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Fatty Acids and Minerals Affect the Liver-Like Off-Flavor in Cooked Beef

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Summary

Sixty knuckle centers were obtained from a local harvesting facility to determine factors causing the liver-like off-flavor in beef. Medium chain unsaturated fatty acids and sodium explain 46% of the variation of the liver-like off-flavor intensity ratings in cooked knuckle center steaks. Future studies to manipulate the fatty acid and mineral profiles of muscle might prove beneficial in lowering the incidence of the liver-like off-flavor in beef.

Introduction

Flavor is an important trait that consumers use to determine acceptability. Meat flavor is a result of reducing sugars and amino acids, differences in fatty acid composition that are responsible for species-specific flavor, off-flavor development due to lipid oxidation, microbial by-products, or other degradative mechanisms. Current research in our laboratory has specifically concentrated on the liver-like off-flavor.

Research has suggested that potential causes of the liver-like off-flavor in beef are lipid oxidation, heme iron content, and elevated degrees of doneness. Slow cooking (36-40 minutes) and subsequent holding for 1 hour of specific muscles from the chuck and round prior to serving reduces off-flavor intensity *(2006 Beef Report*, p. 112). These results suggest off-flavors may result from volatile compounds.

The objectives of this research were to explore more fully the relationships of minerals and fatty acids to liver-like off-flavors in beef.

Procedure

Samples were obtained using a screening procedure. Briefly, two trained sensory panelists tasted a 10 g piece of the knuckle center (*M. rectus femoris*). Knuckles identified as having an off-flavor (n=30) and knuckles not having an off-flavor were vacuum-packaged and shipped to the Loeffel Meat Laboratory at the University of Nebraska. Following a seven-day aging period at 34°F, the *M. rectus femoris* was isolated and cut into 2.54 cm thick steaks, freezer wrapped and frozen (3°F) until sensory analysis was conducted.

Steaks were cooked to an internal temperature of 158°F on an electric broiler. Internal temperature was monitored with a digital thermometer and a type T thermocouple. When the internal temperature reached 95°F, the steak was turned once until the final temperature was reached. The steak was then cut into 0.5 in x 0.5 in x 1.0 in cubes and served warm to the panelists, approximately five minutes post cooking. Six samples, identified using three-digit codes, were served on each day. Eight-point descriptive attribute scales (Muscle fiber tenderness: 1=extremely tough, 8=extremely tender; Connective tissue: 1=abundant,

Table 1. Distribution of fatty acids in "normal" and liver-like samples[a].

Fatty acid	Normal	Liver-Like	*P*>F
14:0	21.83	16.23	0.08
14:1	4.51	3.08	0.05
15:0	11.10	12.57	0.60
16:0	152.82	127.27	0.16
16:1	17.79	12.05	0.03
17:0	5.70	4.76	0.32
18:0	52.97	59.08	0.37
18:1	164.04	158.42	0.79
18:1 (n-7)	29.85	8.63	0.02
18:2	47.56	40.46	0.35
18:3	1.82	1.41	0.99
20:0	1.55	1.12	0.13
20:1	0.84	1.16	0.30
20:2	0.96	0.81	0.71
20:2 (n-6)	3.49	4.05	0.47
20:3	11.51	12.27	0.77
20:4	1.21	0.00	0.53
20.5	1.49	1.94	0.36
22:5	3.37	3.81	0.63
22:6	0.09	0.12	0.77

[a]All fatty acids are expressed as mg/g.

Table 2. Distribution of minerals in "normal" and liver-like samples[a].

Fatty acid	Normal	Liver-Like	*P*>F
Zn	44.73	49.74	0.36
Fe	20.56	22.15	0.26
P	2018.53	2030.04	0.73
Mn	0.05	0.05	0.99
Mg	247.97	254.59	0.27
Ca	49.87	46.48	0.18
Cu	0.83	0.86	0.67
Na	499.65	516.91	0.35

[a]All minerals are expressed as µg/g.

Table 3. Simple correlations of the liver-like off flavor intensity ratings with fatty acids.

	r (*P*>F)
15:0	0.27 (0.05)
18:1 (n-7)	-0.32 (0.02)
20:2 (n-6)	0.34 (0.02)
20:5	0.28 (0.05)

8=none; Juiciness: 1=extremely dry, 8=extremely juicy; Off-flavor intensity: 1=extreme off-flavor, 8=no off-flavor) were used. Off-flavors were rated using a 15-point intensity scale (0=extremely bland; 15=extremely intense).

Heme iron was determined using an acidified acetone extraction procedure while pH was determined using a penetrating pH probe. Moisture and ash (expressed as percentages) were quantified using a LECO Thermogravimetric Analyzer-601 while percent fat was determined using an ether extraction method. Mineral were isolated and quantified using an inductively-coupled argon plasma spectrometer. Fatty acids were extracted using a 2:1 chloroform:methanol solution and methylated using boron fluoride-methanol.

Data were analyzed using the REG procedure of SAS (Version 9.1.3), and the stepwise option was used to determine the final variables to be included in the model. The CORR procedure was used to generate correlation coefficients.

Results

Amount of fatty acids and minerals are presented in Table 1 and Table 2, respectively. Non-liver-like samples had 3.5 times more vaccenic acid (18:1 n-7) when compared to liver-like samples. Simple correlations from our data indicated vaccenic (r=-0.32; *P*=0.02) and cis-11,14-eicosadienoic (20:2 n-6) (r=0.34; *P*=0.02) and eicosapentaenoic acid (20:5) (r=0.28; *P*=0.05) significantly affected the liver-like off-flavor in this study (Table 3). Others have shown vaccenic acid (r= -0.32; *P*<0.05) and cis-11,14-eicosadienoic acid (r=0.38; *P*<0.05) individually account for a significant amount of variation in the livery off-flavor, which is in agreement with our data. Although not significant, our results suggest palmitoleic acid may also play a role in the development of the liver-like off-flavor (r=-0.25; *P*=0.08).

The final model for predicting liver-like off-flavor was: Liver-like off-flavor rating = -0.21+ 0.0008 (Na) + 0.13 ((20:2 (n-6))- 0.005 (16:1) – 0.002 ((18:1 (n-7)) – 0.033 (20:3) which explained 46% of the variation in the liver-like off-flavor. Previous research from our laboratory indicated heme iron might be a cause of the livery off-flavor in beef, but neither heme iron nor total iron played a role in the development of the liver-like off-flavor in this study.

Data from this study indicate individual fatty acids and minerals play a significant role in the development of the liver-like off-flavor. A better understanding of factors influencing fatty acid and mineral profiles might prove beneficial in lowering the incidence of the liver-like off-flavor in beef.

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