-75,000/yr	22.7
$75,001-100,000/yr	18.4
> $100,000/yr	21.1
Education Level	
Non-high school graduate	4.9
High school graduate	17.8
Some college/technical school	37.8
College graduate	27.0
Post graduate	12.4
Cultural Heritage	
African-American	4.3
Asian	0.9
Caucasian/White	64.3
Hispanic	28.7
Native American	0.9
Other	0.8

beef cooked medium rare or medium, but 23.2% prefer medium well-done degree of doneness. Most participants identified as being 'Caucasian/White', but over a quarter indicated 'Hispanic' was their cultural heritage.

Consumer eating quality

Table 4 illustrates the effects of treatment and postmortem aging on the consumer assessment of eating quality traits. Treatment and postmortem aging interacted to influence ($P \leq 0.05$) each palatability trait. Extending the postmortem aging period by 14 d improved tenderness ($P < 0.05$) of all NZ treatments, but had no influence ($P > 0.05$) on tenderness of US beef. Both 21-d and 35-d TCH along with 35-d FBH and 35-d NFBH had greater ($P < 0.05$) tenderness scores than any other treatment × aging combination. On the opposite end of the spectrum, SEL samples aged 21 d or 35 d postmortem and NFBL aged 21 d postmortem had lower ($P < 0.05$) tenderness scores than any other treatment. Within each diet treatment, the expected high eating quality samples were more tender ($P < 0.05$) than the expected low eating quality samples. The only exception to this trend was observed for 35-d aged FB samples, as tenderness did not differ ($P > 0.05$) between FBL and FBH when aged for 35 d.

Although aging and treatment interacted to influence juiciness, no consistent trends due to country (US vs. NZ beef) or aging were observed. The NFBL and NFBH were both juicier ($P < 0.05$) at 35 d compared to 21 d according to consumers. However, consumers indicated SEL were less juicy ($P < 0.05$) at 35 d compared to 21 d. There were no aging differences in juiciness between 21 d and 35 d samples for FBL, FBH, or TCH ($P > 0.05$). Within each diet treatment, the expected high eating quality samples were juicier ($P < 0.05$) than the expected low eating quality samples. The only exception to this trend was observed for 35-d aged FB samples, as juiciness did not differ ($P > 0.05$) between FBL and FBH when aged for 35 d.

Much like juiciness scores, consumers scored NFBL and NFBH greater ($P < 0.05$) for flavor liking at 35 d compared to 21 d, while additional aging did not improve flavor liking of any other treatment ($P > 0.05$). However, TCH samples that were aged 35 d had reduced ($P < 0.05$) flavor liking scores compared to TCH samples aged for 21 d postmortem. Top choice samples aged 21 d had greater ($P < 0.05$) flavor liking than any other treatment by aging combination except NFBH samples aged for 35 d postmortem. Within each diet, the expected high eating quality treatment had greater ($P < 0.05$) flavor liking scores than the expected low eating quality treatment. This trend was observed for all samples except the 21-d aged FB samples, where flavor liking did not differ between FBL and FBH ($P > 0.05$).

Differences in overall liking between 21-d and 35-d samples within each treatment followed the same trend as flavor liking scores. NFBL and NFBH had greater ($P < 0.05$) overall liking scores at 35 d compared to 21 d, while TCH samples had lower ($P < 0.05$) overall liking scores at 35 d versus 21 d postmortem. Additional aging did not affect overall liking of any other treatment ($P > 0.05$). Within each diet, the expected high eating quality treatment had greater overall liking scores than the expected low eating quality treatment ($P < 0.05$). This trend was observed for all samples except the 21-d aged FB samples, where overall liking did not differ ($P > 0.05$) between FBL and FBH.

Ultimately, one of our goals was to determine if consumers can distinguish between FB and NFB, as both can be labeled and marketed as "grass-fed." When samples were aged 35 d, consumers could not distinguish ($P > 0.05$) between FB and NFB for tenderness, juiciness, flavor liking, or overall liking within the high or low expected eating quality classification. When samples were aged 21 d, consumers did not differentiate ($P > 0.05$) be-

Table 4. The effects of treatment and postmortem aging on consumer assessment of tenderness, juiciness, flavor liking, and overall liking of strip loin steaks (n = 1,140)

