Basic Science of Beef Flavor

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Beef flavor importance

NCBA Snapshot Poll

~90% of Consumers say TASTE is why they eat more

Basic tastes

5 basic tastes
- Salt
- Sour
- Sweet
- Bitter
- Umami

• Each taste bud on the tongue
  • 50-150 taste receptor cells

• Contrary to earlier beliefs, there is no ‘taste map’ on the tongue
Basic tastes
• Each receptor cell functions as a dedicated sensor, wired to give the stereotypic response for each taste
• Any taste receptor cell can taste any of the five tastes to varying degrees

Aromas
• Volatiles identified through smell from the olfactory bulb
• Sent directly to the brain unfiltered
• Sensitive to 1-carbon differences between stimulating molecules
• Central to detection of salty and sweet even though traditionally associated with taste

Trigeminal senses
• Trigeminal nerve
  • Contains numerous branches that span the face
  • Responsible for
    • Motor functions
    • Sensory functions
• Examples of trigeminal senses
  • “Cool” feeling of menthol
  • “Pungent” quality of acetic acid
  • “Warm” sensation from ethanol
• Integral to total sensory experience and perception

Chemistry of aroma flavors
• Lipid degradation
  • Thermal degradation
    • Dehydration
    • Decarboxylation
    • Hydrolysis of the ester bond
  • Formation of diglycerides/monoglycerides
    • No preference for the order on the backbone
  • Shorter chains preferred
  • More unsaturation preferred
  • Very little triglyceride degraded – polar fats are preferred for degradation
Lipid degradation
- Fatty acids are modified
  - Ketones
  - Aldehydes
  - Alcohols
  - Acids
  - Alkanes
- Carbon chain length and double bond presence largely determined by the fatty acid itself
- Cleavages at the double bonds

Maillard reaction
- Reducing sugar
  - DNA/RNA
- Protein/Amino Acid
- High heat
- Non-enzymatic browning
- Aroma flavors

HeteroAtomic compounds
- Furans
- Pyrazines
- Pyroles
- Pyrridines
- Others

Strecker degradation
- Decarboxylation of AA
- Deamination of AA
- Reaction with Maillard dicarbonyl intermediates
  - Strecker aldehydes
  - Pyrazine

Volatile compounds
- Generation of volatiles depends on
  - Intrinsic factors:
    - Fatty acid composition
    - pH
    - Proximate composition
  - Extrinsic factors:
    - Cooking method
    - Cooking temperatures
    - Cooking time
- Each meat sample generates from 10 to 200 different individual chemical compounds
- Detection and recognition threshold of each chemical contributes to the complexity of the total aroma
Capturing aromas

- Samples are cooked according to prescribed method
  - Cut into sample size similar to that for trained panel
  - Put into jar in 60°C (~140°F) water bath
  - Solid Phase Micro Extraction
    - Small stainless steel coated fiber
    - Coating absorbs chemical compounds above sample

Flavor/Aroma Techniques

- Sample the air above the cooked meat
- GC/MS separates compounds and odors

Cook surface at 350, 400, 450°F

Cut ½, 1, 1½ inch thick

****Steak thickness has a tremendous impact on which aromas are released****
Cooking Procedures Create Desired Aromas

2.3 Dimethyl pyrazine (Roasted)
- 20% of variation from
  - Steak surface end temperature
  - Cook time

2.5 Dimethyl pyrazine (Roasted)
- 52% of variation from
  - Skillet beginning temperature
  - Steak surface end temperature

Trimethyl pyrazine (Nutty, roasted)
- 20% of variation from
  - Skillet ending temperature
  - Internal steak end temperature
  - Cook loss%

Can We Predict Consumers’ Response to Flavor

Percentage of the overall variation for each Consumer flavor accounted for by aromatic chemicals
- Consumer Overall like - 57%
- Consumer Beef Flavor Identity - 77%
- Consumer Brown/Roasted - 50%
- Consumer Bloody/Serumy - 51%
- Consumer Fat-like - 52%
- Consumer metallic - 77%
- Consumer liver flavor - 82%
- Consumer umami - 79%

