Project Summary

Use of Video Imaging Technology to Predict Sensory Quality of Beef Products Generated From Mature Cow and Bull Carcasses

Principal Investigators: D. R. Woerner, P. D. Bass, T. E. Engle, J. D. Tatum, G. C. Smith, & K. E. Belk,
Colorado State University

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Background

Market cows comprise a significant portion of U.S. beef production. In 2008, 18.3% of all cattle harvested in the U.S. were cows, totaling over six million head. The 2007 National Market Cow and Bull Beef Quality Audit indicated that 100% of audited cow plants were producing and marketing middle-meat products for potential use as whole-muscle steak and roast items. It has been well documented that significant variation exists in the eating qualities of beef produced from carcasses resulting from mature cows. Given that an increased number of consumers are likely to consume cow beef in the form of steaks and roasts, it is imperative that carcasses producing higher quality, more desirable products be identified to ensure a positive beef eating experience.

It is widely accepted that pre-harvest management and feeding practices of market cows influence subsequent carcass quality. The concentrate of the diet level and duration of the finishing period are known to contribute to lean and fat composition and ultimately the sensory attributes of beef resulting from mature cows. In the U.S., cow carcasses are subjectively sorted by company personnel based on perceived carcass quality characteristics. Sorting decisions are most commonly determined by the evaluation of carcass quality traits that indicate the level of feeding that cows have received prior to slaughter; these include fat color, lean color, amount of muscling and degree of marbling. Video image analyses (VIA) has been shown to be a highly effective tool in the fed-beef industry for identifying beef carcass quality and yield characteristics. The effectiveness of VIA instruments to measure similar traits on carcasses resulting from mature cows has not been demonstrated. Potentially, VIA instruments could provide an objective evaluation of carcass traits leading to a more accurate assessment of pre-harvest management and subsequent sensory quality of cow beef.

This study was conducted to further characterize the effects of pre-harvest management on cow carcass quality and the subsequent eating quality of meat produced from their carcasses and to ultimately determine the effectiveness of using VIA technology to identify carcass characteristics that influence eating quality.

Methodology

Market cows (n = 325) were identified to represent three pre-harvest management strategies. The pre-harvest management strategies (MGMT) were as follows: 1) Non-fed cows (NON-FED); cows entering the slaughter facility as culls from grass pasture via sale barns and/or ranching operations); 2) Fed cows (FED); cows entering the slaughter facility from a finishing yard having received a corn-based, high energy diet for a 95 day ± 1 day period); 3) Dairy cows (DAIRY); cows entering the slaughter facility directly from dairies as culls). The experiment was conducted over a five-day period (February 2009) at a beef harvest and fabrication facility in Texas. Cows were transported to the processing facility from a multitude of locations including ranches and sale barns located in Texas, New Mexico, Colorado, Kansas, Wyoming, South Dakota and a single custom-finishing yard located within 50 km of the harvest facility. Data recorded and analyzed for each animal included: 1) live animal characteristics (breed type, 12th rib fat thickness, BCS, muscle score, frame score, dentition and pregnancy), 2)carcass grade factors (USDA marbling score, lean maturity, skeletal maturity and USDA yield grade factors), 3) carcass fat and LM lean color (subjective fat and lean color scores, L*, a*, b* values), 4) concentrations of fat carotenoids (vitamin A, retinol and β-carotene), 5) slice shear force (SSF) for the longissimus muscle (LM), psoas major (PM), and infraspinatus muscle (INFRA) with SSF measured at 14, 21, 28 and 35 days postmortem, 6) trained sensory evaluation (flavor attribute panel), 7) ground beef fatty acid profile, 8) LM collagen content (expressed as hydroxyproline), 9) LM pH and 10) LM myoglobin content. Images of the 12th-13th rib interface were obtained using a single VIA instrument (Computer Vision System Cold Camera, Research Management Systems, USA, Inc., Fort Collins, CO; CVS). Individual images and respective data were stored by CVS. VIA instrument performance was determined by developing regressive prediction models.

Findings

Results of live animal and carcass characteristics are presented in Table 1. Live animal and carcass characteristics were influenced by cow MGMT. Fed cows were clearly the heaviest conditioned animals as indicated by live and carcass evaluations. NON-FED cows and DAIRY cows were similar in fatness with DAIRY cows having only slightly higher BCS.

As expected, DAIRY cows were identified as the most youthful. Additionally, FED cows were the heaviest muscled and produced the heaviest carcasses with the greatest LM areas while NON-FED cows produced the lightest carcasses with the smallest REA. HCW were different for each MGMT group with values of 369, 311 and 251 kg for FED, DAIRY and NON-FED animals, respectively. Substantial LM area differences existed across all MGMT groups. LM area means were 79.9, 64.6 and 56.1 cm^2 for FED, DAIRY and NON-FED cows, respectively.

