Influence of genetics on fatty acid profile, vitamin and mineral content of beef from grain and grass-finishing systems

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Abstract

Finishing systems and genetics can affect nutritional profiles. The objectives of this study were to quantify fatty acids (FA), vitamins, and minerals from two different breeds of cattle finished either on grain or on grass. Red Angus (RA, n = 30) and RA x Akaushi (AK, n = 30) were equally assigned to one of the finishing systems: a mixed-species pasture forage (GRASS) or a total mixed feedlot ration (GRAIN) in three replications. Animals were slaughtered between 18 (GRAIN) and 26 (GRASS) months of age, and meat samples were collected between the 11th and 13th rib. FA profiles were determined using microwave-assisted fat extraction, acid-base methylation, and gas chromatography-mass spectrometry (GC-MS) analysis. Vitamin and mineral content were analyzed by commercial laboratory. Overall (µg/g dry), vitamin E (31.05±5.11 vs 17.43±3.07, $P < 0.0001$), iron (69.28±6.71 vs 47.04±7.64, $P < 0.0001$), copper (1.56±0.89 vs 0.86±0.9, $P = 0.0037$), zinc (139.57±35.72 vs 110.53±15.4, $P = 0.0002$), and molybdenum (0.15±0.04 vs 0±0.01, $P < 0.0001$) were significantly higher in GRASS compared to GRAIN and did not differ by breed. Manganese was significantly higher in GRAIN (0.31±0.07 vs 0.25±0.05, $P = 0.0005$). Iron was significantly higher in GRASS and differed when comparing RA to AK (73.04±6.9 vs 65.51±3.92, $P = 0.018$). Regarding FA (mg/100g beef), total n-6 (115.12±55.7 vs 87.43±33.89, $P = 0.0118$) and the n-6:n-3 ratio (8.39±2.66 vs 1.46±0.34, $P < 0.0001$) were higher in GRAIN, while total n-3 (62.77±30.59 vs 14.39±8.34, $P < 0.0001$), ALA (35.96±25.6 vs 6.23±5.82, $P < 0.0001$), and EPA (8.98±2.22 vs 2.01±0.84, $P < 0.0001$) were higher in GRASS. These results suggest that there are differences in n-3, n-6, n-6:n-3 ratios, ALA, EPA, minerals, and vitamins with results favoring GRASS. Genetics seem to play a minor role in FA profiles and only significantly affected iron content.

Background

- Health-conscious customers are looking for more nutritious and sustainable products[1]
- Consumer interest in grass-finished beef has increased over the last decade with retail sales reaching $272 million in 2016[2]
- Nutritional profile of beef can be modified by diet and genetics[3]
- Meat is a major source of micronutrients especially zinc and iron[4]
- Adults are under consuming some of these micronutrients, especially iron and vitamin E[4]
- Higher n-6:n-3 ratios promote inflammation. Grass-finished beef may lower that ratio[3,5]

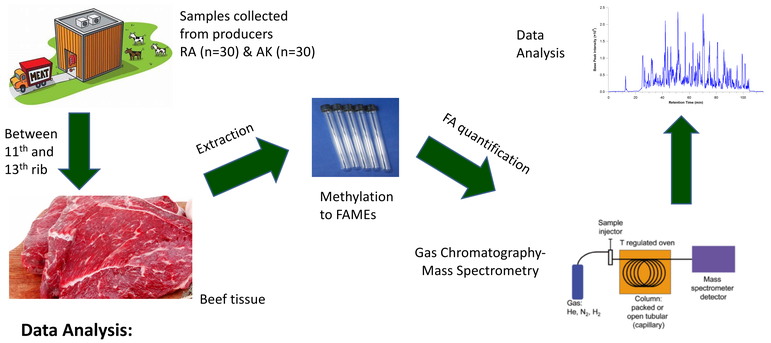
Objectives

1. Quantify the mineral, vitamin, and FA content of beef finished on different systems
2. Evaluate the effects of breed and finishing system on the nutritional profile of beef

Methods

- RA (n=30) and AK (n=30) were equally assigned to either GRASS or GRAIN finishing system.
- Vitamin and mineral analysis was conducted by commercial laboratory.

Fatty Acid Analysis:



Data Analysis:
Data analysis carried out by R and Prism.

Results

Table 1. Vitamin and mineral content of beef based on finishing system (µg/g dry; Mean ± SD)

	GRASS	GRAIN	*P*-value
Vitamin E	31.05 ± 5.11	17.43 ± 3.07	<0.0001
Iron	69.28 ± 6.71	47.04 ± 7.64	<0.0001
Copper	1.56 ± 0.89	0.86 ± 0.90	0.0037
Zinc	139.57 ± 35.72	110.53 ± 15.40	0.0002
Molybdenum	0.15 ± 0.04	0.00 ± 0.01	<0.0001
Manganese	0.25 ± 0.05	0.31 ± 0.07	0.0005

Table 2. Fatty acid profiles by breed and by finishing system (mg/100g beef; Mean ± SEM)

