Sensory acceptability and chemical characteristics of healthy rib-eye steaks from forage-finished steers

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Consumer interest in health benefits of forage-finished beef has led to increased product demand. To date, little information on sensory characteristics of cooked forage-finished beef is available. We evaluated sensory acceptability and chemical characteristics of rib-eye steaks from forage-finished steers. Rib-eye steaks from 3 forage-finished steers [S1 (bermudagrass+ryegrass, etc.); S2 (bermudagrass+ryegrass+berseem, etc.); S3 (bermudagrass+berseem+forage soybean+brown midrib sorghum, etc.)] and one C [commercial steak], cooked by grilling and/or 2-sided grilling, were evaluated for chemical composition and microbial safety. Sensory liking [overall-appearance (OAR) and fat-appearance (FA) for raw steaks; overall-appearance (OAC), overall-flavor (OF), juiciness, tenderness and overall-liking (OL) for cooked steaks] were evaluated by 112 Hispanic consumers. Data were analyzed (PROC MIXED, α=0.05). C (raw) had higher fat (50.2% vs. 23.0-24.9%) and lower protein (49.4% vs. 73.5-74.4%, dry weight basis) contents compared with S1 and S2. S1 and S3 had higher omega-3 (0.49-0.55 vs. 0.09%), lower omega-6/omega-3 ratio (2.51-2.81 vs. 10.07), and lower PUFA (4.31-4.77 vs. 8.4%) contents than C, thus exhibiting a healthier fatty acid profile. Concerning raw steaks, S3 had higher OAR (6.9 vs. 5.4-5.9) and FA (5.9 vs. 4.9-5.1) liking scores than other samples. Purchase intent based on visual appearance was highest for S3 (85.7%). Concerning cooked steaks, the two cooking methods did not cause significant differences in liking scores. Juiciness and OL scores of C steaks (both cooking methods) and S3(Grilling) were not significantly different. Purchase intent (after health benefits of forage-finished steaks was informed) increased from 62.0-73.8 to 69.8-85.7%. The mean drop of liking scores was -1.00 to -2.50 and -0.50 to -2.50 on the 9-point OL scale, respectively, when cooked steaks were not-juicy-enough and not-tender-enough. Cooked and raw rib-eye steaks were free of *E. coli*. This study demonstrated that forage-finished steaks are potentially healthier than grain-fed commercial steaks and have market potential toward Hispanic population.

INTRODUCTION

Numerous studies have demonstrated the need to increase intakes of polyunsaturated fatty acids (PUFA), especially those belonging to the omega-3 (n-3) group, in foods for infants and adults (Riediger et al. 2009). The balance of n-6/n-3 fatty acids is an important determinant in decreasing the risk coronary heart diseases. The n-3 enrichment can be achieved by modifying diets of animals towards grass-oriented feeds (Riediger et al. 2009). US consumers favor grain-finished beef over grass-finished beef in certain sensory attributes including flavor, juiciness, tenderness and overall acceptability. The availability of grass-finished beef during the whole year can be achieved using frozen storage (Kerth et al. 2007). However, freezing and frozen storage can affect the structural and chemical properties of muscle foods (Miller et al. 1980).

Information related with the health benefits of forage-finished beef in conjunction with the growing demand for natural, environmental friendly products and production systems are currently important drivers of the willingness to pay for consumers (Umberger et al. 2009). Hispanic population is an important ethnic group to consider for product marketing.

The objective of this study was to evaluate the sensory acceptability, chemical characteristics and microbial safety of rib-eye steaks from forage-finished steers and one commercial steak cooked by grilling and/or 2-sided grilling using Hispanic consumers. In addition to this, acceptability of 5-months frozen stored rib-eye steaks was also assessed.

MATERIALS AND METHODS

Steers, feeding systems, and rib-eye steaks: Steers were blocked into nine groups (6 steers/group) and each group was randomly assigned to one of three forage feeding systems (Table 1). Two steers per group (18 steers) were selected and harvested. Six rib-eyes from each side (left and right) of each carcass (18 carcasses) were used for two studies. Right-sided steaks were used for the freshly harvested beef consumer study (first study) and left-sided steaks were stored during 5 months at -20 °C for the second study. Treatments to evaluate were rib-eye steaks from S1, S2, S3, and one commercially available grain-finished rib-eye steak (C, USDA Choice grade, Winn-Dixie, Baton Rouge, LA, Table 1).

