Project Title: Determination of Factors that Cause Livery Flavor Development in Various Beef Muscles from the Chuck and Loin

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Background

One of beef's greatest attributes is its flavor. Consumers that detect "off" or uncharacteristic flavors when consuming beef consider that to be an unfavorable eating experience. One such flavor is often described as "livery," and has been identified primarily in top sirloin and tenderloin steaks. Any opportunity to reduce the incidence of livery flavor in beef would be considered beneficial to the industry and would help decrease the incidence of unfavorable eating experiences among consumers.

To date, there is not a significant amount of information available about the prevalence or cause of livery flavor in beef. As a result, Kansas State University conducted a project with the following objectives:

1. Determine the causes of livery flavor in chuck clod (*infraspinatus* muscle), top sirloin (*gluteus medius* muscle) and tenderloin (*psoas major* muscle).
2. Identify the specific volatile compounds associated with livery flavor
3. Determine ways to prevent livery flavor in beef steaks

Methodology

The *infraspinatus* muscle from the chuck clod (IMPS/NAMP 114), the *gluteus medius* muscle from the sirloin (IMPS/NAMP 184) and the *psoas major* muscle from the loin (IMPS/NAMP 189) were obtained from A- and B-bone maturity carcasses with either low-Slight or Small marbling and with either normal pH (5.7 or less) or high pH (6.0 or higher) to evaluate factors that could cause the development of livery flavor development in cooked beef.

Table 1. Number of carcasses sampled with different maturity, marbling and pH combinations

No. of Carcasses	Maturity	Marbling	pH
20	A	Slight	Normal
20	A	Small	Normal
20	A	Slight	High
20	B	Small	High
20	B	Slight	Normal
20	B	Small	Normal
8	B	Slight	High
12	B	Small	High

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The paired boneless subprimals were vacuum packaged and aged for either seven, 14, 21 or 35 days to determine if aging time had an effect on livery flavor development and, if so, to determine if there is a specific point during aging when livery flavor develops.

Cooked steaks were served to a trained, descriptive flavor-profile sensory panel in accordance with established protocols. Characteristics evaluated included:

- Beef-flavor identification
- Brown-roasted
- Bloody/serumy
- Metallic
- Livery
- Rancid
- Sour flavors

Gas chromatography/mass spectrometry, high-pressure liquid chromatography and 2-thiobarbituric acid reactive substances (TBARS) were used to analyze for volatile compounds both in livery flavored and non-livery flavored samples, for fatty acid concentration and lipid oxidation. Samples of beef liver were ground and used for gas chromatography determination of volatile compounds responsible for the liver flavor characteristics.

Findings

The three-way interaction for livery flavor suggested that neither marbling level, maturity or aging time have a consistent effect on livery flavor development. There was somewhat of a trend, however for muscles from carcasses with Small marbling to have less livery flavor and those from carcasses with B-maturity to have more livery flavor.

Both the *gluteus medius* and *psoas major* muscles had a statistically significant more intense livery flavor than the *infraspinatus*, but the numerical differences on the 15-point scale were small enough to probably be of little practical significance.

The incidence of livery flavor in this study was quite low. There were numerous statistical interactions among traits, which made it difficult for the researchers to make clear conclusions. In general, marbling and aging time had little direct effect on livery flavor or any of the laboratory analyses. Muscles from high pH, or dark cutting carcasses had less beef flavor identification than those with normal pH.

Sixteen volatile compounds were identified that were different between samples that were identified by taste panelists as being livery in flavor and those that were not. Chemical analyses revealed that myoglobin content was also positively related to livery flavor.

Following is a table that contains a list of volatile compounds that were frequently different in concentration between samples that were found to have a livery flavor by the trained flavor profile panel and those that were not. Thirteen of the volatile compounds were higher in the samples that had livery flavor, whereas three were higher in the samples that were not livery in flavor.

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Table 2. Volatile compounds found to be different in livery samples versus non-livery samples

Retention Time	Compound Name
2.34	Hexanal
3.89	Butane, 1-(ethenylthio)
6.15	dl-Limonene
7.04	2-Octanel
8.10	Nonanal
9.68	2-Nonenal, (E)-
12.43	2-Decenal-[E]
13.38	2,4-Decadienal, (E, E)
13.99	2,4-Decadienal
15.17	2-Undecenal
16.28	Trans-2-Undecen-1-ol; or Dodecanol
18.88	Pheno, 2,6-bis (1,1-dimethylethyl)-4-methyl-
21.03	Pentan-1,3-Dioldiisobutyrate,2,2,4-tryme
23.66	Tetradecanal
25.90	Octadecanal or Hexadecanal
30.20	Octadecanal

Implications

Based on this project, the researchers concluded that livery flavor in beef is a complex trait that results from the interactions of various factors. Some of the compounds found to be different among the livery versus non-livery samples have been identified previously in the *longissimus* muscle according to a 2002 report that appeared in the *Journal of Food Science*. Further research is needed to study the interactions of volatile compounds, myoglobin, total iron content and marination ingredients and their effect on the development of livery flavor in beef.

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