Differentiation of Flavor Contributing Compounds and Sensory Measures by USDA Quality Grade

Beef composition impacts flavor

Increases in IMF within the Longissimus muscle is related with increased flavor scores by panelists
- Corbin et al., 2015; Legako et al., 2015; Hunt et al., 2014; Emerson et al., 2013; O’Quinn et al., 2012; Lorenzen et al., 2003, 1999; Savell et al., 1987; Smith et al., 1985, 1983

Variation in flavor precursors impacts flavor perception
Quality grade impacts the perception of flavor, but what, if any, impact does it have on precursor and volatile compounds?

Impacts of quality grade and cooking on flavor precursor compounds

Quality grade Categories:
- Prime (Slightly Abundant or greater)
- Low Choice (Small to Small)
- Standard (Trace or lower)

Cooking categories:
- Raw (Maintained at 4°C or lower)
- Cooked (Removed from grill at 71°C)

Chemical measurements:
- Fatty acids of polar and neutral lipids
- Water-soluble compounds
- Free amino acids
- Nucleotides/nucleosides and nitrogenous organic compounds
- Volatile aroma compounds

Sensory evaluation:
- Consumer liking
- Beef lexicon of flavor attributes

Lipid Components

Neutral lipids – triglycerides

Polar lipids – phospholipids

Quality Grade Impacts on MUFA and PUFA

Cooking Impacts on MUFA and PUFA

Increase in PUFA % was due to compositional change, concentration did decrease with cooking.
Water-Soluble Components

- Free amino acids
- Reducing sugars
- Nucleotides/nucleosides and nitrogenous organic compounds

Quality Grade and Cooking Impacts on Reducing Sugars

Glycogen → Glucose and Glucose-6-phosphate

ATP → Ribose and Ribose-5-phosphate

Quality Grade Impacts on Taste Influencing Free Amino Acids

Basic & Aliphatic amino acids
Cited to have bitter taste
QG differences in cooked samples

Cooking Impacts on Nucleotides/nucleosides and Nitrogenous Organic Compounds

Generally decreased with cooking
- Guanosine 5'-monophosphate, Inosine 5' monophosphate, Hypoxanthine, Uridine, Inosine, Carnosine, Creatine, Creatinine

Except:
- Adenosine 5'-monophosphate
Quality Grade Impacts on Taste Influencing Nucleotides

Hexanal, along with pentanal, heptanal, octanal and nonanal, were greater in Standard steaks.

- n-Aldehydes are often associated with oxidation and off-flavors

Hexanal,

Phenylalanine →(Strecker degradation)→Phenylacetaldehyde

- Greater in Low Choice and Prime steaks
- Honey-like descriptor

2,3-butanedione (diacetyl) and 3-hydroxy-2-butanone (acetoin)
- Each greater in Prime steaks
- Buttery descriptors

Quality Grade Impacts on Sensory Scores

Flavor liking, assessed by consumers, followed order of QG

- Prime greatest, Low Choice intermediate, and Standard lowest

Beef flavor lexicon attributes segregated by positives and negatives

- Prime was greater in Beef identity, Brown/roasted, fat-like, overall sweet, and Umami
- Low Choice was intermediate in most cases
- Standard was ranked significantly greater for cardboard, while being numerically greater for green, liver-like, bitter and oxidized

Summation and Conclusions

- Both chemical and sensory components differed between quality grades

Lipid components:
- Quality grade affected ratio of NL:PL and PL fatty acid composition

Water-soluble components:
- Taste contributing molecules known to provide bitterness accumulated in Standard steaks with cooking

Volatile compounds:
- Off-flavor contributing n-Aldehydes accumulated in Standard steaks
- Compounds described as honey-like and butter accumulated in Prime steaks

Perceived flavor goes beyond the simple contribution of IMF %

Changes in flavor contributing compounds were in agreement with Beef Flavor Lexicon Attributes and consumers segregated beef based on the associated attributes and chemical components
Questions?