Treatment[1]	Tenderness[2]	Juiciness[2]	Flavor liking[2]	Overall liking[2]
21 d				
Fodder Beet Low	58.0[de]	65.7[de]	59.6[e]	59.7[ef]
Fodder Beet High	63.2[c]	69.7[abc]	62.0[cde]	62.3[cde]
Non-Fodder Beet Low	52.9[f]	62.7[ef]	55.4[f]	54.7[g]
Non-Fodder Beet High	61.2[cd]	66.3[cd]	59.6[e]	60.5[ef]
Select	52.8[f]	66.0[de]	55.8[f]	57.4[fg]
Top Choice	70.8[a]	72.5[a]	69.0[a]	69.7[a]
35 d				
Fodder Beet Low	63.5[bc]	68.4[bcd]	61.1[de]	62.1[de]
Fodder Beet High	67.5[ab]	70.8[ab]	65.3[bc]	66.0[abc]
Non-Fodder Beet Low	61.9[cd]	66.6[cd]	60.3[de]	61.8[e]
Non-Fodder Beet High	68.0[a]	71.1[ab]	66.4[ab]	67.9[ab]
Select	54.7[ef]	61.5[f]	54.1[f]	55.8[g]
Top Choice	71.1[a]	70.7[ab]	63.5[bcd]	65.6[bcd]
SEM[3]	1.51	1.25	1. 25	1.36
P-value (Treatment)	< 0.01	< 0.01	< 0.01	< 0.01
P-value (Aging)	< 0.01	0.16	0.03	< 0.01
P-value (Treatment × Aging)	0.05	< 0.01	< 0.01	< 0.01

[a-g]Within a column, LS means without a common superscript differ ($P < 0.05$).

[1]Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) and finished on fodder beet crop an average of 81 d (range 63-98 d) immediately prior to slaughter; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Non-Fodder Beet Low = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; low predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA Select. Non-Fodder Beet High = Pasture fed (year-round access to grass, such as hay, silage, lucerne, feed crops or other grazed or conserved forages) with no fodder beet consumption; high predicted eating quality based on marbling score approximately equivalent to carcasses grading USDA lower 1/3 Choice. Select = USDA Select. Top Choice = USDA top (upper 2/3) Choice.

[2]Sensory scores: 0 = not tender/juicy, dislike flavor/overall extremely; 100 = very tender/juicy, like flavor/overall extremely.

[3]SEM (largest) of the least square means.

tween FB and NFB of the high eating quality samples, but actually scored FBL as more tender with greater flavor liking and overall liking than NFBL ($P < 0.05$).

Numerous researchers have shown US consumers prefer TCH over SEL (Bueso et al., 2018, Gomez et al., 2018; Hunt et al., 2014), which was also the current finding, as consumers scored TCH greater than SEL for all palatability traits, regardless of postmortem aging. A similar trend was observed between NFBL and NFBH for all traits regardless of postmortem aging, despite a smaller difference in fat content between the low and high quality samples than what was observed between TCH and SEL. Only flavor and overall liking were greater in FBH than FBL when aged 35 d, while only tenderness and juiciness were greater in FBH than FBL when aged 21 d. FBH did, however, have numerically higher scores than FBL for all remaining traits, and perhaps the lack of difference for all traits could be attributed to the elevated scores of FBL, especially compared to NFBL and SEL.

To our knowledge, no previous research has examined the eating quality of beef from cattle that grazed fodder beet; however, several researchers have examined the comparative quality of beef from grass feeding or grain finishing cattle. Sitz et al. (2005) reported steaks from Australian grass-fed beef had lower scores for tenderness, juiciness, flavor, and overall acceptability than steaks from US grain-finished beef. Conversely, Young and Baumeister (1999) found no difference in the intensity of pastoral flavor or odor of beef from cattle finished either on ryegrass/clover or a restricted intake corn diet for 9 wk. Likewise, trained panelists found juiciness and tenderness were similar between forage and concentrate finished beef (Duckett et al., 2013). However, concentrate finishing did generate greater beef flavor intensity along with lower off-flavor intensity compared to forage finishing (Duckett et al., 2013). In an effort to compare the flavor profile of beef from cattle finished on grass or grain, Maughan et al. (2012) developed a beef flavor lexicon. Barny, bitter,

Table 5. Pearson's correlation coefficients for the relationships between consumer sensory scores and proximate data of longissimus muscle grass fed, fodder beet fed or grain fed beef.

