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American Lamb
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Characterizing Lamb Flavor

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Flavor Perception

- <u>Taste</u> – perceived by taste buds primarily on the tongue; responsible for sweet, sour, bitter, salty, and umami flavors
- <u>Aroma</u> – greatest contributor to perceived flavor; detected by the olfactory system; humans are capable of detecting and discriminating amongst 1000s of different aromas; low molecular weight volatile compounds bind to olfactory receptors and are responsible for perceived flavors

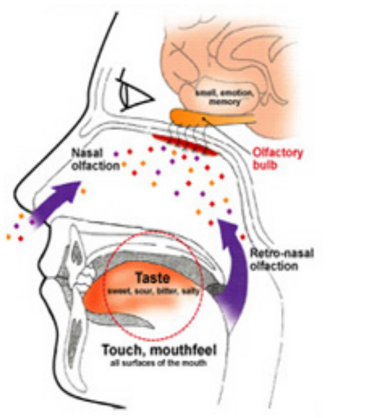


Image: http://www.enologyinternational.com/articles/senses.html

Developing Meat Flavor

- Raw meat has little aroma and only a blood-like taste, but is a reservoir of precursor compounds that can develop into flavor and odor causing compounds.
- Meat flavor development is dependent upon the cooking process and the chemical reactions that occur during cooking.
- During cooking, the Maillard reaction and the thermal oxidation of lipids help to develop meat flavor.

Maillard Reaction

- The Maillard reaction is a complex network of reactions which yield both high molecular-weight brown colored products and numerous volatile aroma compounds.
- The reaction involves the condensation of amino acids (or peptides) with the carbonyl group of a reducing sugar in the presence of heat.
- As the reaction progresses, the intermediates of the reaction can react with other amines, amino acids, aldehydes, hydrogen sulfide, and ammonia through the Amadori rearrangement, Strecker degradation, and Schiff base pathways.

- Classes of compounds formed during Maillard Reaction contributing to beef flavor:
  - Aldehydes
  - Pyrazines
  - Thiophenes
  - Thiazoles
  - Thiazolines
  - Dithianes
  - Dithiolanes
  - Trithiolanes
  - Trithianes

(Mottram, 1998; Shahidi, 1994; Gasser and Grosch, 1990)

Lipid Thermal Oxidation

- Lipids can break down via oxidation of fatty acids to give volatile odor compounds that can be either desirable or undesirable.
- Though thermal oxidation of lipids follows a similar pathway to lipid autoxidation, the process produces slightly different products.
- The degree of saturation of the fatty acids in the reaction plays a key role in the extent to which oxidation occurs.
- The reaction products of fatty acid oxidation can also contribute to volatile formation in the Maillard reaction.

- Classes of compounds formed during lipid thermal oxidation contributing to beef flavor:
  - Alcohols
  - Aldehydes
  - Hydrocarbons
  - Ketones
  - Carboxylic Acids
  - Esters
  - Lactones

(Mottram, 1998; Shahidi, 1994; Gasser and Grosch, 1990)

What Creates Distinctive Lamb Flavor

Specific 8- to 10-carbon branched chain fatty acids (BCFA) are the primary contributors to distinctive lamb flavor (Sutherland and Ames, 1996; Young et al., 2006)

- 4-methyloctanoic acid (MOA)
- 4-methylnonanoic acid (MNA)
- 4-ethyloctanoic acid (EOA)

4-methylactonoic acid (MOA) has the most influence on mutton flavor; MOA increases 13-fold in rams and 1.3 fold in whethers after sexual maturity.

BCFAs are lowest in lambs less than 1 year old, intermediate in sheep 1-2 years old, and greatest in sheep over 2.

What Creates a Pastoral Lamb Flavor

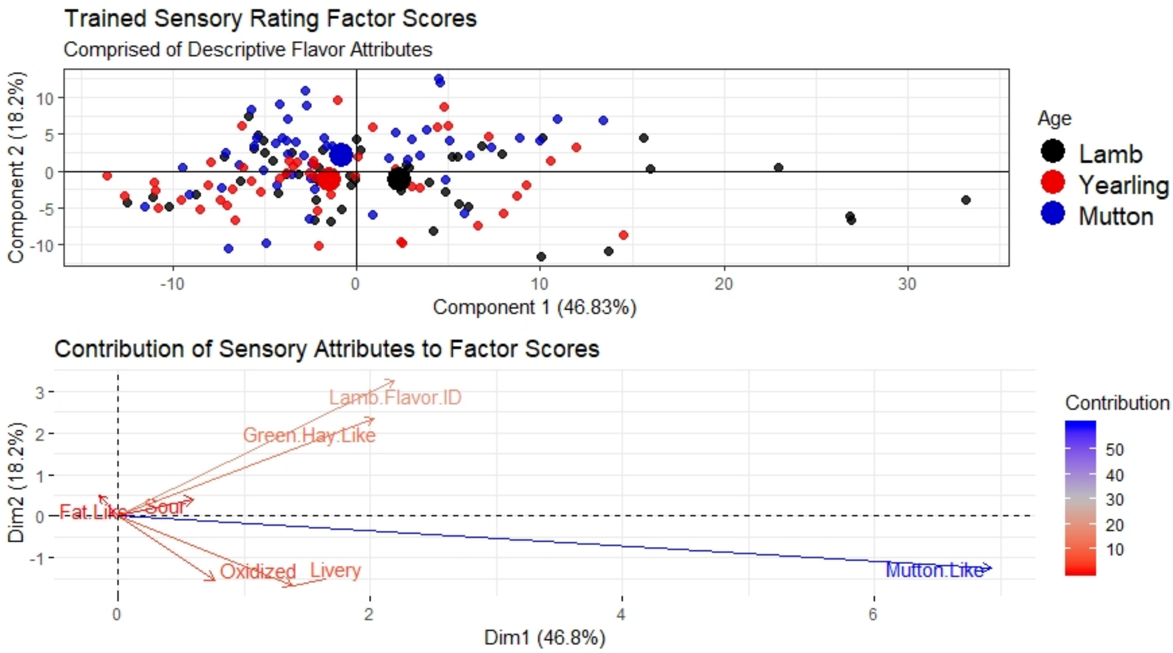
- The main contributors to pastoral flavor of lamb have been identified as 3-methylindole (**skatole**) and **indole** (Young et al., 1997, 2003).
- The presence of 3-methylindole in adipose tissue imparts an “animal” or “fecal” odor (i.e., the odor of confined livestock) to cooked meat (Young et al., 1997, 2003) that appears to be universally disagreeable to consumers (Prescott et al., 2001; Watkins et al., 2013).
- Increased concentrations of indoles and to a lesser extent methylphenols are responsible for pastoral flavor in lamb that is sometimes objectionable. These are formed in the rumen.
- Highly digestible lush pastures that are high in protein comparatively low in energy (i.e. legumes) create these compounds in a higher degree.

