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Nutrient and Tenderness Differences of Beef from Heifers Due to Mutation of the Myostatin Gene

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Summary

Strip loins and eye of rounds were obtained from heifers genotyped with variations of the myostatin gene; 19 homozygous dominant (Angus), 20 heterozygous dominant (Angus x Piedmontese), and 20 homozygous recessive (Piedmontese). Steaks were aged for 14 days, cooked fresh (never frozen), and nutrient steaks were frozen three days postmortem. Meat from homozygous recessive heifers was equal in tenderness to homozygous dominant and heterozygous dominant heifers. Fat content of meat from homozygous recessive heifers decreased while moisture and protein increased compared to homozygous dominant and heterozygous dominant. Calorie content decreased with increasing copies of the recessive gene. Thus, meat from the homozygous recessive cattle was leaner, yet equal in tenderness, to the meat from homozygous dominant cattle.

Introduction

Piedmontese cattle possess a genetic mutation of the myostatin gene, commonly known as double muscling, that results in a dramatic increase in overall muscle mass due to myostatin being unable to regulate/control myogenesis (muscle growth). The increase in muscle mass is due to increase muscle fiber number and, in turn, results in cattle yielding heavier muscled carcasses that are also leaner compared to conventionally raised cattle that do not possess a myostatin mutation. A question within the beef industry is the impact of the mutated myostatin gene on beef tenderness due to increased muscle mass and decreased overall fat content. It was hypothesized that meat from homozygous recessive heifers would be equal in tenderness to homozygous dominant and heterozygous dominant. Thus, the study was conducted to compare tenderness, nutritional, and compositional differences of meat from heifers due to mutation of the myostatin gene.

Procedure

The current study included 59 yearling heifers genotyped and placed into categories based of the myostatin gene that each possessed. Genotypes were confirmed using DNA testing as homozygous dominant (normal myostatin gene; Angus), heterozygous dominant (partially recessive gene; Angus x Piedmontese), and homozygous recessive (mutated myostatin gene; Piedmontese), (n = 19, 20, and 20, respectively). Animals were individually fed a common finishing diet for 191 days using Calan electronic gates at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) Research Feedlot. Heifers received no implants or feed additives to fulfill their requirement in an all-natural feeding program.

At three days postmortem strip loin and eye of round samples were collected from the left side of each carcass. Steaks for nutrient analysis (proximate, lipid, and mineral content) were cut to 0.5-inch thick from each eye of round and strip loin, trimmed to .125-inch subcutaneous fat, and frozen. In most instances, homozygous recessive animals had less than 0.125-inch of subcutaneous fat and did not require trimming. Steaks for Warner-Bratzler Shear Force (WBSF) were cut to 1-inch thickness, vacuum packaged, and after 14 days of aging were cooked fresh/never frozen. Shear force steaks were cooked on a Hamilton Beach Indoor-Outdoor Grill and initial temperature and weight were recorded for each steak. Steaks were cooked to an internal temperature of 95°F and were then turned over and allowed to finish cooking on the other side until the internal temperature reached 160°F. After completion of cooking, steaks were weighed once more for final weight so that cook loss could be calculated. Steaks were wrapped in oxygen-permeable film and placed in a 39°F cooler overnight. The following morning steaks were removed from the cooler and six cores (0.5 inch in diameter) were taken from each steak parallel to the muscle fiber using a Delta Drill Press followed by shearing on a tabletop Warner-Bratzler Shear Force Machine.

Data were analyzed using ANOVA in PROC GLM in SAS (Version 9.2) (SAS Institute, Inc., Cary, N.C.). Fixed effects were the inactive myostatin mutation and random effects were the animal used. Separation of means was determined using LS MEANS and DIFF LINES option of SAS with significance determined at $P \leq 0.05$.

Results

With increasing copies of the recessive myostatin gene, overall fat content decreased ($P < 0\ .001$) and percent protein increased ($P < 0.001$) (Tables 1 and 2), which is expected as Piedmontese cattle yield heavier muscled carcasses compared to cattle that do not possess a myostatin mutation. Fat contains little to no moisture and thus with increasing copies of the recessive myostatin gene moisture content increased ($P < 0.001$) while caloric content decreased ($P < 0.001$) with increasing copies. Steaks from homozygous recessive heifers had greater cholesterol content ($P \leq 0.001$) than homozygous dominant. Cholesterol helps stabilize the cell membrane

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and with Piedmontese cattle having an increase in muscle mass due to increase muscle cell numbers (hyperplasia) an increase in cholesterol concentration is needed to stabilize the increase in cells. Saturated fatty acids and monounsaturated fatty acids decreased ($P < 0.001$) with increasing copies of the recessive gene for myostatin, while strip loin steaks from homozygous recessive heifers had a lower ($P < 0.001$) trans fatty acid concentration compared to heterozygous dominant and homozygous dominant. Polyunsaturated fatty acid concentration decreased ($P < 0.001$) in eye of round samples with increasing copies of the recessive myostatin gene, while strip loin samples from homozygous dominant heifers had a greater ($P < 0.001$) polyunsaturated fatty acid concentration than heterozygous dominant and homozygous recessive samples. Mineral analysis showed increased potassium levels ($P < 0.001$) and increased calcium ($P < 0.001$) for homozygous recessive compared to homozygous dominant and heterozygous dominant. There were no differences in WBSF values (Table 3) detected for strip loin ($P = 0.16$) and eye of round ($P = 0.19$) samples. This indicates that meat from homozygous recessive heifers is leaner, yet equivalent in tenderness, to homozygous dominant and heterozygous dominant heifers.

