

Project Summary

Volatile Compounds in Beef and their Contributions to Off-Flavors

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Project Summary

Background

The popularity of the beef cuts from the chuck and the round is rising at a substantial rate due to the promotion of these muscles as palatable and inexpensive. With increased sales of muscles from the chuck and the round there has been an increasing number of complaints about a liver-like off-flavor perceived in some of the cuts. Beef value cuts cooked to a higher degree of doneness are more likely to have a livery or off-flavor which is likely due to concentration of the livery attributes (Calkins, 2002). Cooking the value cuts quickly (grill temperatures of 250°C) and having no hold time prior to serving led to more undesirable off-flavor intensity scores. Previous work completed in this laboratory identified an interesting trend developed in which the presence of off-flavor notes in a muscle was indicative of off-flavor notes from other muscles of the same animal. This suggests the problem may be animal specific with the source of origin being a feedstuff, pharmaceutical, etc. It is important to identify the compounds that are causing the problem and then look to find the candidate substances that the animals may be exposed to that could lead to the off-flavor profile.

The objectives of this project were:

1. Establish a methodology to isolate compounds in raw meat samples that contribute to the liver-like off-flavor identified in some beef cuts.
2. Identify the class(es) of compounds that are contributing to the liver-like off-flavor
3. Chemically characterize the muscles with the liver-like compounds
4. Explore connections between the compounds of interest and possible sources or origin

Methodology

Phase I: Methodology for obtaining volatile profiles from liver-like samples

Select beef clods (IMPS #140) and knuckles (IMPS #167) were obtained, denuded of external fat, and fabricated into individual muscles. Steaks from the chuck and the knuckle (*Infraspinatus*, *Teres major*, *Triceps brachii*, *Rectus femoris*, *Vastus lateralis*, *Vastus intermedius*, and *Vastus medialis*) were identified by a trained taste panel as off-flavored or not (control). Raw samples from each muscle were powdered and stored below -20°C until analyzed.

Prior to running samples on a mass spectrometer to learn the identity of the compounds of interest, a method to collect the volatiles was established with gas chromatography. Times for the release of the off-odors were determined for different flow rates of nitrogen. It was determined that the optimal flow rate of nitrogen was 150 mL/min. In the off-flavored samples the undesirable aromas would start at 0.36 min and continue until 2.40 min. A second peak of undesirable aromas would start at 5.20 min and end at 6.00 min. The normal samples, as indicated by taste panels, never exhibited the undesirable aroma.

After the initial tests on mass spectroscopy, it was determined that several modifications needed to be made. 1) The ethyl ether peak eluted at the same time as some of the major peaks in the sample. 2) Some of the peaks that were different between the normal and off-flavored samples were not high enough in concentration to determine the identity of the compound.

PHASE II: Characteristics of muscles with liver-like volatiles

In addition to GC/MS, proximate analysis, fatty acid analysis, pH, and heme iron were run on *Rectus femoris* samples to validate the procedure. Spectrum taste panels characterized the off-flavors, focusing on liver-like. Using statistical methods (correlations), the taste panel results, chemical analyses and information obtained from the mass spectrometer will allow a better understanding of possible sources of off-flavors.

Findings

Phase I

Results from the initial GC study, indicated it was possible to determine differences in the off-flavored samples and the normal samples. Figure 1 visually depicts the differences seen in the chromatogram of a normal *Rectus femoris* and an off-flavored *Rectus femoris*. Table 1 shows the presence or absence of a compound in the normal or off-flavored sample as well as the peaks that revealed differences in concentration. There were differences observed in this method. Unfortunately, mass spectroscopy was not able to determine the identity of the compounds.