Trait	Juiciness	Flavor liking	Overall liking	Fat	Moisture	Protein
Tenderness	0.79*	0.76*	0.85*	0.35*	-0.28*	-0.26*
Juiciness		0.70*	0.76*	0.25*	-0.19*	-0.21*
Flavor Liking			0.94*	0.31*	-0.25*	-0.21*
Overall Liking				0.31*	-0.25*	-0.21*
Fat					-0.90*	-0.42*
Moisture						0.14*

*Correlation coefficients were significant ($P < 0.01$).

gamey, and grassy flavors were more prevalent in beef from grass-fed cattle, while umami was more prevalent in grain-finished beef (Maughan et al., 2012). Degree of liking was negatively related to gamey, barny, bitter, and grassy flavors, and positively associated with brothy, umami, roast beef, browned, fatty, and salty flavors (Maughan et al., 2012). It should be pointed out that the grass-fed samples were supplemented with alfalfa during the winter and finished on grass for 120 d, but no further description of the finishing grass was provided (Maughan et al., 2012). We believe this is relevant because Larick and Turner (1990) demonstrated that different forages elicit different flavor notes, suggesting not all grass-fed cattle will taste the same. Grazing sorghum-sudangrass for 84 d generated a sweeter flavor with a gamier aftertaste compared to grazing fescue-clover pasture (Larick and Turner, 1990).

The US consumers often prefer the flavor of grain-finished beef compared to grass-fed beef. When Sitz et al. (2005) matched US strip steaks to Australian grass-fed strip steaks according to similar Warner-Bratzler shear force values and marbling, US consumers were accustomed to US domestic beef flavor and preferred that over grass-fed beef. Grass-fed beef flavor can undoubtedly vary from country to country depending on the type, quality, and maturity of the forage the cattle consume. However, in the current study, SEL had a slightly higher marbling score (and fat percentage) than either of the expected low eating quality NZ treatments, regardless if they were fed fodder beet or not. Hypothetically speaking, these carcasses will all be considered USDA Select based on their marbling score and maturity, and there were no differences in tenderness, juiciness, and overall liking between SEL, FBL, and NFBL for 21 d samples. For 35 d samples, however, FBL and NFBL outscored SEL for all palatability traits, which contradicts the findings of Sitz et al. (2005) that US consumers prefer the domestic beef flavor over imported grass-fed beef. Moreover, when samples were aged to 35 d postmortem, consumers scored TCH similarly to FBH and NFBH for all palatability traits, despite those NZ treatments having a much lower fat content. Granted, TCH was more palatable than FBH and NFBH when samples were only aged 21 d postmortem.

Corbin et al. (2015) conducted a sensory study of tender beef strip loins, screened by Warner-Bratzler shear force (< 3.4 kg), representing various fat percentages and feeding programs. When standardizing tenderness, consumers rated NZ grass-fed samples similarly to the 2 treatments with a comparable fat percentage (Select and Holstein Select) for tenderness and juiciness, but grass-fed loin samples were scored lower for flavor and overall liking than Select and Holstein Select, indicating the importance of flavor to overall acceptability. These results support the findings of Sitz et al. (2005) that US consumers prefer domestic beef flavor but contradict the findings of the current study.

Lastly, Lucherk et al. (2017) evaluated the eating quality of strip loin steaks from US grain- and NZ grass-fed beef across 5 USDA marbling score ranges from Standard to Prime and three postmortem aging periods from 7 to 42 d postmortem. Tenderness, flavor liking, and overall liking were influenced by the interaction of diet × quality grade. When specifically focusing on TCH and SEL, consumers scored grass-fed TCH higher than grain-fed TCH for tenderness, flavor liking, and overall liking. However, all palatability traits were scored similarly between the 2 diets for SEL (Lucherk et al., 2017), providing further support that consumers may not always score grain fed beef higher than grass-fed beef simply because they are accustomed to the flavor of domestic grain-fed beef.

Correlations

To estimate the extent to which eating quality scores and proximate components are linked to overall liking, correlations between palatability traits and compositional data were determined (Table 5). Consumer overall liking was correlated ($P < 0.01$) with consumer tenderness ($r = 0.85$) and juiciness ratings ($r = 0.76$), but most highly correlated with flavor liking ($r = 0.94$). Each of the proximate components was related ($P < 0.01$) to overall liking. As the percentage of fat increased, overall liking increased, while moisture and protein were inversely related to overall liking. Individual palatability traits were strongly related to each other ($r \geq 0.70$), indicating that individual improvements of these traits could influence the perception of another trait.

The current results were not unexpected as the previous reports of beef eating quality for US consumers align with these coefficients for grain-fed beef (Corbin et al., 2015; Hunt et al., 2014) and grass-fed beef (Crownover et al., 2017; Hardcastle et al., 2018). These data also support the relationship of tenderness, flavor, and juiciness conjointly contributing to the consumer perception of overall liking as reported by Neely et al. (1998).