Proximate, fatty acid and microbiological analyses of different rib-eye steaks: Analyses were done following AOAC standard procedures

Consumer studies of different rib-eye steaks: For both studies (freshly harvested and frozen stored beef), Hispanic population (N=112 for the first study and N=51 for the second study) answered questions on evaluation of the product appearances, their own preferences, willingness to pay for forage-fed beef, and degree of doneness. Two cooking procedures were used: "2-sided grilling" and "grilling". A Balanced Incomplete Design, Plan 11.10 (t = 8, k = 4, r = 7, b =14, λ = 1, E = 0.86, Type I) was used (Cochran & Cox, 1957) for the first study (8 samples; 3 forage treatments + commercial grain-fed sample x 2 cooking methods). For the second study, a Randomized Complete Block Design (RCBD) since consumers only tested 3 samples (cooked rib-eye steaks from 3 forage systems using only a grilling method and excluding C). Visual appearance was assessed by visual observation of pictures (Figure 1, size of each picture of 8" x 11") of the different treatments. Attributes evaluated of the cooked steaks samples were overall appearance, overall beef flavor, juiciness, tenderness, and overall liking. Consumers rated the samples in the order in which they were presented using a 9-point hedonic scale. Consumers were also asked to rate the intensities of juiciness and tenderness using the just-about-right scale (JAR) with 3 categories (not enough, just about right, and too much). Consumers determined overall acceptance and purchase intent of each product, based on sensory liking, using the binomial (yes/no) scale.

Statistical analyses: All data were analyzed at α=0.05 using the SAS software 9.1.3 ANOVA was used to determine significant differences among steak samples followed by the Tukey's studentized range test. A penalty analysis was used to analysis JAR ratings. MANOVA was used to determine if significant differences exist among steak samples including all sensory attributes followed by a Descriptive Discriminant Analysis. Cochran's Q test and the simultaneous confident intervals were used to determine differences in prices.

Table 1 Descriptions of the treatments used in the study

Treatment label	Description*
S1	Rib-eye steaks obtained from steers that were fed with: **Paddock A**: bermudagrass (Cynodon dactylon, BG); **Paddock B**: annual ryegrass (Lolium multiflorum, RG; seeding rate of 23 kg/ha); **Paddock C**: BG+RG (seeding rate of 14 kg/ha).
S2	Rib-eye steaks obtained from steers that were fed with: **Paddock A**: BG; **Paddock B**: RG (seeding rate of 14 kg/ha) + rye (Secale cereale; seeding rate of 14 kg/ha) + berseem (Trifolium alexandrium; seeding rate 7 kg/ha), red (Trifolium pratense; seeding rate 5 kg/ha) and white (Trifolium repens; seeding rate 3 kg/ha) clovers; **Paddock C**: dallisgrass (Paspalum dilatatum) + berseem, and white clovers.
S3	Rib-eye steaks obtained from steers that were fed with: **Paddock A**: BG; **Paddock B**: dallisgrass + berseem, red, and white clovers; **Paddock C**: RG+rye+berseem, red, and white clovers; **Paddock D**: forage soybean (Glycine max, seeding rate 30 kg/ha)/RG (for summer and winter, respectively); **Paddock E**: brown midrib sorghum (Sorghum bicolor (L.) Moench.) x sudangrass (Sorghum sudanese Piper) hybrid (; seeding rate 14 kg/ha)/RG (for summer and winter, respectively).
C	Commercial rib-eye steaks obtained from Win-Dixie (Baton Rouge, LA)

* S1, S2, and S3 denote rib-eye steaks obtained from steers feed with the forage described in the table above. C refers to commercial rib-eye steaks obtained from Win-Dixie (Baton Rouge, LA)

RESULTS

Table 2 Mean values* for the proximate and fatty acid analyses of the raw rib-eye steaks

Proximate analysis (%)				
Treatment*	**Moisture**	**Fat****	**Protein****	**Total ashes****
S1	72.21±0.92^{a}	6.44±1.62^{c}	20.64±1.01^{a}	0.83±0.05^{a}
S2	66.28±1.42^{b}	14.13±2.10^{ab}	18.84±0.85^{bc}	0.74±0.05^{b}
S3	71.48±0.34^{a}	7.10±1.22^{bc}	20.96±0.78^{ab}	0.75±0.04^{ab}
C	63.40±0.29^{b}	18.36±0.48^{a}	18.09±0.58^{c}	0.67±0.02^{b}
Fatty Acids analysis (%)				
Treatment*	**Σn-6*****	**Σn-3*****	**Σn-6/Σn-3******	**PUFA*****
S1	1.35±0.16^{a}	0.55±0.06^{a}	2.51±0.49^{b}	4.31±0.25^{bc}
S2	1.05±0.11^{a}	0.35±0.04^{ab}	3.05±0.40^{b}	2.95±0.24^{c}
S3	1.37±0.12^{a}	0.49±0.07^{a}	2.81±0.17^{b}	4.77±0.53^{b}
C	0.87±0.09^{a}	0.09±0.01^{b}	10.07±0.34^{a}	8.40±0.16^{a}