	GRASS AK	GRASS RA	GRAIN AK	GRAIN RA	*P*-value
Total SFA	1484.19 ± 409.16	1263.36 ± 237.16	2015.12 ± 182.15	1140.84 ± 379.04	0.2265
Total MUFA	1223.90 ± 343.84	1050.81 ± 200.49	1631.24 ± 144.30	830.31 ± 342.36	0.2119
Total PUFA	148.05 ± 20.89	154.58 ± 10.57	157.81 ± 14.00	116.39 ± 18.58	0.2759
Total n-6	84.24 ± 11.00	90.62 ± 6.09	137.57 ± 12.24	102.15 ± 16.71	0.0140
Total n-3	62.62 ± 10.12	62.93 ± 5.17	19.07 ± 1.75	13.08 ± 2.48	<0.0001
n-6:n-3 ratio	1.38 ± 0.10	1.54 ± 0.07	7.61 ± 0.25	8.01 ± 0.73	<0.0001
Total OBCFA	60.97 ± 18.98	49.27 ± 11.65	43.74 ± 4.60	23.30 ± 8.80	0.1841
Total OCFA	38.83 ± 11.70	31.19 ± 7.25	27.91 ± 3.52	16.26 ± 5.50	0.2200
Total BCFA	22.13 ± 7.29	18.08 ± 4.45	15.83 ± 1.32	7.03 ± 3.61	0.1475
Total iso BCFA	17.27 ± 5.56	14.02 ± 3.41	13.89 ± 1.16	6.3 ± 3.12	0.1962
Total anteiso BCFA	4.86 ± 1.73	4.06 ± 1.04	1.93 ± 0.19	0.74 ± 0.52	0.0273
Oleic	1175.63 ± 329.90	1012.61 ± 192.00	1563.70 ± 135.10	792.92 ± 329.10	0.2106
Linoleic	63.24 ± 10.16	67.12 ± 4.83	102.10 ± 9.04	68.02 ± 14.13	0.0296
ALA	36.32 ± 8.53	35.59 ± 4.21	9.29 ± 0.94	4.76 ± 2.02	<0.0001
EPA	8.27 ± 0.52	9.69 ± 0.59	2.34 ± 0.24	2.14 ± 0.15	<0.0001
DHA	0.41 ± 0.07	0.33 ± 0.07	0.32 ± 0.06	0.23 ± 0.05	0.2873

SFA: saturated FA, MUFA: monounsaturated FA, PUFA: polyunsaturated FA, OBCFA: odd branched-chain FA, OCFA: odd-chain FA, BCFA: branched-chain FA
P-values for ANOVA, no significant differences between breeds according to Tukey HSD test ($P < 0.05$)

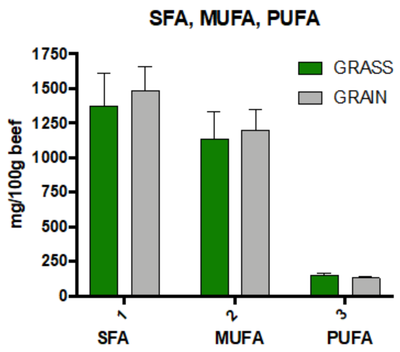


Figure 1. Total SFA, MUFA, and PUFA by finishing system
No significant differences ($P < 0.05$) (Mean ± SEM)

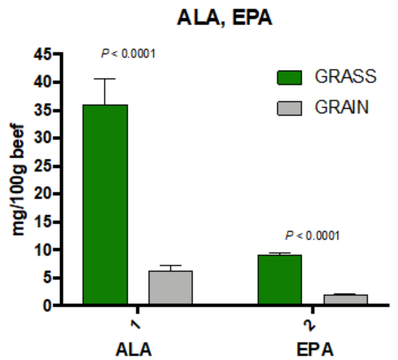


Figure 2. ALA and EPA by finishing system
Significant differences at ($P < 0.05$) (Mean ± SEM).
GRASS higher in ALA and EPA.

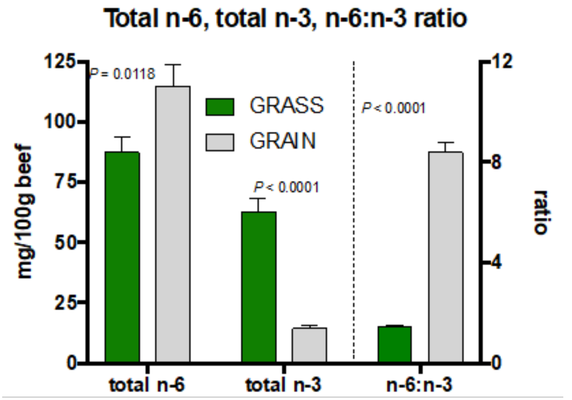


Figure 3. Total n-3, n-6, and n-6:n-3 ratio by finishing system (Mean ± SEM). GRASS had a lower ratio compared to GRAIN.

Significance and Future Directions

- These results suggest that micronutrients and FA can be manipulated by finishing system and breed to a lesser extent.
- Genetics only significantly influenced iron concentrations and barely affected FA content.
- Vitamin E, iron, copper, zinc, and molybdenum were significantly higher in GRASS.
- Manganese was significantly higher in GRAIN.
- Iron differed by breed with concentrations being significantly higher in RA.
- Total n-6 and the n-6:n-3 ratio were significantly higher in GRAIN, while total n-3, ALA, and EPA were significantly higher in GRASS.
- Beef finished on pasture displayed higher levels of beneficial nutrients.
- Future studies should include mineral, vitamin, and FA content of feeds.

References

1. Gwin, L. Scaling-up Sustainable Livestock Production: Innovation and Challenges for Grass-Fed Beef in the U.S. *J. Sustain. Agric.* **2009**, *33* (2), 189–209.
2. Cheung, R. et al. *Back to Grass: The Market Potential for U.S. Grassfed Beef*; 2017
3. Vahmani, P. et al. The Scope for Manipulating the Polyunsaturated Fatty Acid Content of Beef: A Review. *J. Anim. Sci. Biotechnol.* **2015**, *6* (1), 1–13.
4. Decker, E. A.; Park, Y. Healthier Meat Products as Functional Foods. *Meat Sci.* **2010**, *86* (1), 49–55.
5. Saini, R. K.; Keum, Y. S. Omega-3 and Omega-6 Polyunsaturated Fatty Acids: Dietary Sources, Metabolism, and Significance — A Review. *Life Sci.* **2018**, *203* (April), 255–267.

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