Figure 1. Gas chromatograms of an off-flavored and normal *Rectus femoris*

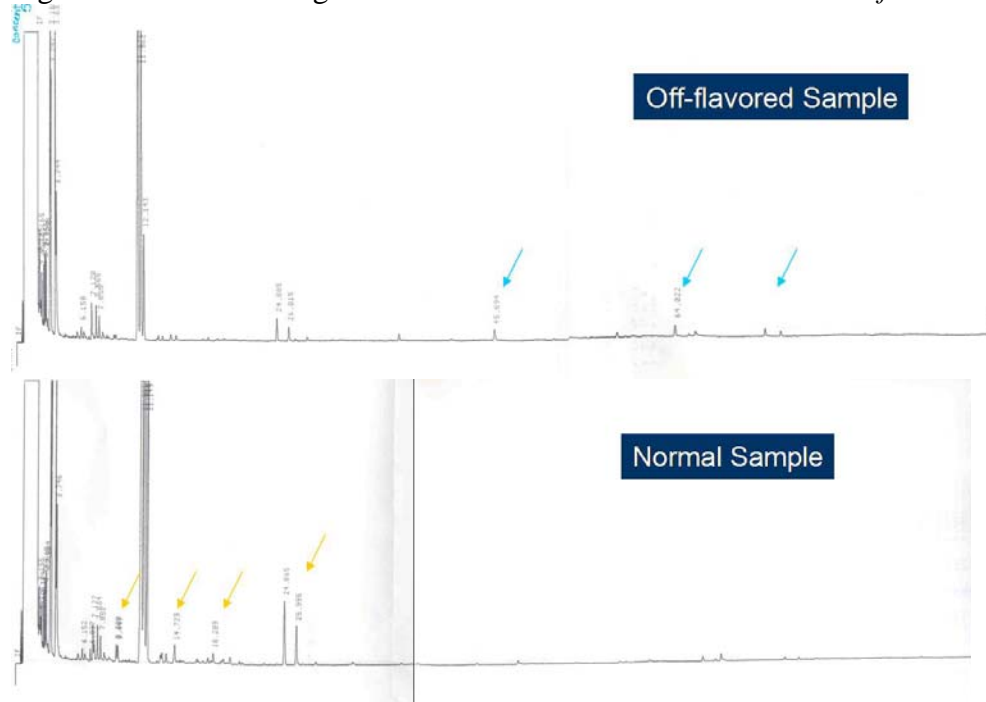


Table 1. Average retention times and area for off-flavored and normal *Rectus femoris* samples

Retention Times Off-flavored/Normal	Average Area of Off- flavored Sample	Average Area of Normal Sample
2.145/2.155	1526	3451
2.165/- -/2.310	3953	2738
2.371/2.379	3737	3858
2.579/2.586	2974	2982

2.659/2.665	3894	3773
2.789/2.804	5735	6471
3.160/3.155	38800	29986
3.247/3.258	21333	32279
3.631/3.623	28207	25955
3.744/3.746	16743	20533
6.158/6.152	1551	1755
-/6.897		1400
7.128/7.127	2834	4140
7.565/7.564	3749	4506
7.855/7.851	2457	3100
-/9.300		2563
-/9.447		2669
11.571/11.611	154890	646254
11.862/11.888	75908	322656
12.143/12.149	15360	58779
-/14.723		4106
-/18.289		2255
24.885/24.865	3808	12600
26.015/25.995	2438	7774
45.694/-	2770	
64.022/-	2258	

Thirty-eight to 74 volatile compounds were present in the samples, with *Triceps brachii* having the least and *Vastus intermedius* having the most. Differences in the presence and concentration of compounds was noted between liver-like and normal samples as well as between muscles. When the concentration of compounds were different, normal samples typically had lower concentrations than the liver-like. The *Rectus femoris* had the fewest compound concentration differences between the normal and off-flavored samples. The majority of the compounds appear to be compounds associated with oxidation. These results, in conjunction with other published findings, still suggest that there is a difference at the animal level, such as a feedstuff that will allow for increased amounts of these lipid oxidation compounds within the muscle tissue.

Phase II

Significant correlation results to determine the relationship of liver-like off-flavor to other chemical characteristics of the muscle tissue are found in Table 2. Vaccenic acid (C18:1 n-7), cis-11, 14 eicosadienoic acid (C20:2 n-6), and 5,8,11,14,17-eicosapentaenoic acid (C20:5 n-3) were found to have a significant correlation ($P < 0.05$) to the liver-like off-flavor. Moisture ($P= 0.1081$), pentadecanoic acid (C15:0; $P= 0.0585$), palmitoleic acid (C16:1; $P= 0.0836$), 11-eicosenoic acid (C20:1; $P= 0.0750$), and 5,8,11-eicosatetraenoic acid (C20:3; $P= 0.0871$) were all approaching a significant correlation with liver-like off-flavor. Heme iron and pH as well as the other fatty acids tested did not appear to have a strong relationship to liver-like off-flavor.

Table 2. Simple correlations of liver-like off-flavor with chemical components of *Rectus femoris* muscle.

	Liver-like Off-flavor
Moisture	0.22
C15:0	0.27
C16:1	-0.24
C18:1 n-7	-0.32
C20:1	0.25
C20:2 n-6	0.34
C20:3	0.24
C20:5	0.28

Implications

Identification of compounds that were present in different concentrations of liver-like and normal samples indicate the volatile compounds are related to lipid oxidation. The validation study in Phase II supported those results. Correlations to chemical components of the muscle tissue also showed that there may be a relationship of liver-like off-flavor to a few medium and long chain fatty acids. A relationship with moisture was also seen which further supports the notion that the off-flavor compounds are water soluble.

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