Conclusion

Extending postmortem aging by 14 d improved tenderness scores of all NZ-sourced beef, and improved juiciness, flavor liking, and overall liking of NFB, but had no positive impact on eating quality of US beef. When focusing on the high eating quality samples, consumers did not discriminate between finishing systems when samples were aged 35 d, scoring TCH, FBH, and NFBH similarly for all palatability traits. FBL and NFBL were normally scored similarly or with a slight advantage over SEL, regardless of aging period. Ultimately, finishing beef cattle using fodder beet in New Zealand seems to be a viable option to supply beef cattle during winter months and meet demand for high quality beef, while maintaining the eating quality expectations associated with grass fed beef according to US consumers located in the Lubbock, TX area.

Literature Cited

Anderson, S. 2007. Determination of fat, moisture, and protein in meat and meat products using the FOSS FoodScan near-infrared spectrophotometer with FOSS Artificial Neural Network Calibration Model and Associated Database: Collaborative study. J. AOAC Int. 90:1073–1083.

ASD. 2016. Animal Status Declaration. Ministry for Primary Industries of New Zealand. http://www.foodsafety.govt.nz/elibrary/industry/animal-status-declaration/asd-form-2016.pdf (accessed: 21 July, 2017).

Boykin, C. A., L. C. Eastwood, M. K. Harris, D. S. Hale, C. R. Kerth, D. B. Griffin, A. N. Arnold, J. D. Hasty, K. E. Belk, D. R. Woerner, R. J. Delmore Jr., J. N. Martin, D. L. VanOverbeke, G. G. Mafi, M. M. Pfeiffer, T. E. Lawrence, T. J. McEvers, T. B. Schmidt, R. J. Maddock, D. D. Johnson, C. C. Carr, J. M. Scheffler, T. D. Pringle, A. M. Stelzleni, J. Gottlieb, and J. W. Savell. 2017. National Beef Quality Audit–2016: In-plant survey of carcasscharacteristics related to quality, quantity, and value of fed steers and heifers. J. Anim. Sci. 95:2993-3002

Bueso, M. E., A. J. Garmyn, T. G. O'Quinn, J. C. Brooks, M. M. Brashears, and M. F. Miller. 2018. A comparison of Honduras and United States consumers' sensory perception of Honduran and U.S. beef. Meat and Muscle Biology. 2:233-241. doi:10.22175/mmb2018.03.0003

Charteris, P. L., D. J. Garrick, and S. T. Morris. 1998. New Zealand beef industry structure and opportunities to improve income. Proc. New Zeal. Soc. An. 58:228–230.

Corbin, C. H., T. G. O'Quinn, A. J. Garmyn, J. F. Legako, M. R. Hunt, T. T. N. Dinh, R. J. Rathmann, J. C. Brooks, and M. F. Miller. 2015. Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments. Meat Sci. 100:24–31. doi:10.1016/j.meatsci.2014.09.009

Crownover, R. D., A. J. Garmyn, R. J. Polkinghorne, R. J. Rathmann, B. C. Bernhard, and M. F. Miller. 2017. The effects of hot- vs. cold-boning on eating quality of New Zealand grass fed beef. Meat Musc. Biol. 1:207–217. doi:10.22175/mmb2017.06.0030

Daly, C. C., O. A. Young, A. E. Graafhuis, and S. M. Moorhead. 1999. Some effects of diet on beef meat and fat attributes. New Zeal. J. Agr. Res. 42:279:287. doi:10.1080/00288233.1999.9513377

Duckett, S. K., J. P. S. Neel, R. M. Lewis, J. P. Fontenot, and W. M. Clapham. 2013. Effects of forage species or concentrate finishing on animal performance, carcass and meat quality. J. Anim. Sci. 91:1454–1467. doi:10.2527/jas.2012-5914

Gee, A. 2006. Protocol Book 4: For the thawing preparation, cooking and serving of beef for MSA (Meat Standards Australia) pathway trials. North Sydney: Meat and Livestock Australia.

Gibbs, J., and B. Saldias. 2014. Feeding fodder beet in New Zealand beef and sheep production. Proceedings of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association Annual Conference. 2014:6.14.1-6.14.7.