*Treatment labels are specified in Table 1. Data are represented in percentage as mean and standard deviation values of duplicate samples.
** Percentage values on wet basis. Σn-6 = Total percentage of omega-6 fatty acids. Σn-3 = Total percentage of omega-3 fatty acids. PUFA = Total percentage of polyunsaturated fatty acids
*** Percentage of total fatty acids identified.
**** Σn-6/Σn-3 = Ratio between total percentage omega-6 and total omega-3 fatty acids.
a-c Mean scores with the same letter within the same column are not significantly different ($P \geq 0.05$).

Table 3 Mean consumer acceptance scores for overall appearance and overall appearance of the fat of rib-eye steaks and their positive purchase intent (%)

Treatment*	Overall appearance	Overall appearance of the fat	Purchase intent (%Yes)**
S1	5.92±1.85^{b}	5.11±2.02^{b}	61.43%^{b}
S2	5.63±1.86^{b}	4.86±1.86^{b}	45.71%^{b}
S3	6.89±1.70^{a}	5.94±1.82^{a}	85.71%^{a}
C	5.44±2.14^{b}	4.94±2.19^{b}	47.14%^{b}

* Treatment labels are specified in Table 1. Data are represented as mean and standard deviation values (N = 71). All values are based on a nine-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.
** Percentages of purchase intent (%) with different letters indicate significant differences [Cochran's Q test and simultaneous confidence interval testing (df = 3) = 28.91, $P \geq 0.05$].
a-b Mean scores with the same letter within the same column are not significantly different (P ≥ 0.05).

Figure 1 Pictures of the different rib-eye steaks treatments*

* 789=S1, 128 = S2, 843=S3 and 405=C. Treatment labels are specified in Table 1.

Table 4 Mean consumer acceptance scores for sensory attributes of rib-eye steaks

Treatment*	Overall Appearance	Overall Beef Flavor	Juiciness	Tenderness	Overall Liking
S1(Grilling)	6.26±1.72^{a}	6.14±1.68^{a}	6.21±1.56^{abcd}	6.09±1.47^{ab}	6.14±1.54^{bc}
S1(2-sided Grilling)	5.84±1.81^{a}	6.27±1.51^{a}	6.30±1.74^{abcd}	6.04±1.54^{ab}	6.16±1.55^{abc}
S2(Grilling)	6.09±1.66^{a}	6.47±1.35^{a}	5.96±1.96^{bcd}	5.89±1.99^{b}	6.11±1.66^{bc}
S2(2-sided Grilling)	6.04±1.67^{a}	6.18±1.47^{a}	5.89±1.86^{cd}	5.82±1.70^{b}	6.07±1.45^{c}
S3(Grilling)	6.32±1.82^{a}	6.67±1.64^{a}	6.68±1.64^{ab}	6.51±1.76^{ab}	6.65±1.67^{abc}
S3(2-sided Grilling)	6.04±1.97^{a}	6.09±1.70^{a}	5.71±1.69^{d}	5.88±1.75^{b}	6.05±1.73^{c}
Commercial(Grilling)	5.76±1.87^{a}	6.76±1.57^{a}	6.57±1.72^{abc}	6.89±1.55^{a}	6.67±1.61^{ab}
Commercial(2-sided Grilling)	6.45±1.69^{a}	6.71±1.71^{a}	6.96±1.41^{a}	6.79±1.58^{a}	6.93±1.54^{a}

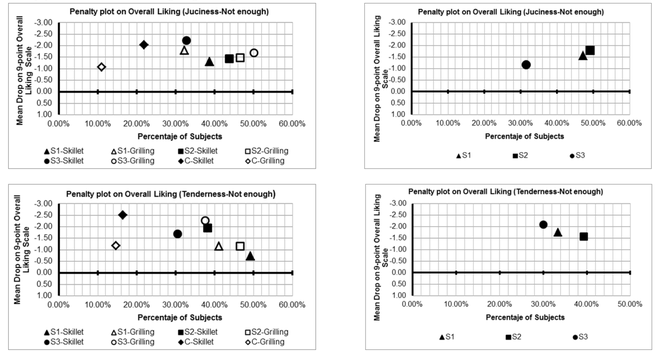
* Treatment labels are specified in Table 1. Data are represented as mean and standard deviation values (N = 56). Nine-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.
a-d Mean scores with the same letter within the same column are not significantly different (P ≥ 0.05).