FED and DAIRY carcasses had similar levels of MARB, while NON-FED carcasses clearly exhibited the lowest MARB scores. FED carcasses exhibited the lightest LM lean color scores. DAIRY carcasses had the darkest and most red colored lean, whereas NON-FED and FED carcass were similar in LM redness. NON-FED carcasses exhibited the most yellow-colored fat. FED and DAIRY carcasses had similar fat color, which was clearly whiter than NON-FED cows. As expected, NON-FED carcasses had the highest β-carotene and vitamin A levels in carcass fat. LM steaks from NON-FED carcasses had the highest SSF values, whereas LM steaks from FED carcasses were the most tender. Postmortem aging was identified as an effective tool to improve LM tenderness (Figure 1).

Helping to explaining LM tenderness differences, collagen content was the lowest for LM steaks resulting from FED carcasses. NON-FED animals had the highest incidence of flavor attributes that are known to be undesirable to consumers, while FED and DAIRY beef were similar in flavor with more desirable flavor profiles. A multiple regression model developed from VIA instrument outputs demonstrated the ability to predict the MGMT of beef-type market cows with 94.2% accuracy; this demonstrates that considerable potential exists to predict cow carcass quality using VIA instruments. Further development of instrument-based assessment of cow carcass quality will continue.

Implications

The pre-harvest management of market cows is very influential on the quality of beef produced. Cows receiving high levels of nutrition prior to harvest exhibited a clear advantage over non-fed animals to produce higher quality, more palatable beef items. Market cows culled from dairy operations performed similarly to fed cows and were superior to non-fed animals. Post-mortem aging has been shown to be an effective tool for the improvement of LM tenderness of beef produced from market cows. As an objective tool, VIA instruments demonstrate the ability to accurately identify differences in cow carcass quality and pre-harvest cow management.

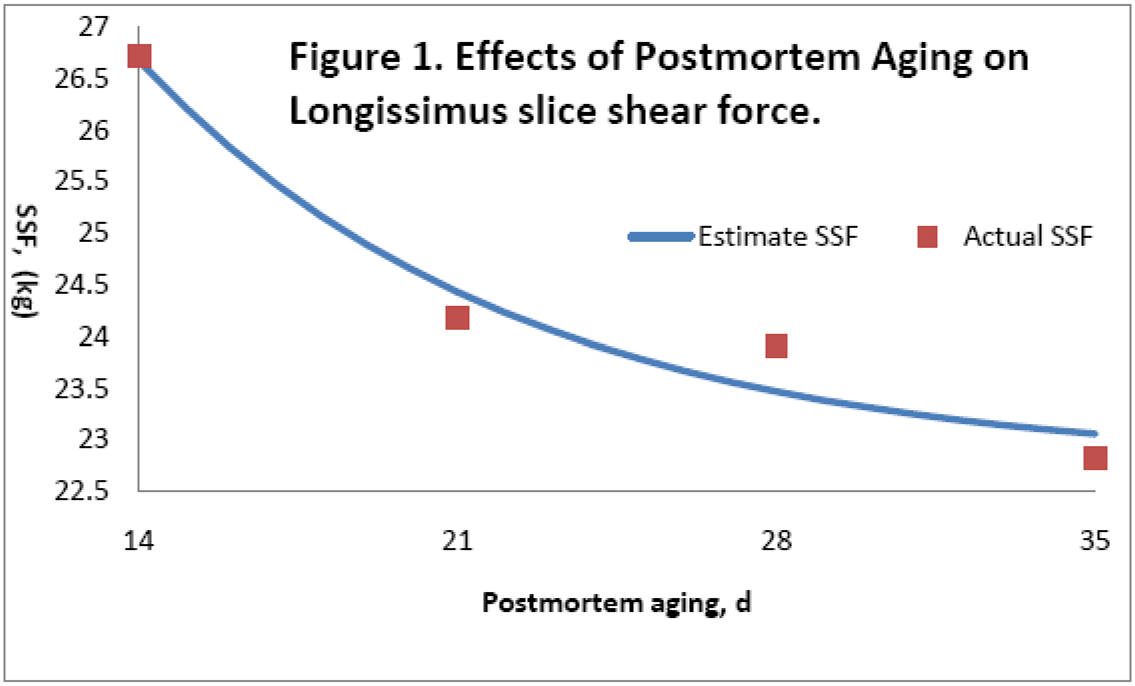

Table 1. Least squared means comparing live animal and carcass characteristics of cattle in the sample population according to pre-harvest management strategy.

