Project Title: Development of Relative Aroma Intensity Values for Aroma Chemical Compounds Using Published Aroma Thresholds for Important Aroma Chemicals

Principle Investigator(s): Chris Kerth, Ph.D. and Rhonda Miller, Ph.D.

Institution(s): Texas A&M University

Completion Date: June 2015

Background

Beef flavor is incredibly complex, and it is not completely understood how flavor influences palatability of beef. Although previous research studies have done an admirable job of reviewing current literature and describing many of the factors involved in determining beef flavor, much still needs to be accomplished to gain a full understanding of the subject. In the development of quantitative descriptions of the chemical compounds responsible for beef flavor, one research study described over 100 chemical compounds that were found to influence beef flavor, with their resulting aroma thresholds and aroma descriptors. Furthermore, numerous studies have described methods of determining an odor activity value (OAV) derived from the quantity of an aroma chemical compound found from gas chromatography/ mass spectroscopy/olfactory (GC/MS/O) and its detection threshold. This OAV then describes the relative contribution of each aroma chemical to the overall aroma/flavor of the meat. It was then hypothesized that a similar value (Relative Aroma Intensity Value) could be calculated using only the total ion counts from GC/MS/O and the thresholds reported in the literature.

The objective of this study is to determine if converting a quantitative measurement of each chemical responsible for beef flavor into a Relative Aroma Intensity Value (RAIV) will prioritize the aroma chemicals by their relative contribution to overall aroma/flavor of beef.

Methodology

Aroma chemical compounds derived from GC/MS/O analyses were analyzed from 3 different checkoff-funded projects: 1) Beef flavor attributes and consumer perception I (heavy beef eaters), 2) Beef flavor attributes and consumer perception II (light beef eaters) and 3) Consumer attitudes of predicted flavor aromas in steaks created with different steak thickness, quality grade and cooking surface temperature. Total ion counts were taken for each aroma chemical compound and subsequently divided by its aroma threshold value to derive a Relative Aroma Intensity Value. Each chemical was then ranked based on the RAIV to determine the relative contribution of each chemical compound to the overall aroma/flavor of the beef.

Finding

The resulting RAIV for heavy beef eaters are reported in Table 1. DL-Limonene (lemon-like, citrus), Nonanal (citrus/soapy), hexanal (green/grassy), E-2-noneneal (fatty/green), methanethiol (vegetable oil/creamy), heptanal (fatty), octanal (citrus/green) and 1-octen-3-ol (mushroom/earthy) ranked among the highest RAIV for heavy beef eaters for all treatment groups. Hexanal is a fixture near the top of all three tables as hexanal is almost universally found in the highest quantities in cooked meat, and has a moderately high detection threshold, resulting in a high RAIV.

2,3-butanedione (buttery) has been shown to be significantly related to consumer like. This compound's rank declined as the severity of cooking method increased as shown with higher

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degrees of doneness on the grill compared to lower degrees of doneness in the slow cooker. This is an indication that 2,3-butanedione is favored in low-heat, slow cooking scenarios as opposed to high heat grilling. In contrast, pyrazines as a whole, and trimethyl pyrazine (raw/ musty) in particular ranked higher as degree of doneness and grilling increased. Pyrazines are Ffa product of the Maillard reaction and also tend to be characterized as caramel or roasted in nature. Maillard reaction products would be expected to be higher in concentration in higher heat cooking methods, which agree with the findings of this study.

Implications

The use of RAIV is a useful tool to determine the relative contribution of aroma chemical compounds to the development of beef flavor and is another tool to describe beef flavor. Additional efforts need to be developed to use relative aroma intensity values as a modeling tool to synthesize experimental beef flavor profiles as a method to research the impact of influencing one or more step in the development of aroma chemical compounds.

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Table 1. Heavy beef eaters (Relative Aroma Intensity Values were calculated and each aroma chemical was ranked form the highest to the lowest with the highest RAIV being at the top of each column and lowest at the bottom).