Familiarity and Preference

- Research in other countries has demonstrated that consumers differ in their acceptance of various sheep-specific meat flavor notes depending upon past eating experiences (Sanudo et al., 2000; Prescott et al., 2001).
- Consumers who are accustomed to eating lamb or mutton with a particular flavor profile seem to prefer ovine meat products with a familiar flavor (Sanudo et al., 2000; Prescott et al., 2001).
- Consumers who seldom eat lamb or mutton tend to exhibit the greatest aversion to sheep-specific meat flavor notes, sometimes finding even mildly detectable levels of theses flavors unacceptable (Prescott et al., 2001; Watkins et al., 2013).

Address Factors Contributing to Lamb Flavor

- Development of a Total Quality Management approach on production management effects on flavor
  - Utilized to identify and eliminate practices that contribute to negative lamb flavor attributes and utilize best practices that ensure eating satisfaction.
- Assessment to determine current diversity in lamb flavor and define consumer flavor preferences and expectations in the market place for American Lamb
  - Target the right flavor for the right customer.
- Strive to develop rapid, processing plant-based tools to identify flavor attributes and compounds, segregate current lamb supply into groups that fit market channels, and implement value-based marketing that delivers predictable flavor.



Trained Sensory Panel Evaluation

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Attributes that contributed the most to flavor performance → Assigning samples to overall flavor groups

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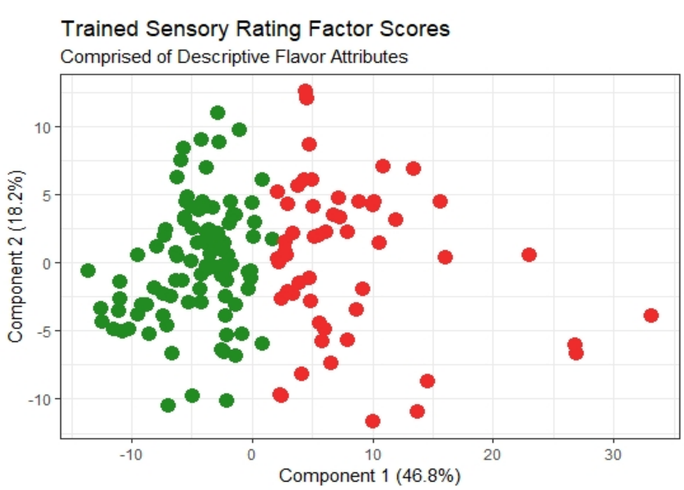
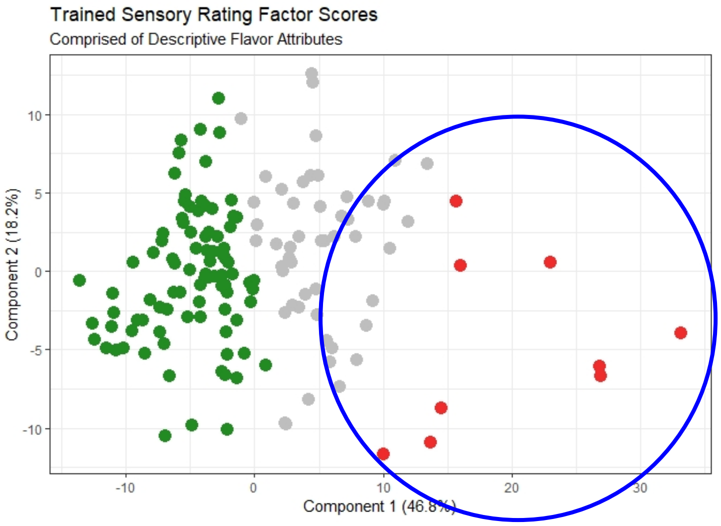
Using chemical data to predict overall flavor groups

Using Sensory Data to Classify Samples



Overall Prediction Accuracy	62.1%

Using Sensory Data to Classify Samples



Overall Prediction Accuracy	34.5%

Overall Flavor Classification
- Negative
- Neutral
- Positive

Accuracy decreased with addition of a 3rd classification group with fewer samples represented (n=9 negative samples)

CONCLUSIONS AND FUTURE WORK

Successfully classified several models with moderate to high accuracy

Refine and expand machine learning algorithms

Developing best data management tools (i.e., preprocessing, scaling, etc.)

Improving predictability could have a large impact in differentiating positive flavor profiles from off-flavors

Next study will use REIMS and consumer intensities

- Now that we have confirmed flavor attributes and ability of REIMS to be used with trained sensory panels, next step is to use consumer responses

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