	Pre-harvest management[1]				
Item	NON-FED	FED	DAIRY	SEM	$P > F_{TRT}$
Number of animals	104	108	113		
Continental cattle, %[2]	26.9	42.6	0		
British cattle, %[3]	48.1	51.8	0		
Brahman cattle, %[4]	25.0	5.6	0		
Non-Holstein cattle, %[5]	100	100	9.7		
Incidence of Pregnancy, %[6, 7]	0.73^a	0.68^{ab}	0.57^b	0.05	0.038
12th rib fat thickness, cm	0.53^b	1.31^a	0.51^b	0.03	< 0.001
Body condition score[8]	3.29^b	5.85^a	3.02^c	0.08	< 0.001
Frame score[9]	286^c	303^b	324^a	4.7	< 0.001
Muscle score[10]	3.3^b	5.7^a	2.9^c	0.09	< 0.001
Number of permanent incisors	7.5^b	7.8^a	7.0^c	0.14	< 0.001
HCW, kg	251^c	369^a	311^b	69	<0.001
Adj. PYG, cm	0.2^c	1.3^a	0.4^b	0.05	<0.001
LM area, cm²	56.1^c	79.9^a	64.6^b	1.3	<0.001
Skeletal maturity score[11]	562^a	566^a	483^b	8.7	<0.001
Lean maturity score[11]	540^a	340^c	445^b	12	<0.001
Overall maturity score[11]	555^a	463^b	471^b	9	<0.001
Marbling score[12]	215^b	362^a	385^a	12	<0.001
LM intramuscular fat,%	3.56^c	7.02^a	6.28^b	0.26	<0.001
LM L*	36.72^b	43.01^a	34.37^c	0.63	<0.001
LM a*	6.82^b	6.72^b	9.14^a	0.28	<0.001
LM b*	8.53^b	9.38^a	9.58^a	0.24	0.004
LM lean color score[13]	4.4^a	3.5^b	4.2^a	0.1	<0.001
Fat L*	70.70	68.41	114.02	29.00	0.432
Fat a*	3.02^a	1.51^b	1.25^b	0.16	<0.001
Fat b*	22.14^a	11.93^b	10.54^b	0.52	<0.001
Fat color score[14]	5.3^a	2.2^b	2.1^b	0.16	<0.001
LM ultimate pH	5.78^a	5.68^c	5.72^b	0.016	<0.001
LM myoglobin content, mmol/L	0.032^c	0.035^b	0.037^a	0.0007	<0.001
LM hydroxyproline content, μg/g	676.30^a	479.35^b	617.37^a	37.80	<0.001
Fat retinol, μg/g	0.42^b	0.91^a	0.51^b	0.45	<0.001
Fat β-carotene, μg/g	11.26^a	6.95^b	4.05^c	0.43	<0.001
Fat Vitamin A, IU/100 g	2018.14^a	1463.36^b	845.46^c	72.97	<0.001
LM shear force, kg	28.27^a	21.20^c	23.75^b	0.59	< 0.001
Psoas major shear force, kg	16.59^a	17.30^a	15.71^b	0.28	< 0.001

[1] NON-FED = cows entering the slaughter facility as culls from grass pasture via sale barns and/or ranching operations; FED = cows entering the slaughter facility from a finishing yard having received a corn-based, high energy diet for 95 d ± 1 d period; DAIRY = cows entering the slaughter facility directly from dairies as culls.
[2] Continental (purebreds or crosses visually exhibiting predominantly continental breed characteristics).
[3] British (purebreds or crosses visually exhibiting predominantly British breed characteristics
[4] Brahman (purebreds or crosses exhibiting visually 25% or more *Bos indicus* genetic characteristics).
[5] Non-Holstein (dairy cows appearing to not be purebred Holstein).
[6] Determined using a generalized linear mixed model for binomial data.
[7] Determined by the existence of a fetus in the reproductive track.
[8] 9 = excessive fat cover; 5 = average/optimum fat cover; 1 = minimum/thin fat cover.
[9] Small = 100 to 199; Med = 200 to 299; Lg = 300 to 400.
[10] 9 = thick+; 5 = average°; 1 = thin-.
[11] 100 to 199 = A^{00} to A^{99}; 200 to 299 = B^{00} to B^{99}; 300 to 399 = C^{00} to C^{99}; 400 to 499 = D^{00} to D^{99}; 500 to 599 = E^{00} to E^{99}.
[12] 200 to 299 = $Traces^{00}$ to $Traces^{99}$; 300 to 399 = $Slight^{00}$ to $Slight^{99}$.
[13] 1 = the light, pinkish-red, 2 = cherry red, and 6 = the dark, purplish-red.
[14] 0 = bright white; 5 = pale yellow, and 8 = dark, yellowish-orange.
[a, b, c] Means in the same row without a common superscript differ ($P < 0.05$).

For more information contact:

National Cattlemen's Beef Association
9110 East Nichols Avenue
Centennial, Colorado 80112-3450
(303) 694-0305