Crock pot 137 °F	Clamshell 137 °F	Grill 137 °F	Crock pot 176 °F	Clamshell 176 °F	Grill 176 °F
Dl-Limonene	Dl-Limonene	Dl-Limonene	Dl-Limonene	Dl-Limonene	Dl-Limonene
Nonanal	Nonanal	Nonanal	Nonanal	Nonanal	Nonanal
Hexanal	2-Nonenal,(E)-	2-Nonenal,(E)-	Methanethiol	Hexanal	Hexanal
2-Nonenal,(E)-	Hexanal	2-Acetyl-2-thiazoline	Hexanal	NHEPTANAL	2-Acetyl-2-thiazoline
NHEPTANAL	NHEPTANAL	NHEPTANAL	Disulfide,dimethyl	2-Nonenal,(E)-	2-Nonenal,(E)-
NONENAL	NONENAL	NONENAL	2-Nonenal,(E)-	Disulfide,dimethyl	NHEPTANAL
Methanethiol	1-OCTEN-3-OL	Hexanal	NHEPTANAL	2-Acetyl-2-thiazoline	Methanethiol
Octanal	Octanal	Octanal	Methane,thiobis-	1-OCTEN-3-OL	NONENAL
Methane,thiobis-	Methanethiol	1-OCTEN-3-OL	Octanal	Octanal	Octanal
1-OCTEN-3-OL	Disulfide,dimethyl	Dodecanal	NONENAL	NONENAL	Disulfide,dimethyl
2,3-Butanedione	2-Decenal,(E)-	Methane,thiobis-	2-Acetyl-2-thiazoline	Styrene	1-OCTEN-3-OL
2-Acetyl-2-thiazoline	2-Acetyl-2-thiazoline	2-Decenal,(E)-	2,3-Butanedione	Methane,thiobis-	2-Decenal,(E)-
2-Decenal,(E)-	Methane,thiobis-	2,3-Butanedione	1-OCTEN-3-OL	2,3-Butanedione	Methane,thiobis-
Dodecanal	Styrene	1-Heptanol	Pentanal	Methanethiol	Styrene
Pentanal	2,3-Butanedione	Styrene	Heptanal	Pentanal	Dodecanal
Disulfide,dimethyl	1-Heptanol	Heptanal	Dodecanal	Furan,2-pentyl-	2,3-Butanedione
Furan,2-pentyl-	Pentanal	Pentanal	2-Decenal,(E)-	Dodecanal	1-Heptanol
Heptanal	Furan,2-pentyl-	Furan,2-pentyl-	Furan,2-pentyl-	1-Heptanol	Pentanal
1-Heptanol	Dodecanal	Benzaldehyde	Styrene	2-Decenal,(E)-	Furan,2-pentyl-
Styrene	Nonanoicacid	Propanal,3-(methylthio)-	Benzaldehyde	Benzaldehyde	Heptanal
Benzaldehyde	Benzaldehyde	Nonanoicacid	PHENYLACETALDEHYDE	PHENYLACETALDEHYDE	PHENYLACETALDEHYDE
2-Heptenal,(E)-	2-Heptenal,(E)-	PHENYLACETALDEHYDE	Propanal,3-(methylthio)-	Heptanal	Benzaldehyde
PHENYLACETALDEHYDE	1-Octanol	1-Octanol	1-Heptanol	Nonanoicacid	Propanal,3-(methylthio)-
Propanal,3-(methylthio)-	PHENYLACETALDEHYDE	2-Heptenal,(E)-	Nonanoicacid	Propanal,3-(methylthio)-	1-Octanol
1-Octanol	Propanal,3-(methylthio)-	2-Pentanone	2-Heptenal,(E)-	2-Heptenal,(E)-	Nonanoicacid
Nonanoicacid	Heptanal	1-Butanol	1-Octanol	1-Octanol	2-Pentanone
2-Pentanone	1-Butanol	2-Butanone,3-hydroxy-	1-Butanol	2-Pentanone	2-Heptenal,(E)-
1-Butanol	2-Pentanone	Pyrazine,2-ethyl-3-methyl-	2-Pentanone	1-Butanol	1-Butanol