Gomez, A. R., A. J. Garmyn, T. G. O'Quinn, M. E. Bueso, J. C. Brooks, M. M. Brashears, and M. F. Miller. 2018. Honduran and U.S. consumer assessment of beef from various production systems with or without marination. Meat Musc. Biol. 2:242–253. doi:10.22175/mmb2018.03.0004

Hardcastle, N. C., A. J. Garmyn, J. F. Legako, M. M. Brashears, and M. F. Miller. 2018. Honduran consumer perception of palatability of enhanced and non-enhanced beef from various finishing diets. Meat Musc. Biol. 2:277–295. doi:10.22175/mmb2018.05.0012

Hunt, M. R., A. J. Garmyn, T. G. O'Quinn, C. H. Corbin, J. F. Legako, R. J. Rathmann, J. C. Brooks, and M. F. Miller. 2014. Consumer assessment of beef palatability from four beef muscles from USDA Choice and Select graded carcasses. Meat Sci. 98:1–8. doi:10.1016/j.meatsci.2014.04.004

Larick, D. K., and B. E. Turner. 1990. Flavor characteristics of forage- and grain-fed beef as influenced by phospholipid and fatty acid compositional differences. J. Food Sci. 55:312–317. doi:10.1111/j.1365-2621.1990.tb06751.x

Li, F. Y., V. O. Snow, and D. P. Holzworth. 2011. Modelling the seasonal and geographical pattern of pasture production in New Zealand. New Zeal. J. Agr. Res. 54:331–352.

Lucherk, L. W., T. G. O'Quinn, J. F. Legako, J. C. Brooks, and M. F. Miller. 2017. Palatability of beef strip loin steaks from grass- and grain-finished beef representing various fat levels and aging times. In: Proc. 63rd International Congress of Meat Science and Technology, Cork, Ireland. Wageningen Academic Publishers, Wageningen, the Netherlands. p. 220-221.

Maughan, C., R. Tansawat, D. Cornforth, R. Ward, and S. Martini. 2012. Development of a beef flavor lexicon and its application to compare the flavor profile and consumer acceptance of rib steaks from grass- or grain-fed cattle. Meat Sci. 90:116–121. doi:10.1016/j.meatsci.2011.06.006

Neely, T. R., C. L. Lorenzen, R. K. Miller, J. D. Tatum, J. W. Wise, J. F. Taylor, M. J. Buyck, J. O. Reagan, and J. W. Savell. 1998. Beef customer satisfaction: Role of cut, USDA quality grade, and city on in-home consumer ratings. J. Anim. Sci. 76:1027–1033. doi:10.2527/1998.7641027x

New Zealand Food Composition Database. 2018. New Zealand Institute for Plant and Food Research and Ministry of Health (New Zealand). Available at: Http://foodcomposition.co.nz/search/food/M1059/nip (accessed 4 September 2018).

Oswald, A. 2011. Fodder beet use in sheep and beef farming. Proceedings of the Society of Sheep and Beef Cattle Veterinarians of the New Zealand Veterinary Association Annual Conference. 2011:2.29.12.29.4.

Pethick, D., P. McGilchrist, R. Polkinghorne, R. Warner, G. Tarr, A. Garmyn, J. Thompson, and J. Hocquette. 2018. Travaux de recherche internationaux sur la qualité sensorielle de la viande ovine et bovine (International research on beef and lamb eating quality). Viandes et Produits Carnés (http://www.viandesetproduitscarnes.fr/index.php?lang=fr). doi: VPC-2017-33-4-3.

Samuelson, K. L., M. E. Hubbert, M. L. Galyean, and C. A. Löest. 2016. Nutritional recommendations of feedlot consulting nutritionists: The 2015 New Mexico State and Texas Tech University survey. J. Anim. Sci. 94:2648–2663. doi:10.2527/jas.2016-0282

Sepulveda, C. A., A. J. Garmyn, K. S. Spivey, M. R. Hunt, R. J. Polkinghorne, and M. F. Miller. 2018. Benchmarking New Zealand carcass quality and yield characteristics. 71st Recip. Meat Conf. Proc., Kansas City, MO, 24-27 June, 2018. (Abstr. 23).

Sitz, B. M., C. R. Calkins, D. M. Feuz, W. J. Umberger, and K. M. Eskridge. 2005. Consumer sensory acceptance and value of domestic, Canadian, and Australian grass-fed beef steaks. J. Anim. Sci. 83:2863–2868. doi:10.2527/2005.83122863x

USDA. 1997. United States standards for grades of carcass beef. Livest. Seed Program, Agric. Market. Serv., Washington, DC.

Watson, R., A. Gee, R. Polkinghorne, and M. Porter. 2008. Consumer assessment of eating quality- Development of protocols for MSA testing. Aust. J. Exp. Agr. 48:1360-1367. http://www.publish.csiro.au/nid/72/issue/4061.htm

Young, O. A., and B. M. B. Baumeister. 1999. The effect of diet on the flavor of cooked beef and the odour compounds in beef fat. New Zeal. J. Agr. Res. 42:297–304. doi:10.1080/00288233.1999.9513379