In conclusion, steaks from homozygous recessive cattle had a decreased fat content, greater cholesterol, and decreased concentration of saturated, monounsaturated, polyunsaturated, and trans fatty acid, and greater protein levels when compared to homozygous normal cattle. As hypothesized, beef from homozygous recessive heifers is equivalent in tenderness when compared to homozygous dominant and heterozygous dominant recessive cattle even though the product is leaner.

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Table 1. Proximate, lipid, and mineral analysis of strip loin.

		Genotype				
	Unit	MM	Mm	mm	SEM	*P*-value
Number of Loins Analyzed		19	20	20		
Proximate Analysis						
Moisture	%	57.00[c]	62.29[b]	67.27[a]	0.603	< 0.001
Protein	%	19.65[c]	20.88[b]	22.32[a]	0.257	< 0.001
Fat	%	21.48[a]	15.96[b]	9.46[c]	0.728	< 0.001
Ash	%	0.50[b]	0.74[a]	0.81[a]	0.046	< 0.001
Carbohydrates	%	0.66	0.48	0.59	0.135	0.69
Calories	kCal	306.58[a]	255.90[b]	197.30[c]	6.627	< 0.001
Lipid Analysis						
Cholesterol	mg/100g	42.26[c]	46.65[b]	49.70[a]	1.100	< 0.001
Saturated Fatty Acids	mg/100g	9.64[a]	7.19[b]	4.37[c]	0.458	< 0.001
Monounsaturated Fatty Acids	mg/100g	10.85[a]	7.92[b]	4.36[c]	0.539	< 0.001
Polyunsaturated Fatty Acids	mg/100g	0.75[a]	0.64[b]	0.59[b]	0.038	< 0.001
Trans Fatty Acids	mg/100g	0.23[a]	0.21[a]	0.14[b]	0.018	< 0.001
Mineral Analysis						
Sodium	mg/kg	381.82[b]	401.68[a]	404.39[a]	5.915	0.02
Potassium	mg/kg	2597.21[c]	2939.90[b]	3134.65[a]	37.978	< 0.001
Calcium	mg/kg	69.77[c]	85.96[b]	94.23[a]	2.714	< 0.001
Iron	mg/kg	13.26	14.76	14.10	0.511	0.125

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Table 2. Proximate, lipid, and mineral analysis of eye of round.

		Genotype				
	Unit	MM	Mm	mm	SEM	*P*-value
Number of Eyes Analyzed		19	20	20		
Proximate Analysis						
Moisture	%	65.21[c]	69.38[b]	72.78[a]	0.449	< 0.001
Protein	%	20.79[c]	22.73[b]	23.68[a]	0.218	< 0.001
Fat	%	12.85[a]	6.91[b]	2.08[c]	0.590	< 0.001
Ash	%	0.91[b]	0.67[c]	1.04[a]	0.044	< 0.001
Carbohydrates	%	0.45	0.57	0.80	0.144	0.22
Calories	kCal	224.16[a]	173.30[b]	129.20[c]	5.258	< 0.001
Lipid Analysis						
Cholesterol	mg/100g	41.47[c]	43.70[b]	48.55[a]	0.724	< 0.001
Saturated Fatty Acids	mg/100g	5.52[a]	3.00[b]	0.88[c]	0.362	< 0.001
Monounsaturated Fatty Acids	mg/100g	6.71[a]	3.44[b]	0.94[c]	0.435	< 0.001
Polyunsaturated Fatty Acids	mg/100g	0.49[a]	0.40[b]	0.23[c]	0.034	< 0.001
Trans Fatty Acids	mg/100g	0.13[a]	0.08[b]	0.03[c]	0.010	< 0.001
Mineral Analysis						
Sodium	mg/kg	368.94	373.89	373.31	5.280	0.77
Potassium	mg/kg	3091.16[c]	3398.40[b]	3529.20[a]	35.151	< 0.001
Calcium	mg/kg	61.80[b]	61.48[b]	67.01[a]	1.912	0.007
Iron	mg/kg	15.35[a]	14.60[a]	12.49[b]	0.315	< 0.001

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Table 3. Tenderness (shear force) and cooking loss of strip and eye of round steaks.

	Genotype				
	MM	Mm	mm	SEM	*P*-value
Strip Steak Cooking Loss (%)	14.35[b]	21.19[a]	15.96[b]	1.254	< 0.001
Strip Steak Shear Force (kg)	2.62	3.08	2.82	0.097	0.16
Eye of Round Cooking Loss (%)	23.16	26.14	27.00	1.551	0.19
Eye of Round Shear Force (kg)	3.60	3.70	3.45	0.117	0.29

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

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