2-Butanone,3-hydroxy-	2-Butanone,3-hydroxy-	Hexanoicacid	2-Butanone,3-hydroxy-	2-Butanone,3-hydroxy-	2-Butanone,3-hydroxy-
Hexanoicacid	Ethanone,1-phenyl-	2-Nonanone	Acetophenone	Ethanone,1-phenyl-	Ethanone,1-phenyl-
Ethanone,1-phenyl-	Hexanoicacid	1-Hexanol	Hexanoicacid	Hexanoicacid	2-Nonanone
1-Dodecanol	1-Hexanol	Acetophenone	1-Dodecanol	2-Nonanone	Hexanoicacid
1-Hexanol	Acetophenone	Ethanone,1-phenyl-	Pyrazine,2-ethyl-3-methyl-	Pyrazine,2-ethyl-3-methyl-	Pyrazine,2-ethyl-3-methyl-
2-Nonanone	1-Dodecanol	3-Pentenoicacid,4-methyl-	2-Nonanone	Acetophenone	1-Hexanol
3-Pentenoicacid,4-methyl-	3-Pentenoicacid,4-methyl-	Heptanoicacid	1-Hexanol	1-Hexanol	Acetophenone
Hexanoicacid,butylester	Heptanoicacid	1-Butanol,3-methyl-()	1-Butanol,3-methyl-()	Heptanoicacid	1-Butanol,3-methyl-(impure)
Octanoicacid	Octanoicacid	Octanoicacid	Ethanone,1-phenyl-	3-Pentenoicacid,4-methyl-	3-Pentenoicacid,4-methyl-
Heptanoicacid	Pyrazine,2-ethyl-3-methyl-	Octanoicacid	3-Pentenoicacid,4-methyl-	Octanoicacid	Octanoicacid
Pentanoicacid	2-Nonanone	Aceticacid	Heptanoicacid	Hexanoicacid,butylester	Heptanoicacid
Aceticacid	1-Butanol,3-methyl-()	Pyrazine,3-ethyl-2,5-dimethyl-	Octanoicacid	Pyrazine,3-ethyl-2,5-dimethyl-	Pyrazine,3-ethyl-2,5-dimethyl-
Octanoicacid	Octanoicacid	Hexanoicacid,butylester	Hexanoicacid,pentylester	Hexanoicacid,pentylester	Hexanoicacid,pentylester
2-Propanone	Hexanoicacid,pentylester	Hexanoicacid,pentylester	Pyrazine,3-ethyl-2,5-dimethyl-	Aceticacid	Hexanoicacid,butylester
1-Butanol,3-methyl-()	Hexanoicacid,butylester	2-Propanone	Hexanoicacid,butylester	Octanoicacid	Aceticacid
Pyrazine,3-ethyl-2,5-dimethyl-	Aceticacid	2-Furancarboxaldehyde	Aceticacid	2-Propanone	2-Propanone
2-Furancarboxaldehyde	Pentanoicacid	1-Propanol	Octanoicacid	Pentanoicacid	Sulfurdioxide
Hexanoicacid,pentylester	2-Propanone	Pentanoicacid	2-Propanone	1-Propanol	2-Furancarboxaldehyde
1-Propanol	1-Propanol	1-Dodecanol	Sulfurdioxide	1-Butanol,3-methyl-()	1-Propanol
Sulfurdioxide	2-Furancarboxaldehyde	Disulfide,dimethyl	1-Propanol	2-Furancarboxaldehyde	Pentanoicacid
Acetophenone	Pyrazine,3-ethyl-2,5-dimethyl-	Methanethiol	2-Furancarboxaldehyde	Sulfurdioxide	1-Dodecanol
Pyrazine,2-ethyl-3-methyl-	Sulfurdioxide	Sulfurdioxide	Pentanoicacid	1-Dodecanol	Octanoicacid

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