Table 5 Mean consumer acceptance scores for sensory attributes of rib-eye steaks cooked by the grilling method (frozen stored during 5 months)

Treatment*	Overall Appearance	Overall Beef Flavor	Juiciness	Tenderness	Overall Liking
S1	6.35±1.66^{a}	6.61±1.55^{a}	6.41±1.58^{a}	6.73±1.51^{a}	6.45±1.57^{ab}
S2	5.76±1.97^{a}	6.43±1.33^{a}	5.92±1.70^{a}	5.94±1.87^{a}	5.92±1.65^{b}
S3	6.33±2.00^{a}	6.84±1.53^{a}	6.63±1.67^{a}	6.55±1.88^{a}	6.69±1.58^{a}

* Treatment labels are specified in Table 1. Data are represented as mean and standard deviation values (N = 51). Nine-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.
a-b Mean scores with the same letter within the same column are not significantly different (P ≥ 0.05).

Figure 2 Penalty plot on Overall Liking regarding the Juiciness and Tenderness of the rib-eye steaks*



*Treatment labels are specified in Table 1.

Table 6 Pooled within canonical structure (*r*'s) describing variables that underlie group differences

	Freshly harvest beef			Frozen stored during 5 months	
Variables	**Can 1***	**Can 2***	**Can 3***	**Can 1***	**Can 2***
Overall appearance	-0.028	0.543	0.219	0.611	-0.267
Overall beef flavor	0.504	-0.082	-0.219	0.483	0.211
Juiciness	***0.721***	***0.596***	-0.211	***0.814***	0.041
Tenderness	***0.830***	0.095	0.291	***0.805***	-0.471
Overall Liking	***0.648***	0.267	0.264	***0.910***	0.049
Cumulative variance explained (%)	58.18%	82.53%	91.62%	62.58%	100.00%

* Based on the pooled within group variances with $P < 0.01$ of Wilks' Lambda from MANOVA. Bolded and italicized values indicate attributes largely contributing to the overall differences among all rib-eye steaks. Can 1, Can 2 and Can 3 refer to the pooled within canonical structure in the 1st, 2nd and 3rd canonical discriminant functions, respectively.

DISCUSSION

Consumer acceptability of different cooked rib-eye steaks (freshly harvested beef): For all sensory attributes, no significant differences were found between the two cooking methods except for juiciness in S3 where the grilling method had a higher mean score compared to 2-sided grilling. For overall appearance and overall beef flavor, no significant differences were found ($P \geq 0.05$) among steak treatments regarding the mean consumer acceptance scores. For juiciness, tenderness and overall liking, C (2-sided grilling and/or grilling) and S3(Grilling) consistently presented higher mean scores compared to other treatments. Differences among forage-finished steak treatments could be due to differences in sensory panels or quality of the grasses (Melton, 1983). The purchase intent of all cooked steaks treatments was greater than 60%. Overall liking of S2 and S3 was negatively affected by the lack of juiciness and/or tenderness. Conversely for C, less than 21.82% of the panelists considered the steaks to be not juicy enough and less than 16.36% considered the steaks to be not tender enough. The attributes tenderness, juiciness and overall liking were the main sensory criteria differentiating among all rib-eye steaks treatments considering the first dimension (Can 1) of the linear discriminant functions.

Consumer acceptability of different cooked rib-eye steaks (frozen stored for 5 months): For overall liking, S3 presented a significant higher mean score compared to S2 but was not significantly different to S1. The purchase intent of cooked S3 was significantly higher than S2 but it was not significantly different from S1. The overall purchase intent of the rib-eye steaks increased after knowing the health benefits of steaks obtained from forage-fed cattle. Overall liking of all steaks was negatively affected by the lack of juiciness and/or tenderness. Mean consumer acceptance scores between freshly harvested and 5-moths frozen stored rib-eye steaks were somewhat similar. These results indicate that the acceptability of forage-finished steaks was not affected by the frozen storage.

CONCLUSIONS

Two cooking methods did not cause significant differences in liking scores. Purchase intent was affected by the fact of knowing the health benefits of forage-finished steaks. The acceptability of forage-finished beef was not affected by the frozen storage. This study demonstrated that forage-finished steaks are potentially healthier than grain-finished commercial steaks and forage-finished steaks, especially those obtained from S3 production system, have market potential toward Hispanic population.

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