Identification of Compounds Responsible for Positive Beef Flavor

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Identification of Compounds Responsible for Positive Beef Flavor: Project Summary

Background
Beef flavor has been defined as an important component of beef demand. Beef flavor, however, is not a “single” attribute, but is composed of multiple attributes that can be dynamic. The beef industry took the first big step in addressing beef flavor by funding the development of the Beef Flavor Lexicon (Miller, 2010) that identified major and minor beef flavor components. We cannot develop systems for identifying beef flavor if we do not know what “beef flavor” is or how the human perceives beef flavor. Now that the beef lexicon has been developed, understanding what compounds are responsible for each attribute in the lexicon is important prior to understanding how to enhance, control or measure beef flavor with novel or new technologies.

Early flavor chemistry research has shown that lean flavors are associated with reactions between reducing sugars (mainly glucose) and amino acids during cooking, called the Maillard reaction. Additionally, during cooking Strecker reactions occur and produce pyrazine compounds that affect beef flavor. This is why raw beef is not beefy, but cooked beef is. The amount and fatty acid composition of the lipid component of beef and changes in the phospholipid composition also have been associated with flavors, both positive and negative. Additionally, the oxidative state of lipids contributes to flavor or alters the flavor contribution of lipids to beef. Products of lipid oxidation, either from the lipid fraction or from phospholipids, have also been shown to react with Maillard reaction products. These reactions can occur during cooking or during storage. In addition, water-soluble compounds from feed-stuffs deposited in lipid contributes to beef flavor. This is where off-flavors in grass-fed beef are derived. The myoglobin content and meat pH also can affect flavor attribute expression, but their contribution has not been fully elucidated (Meisinger et al., 2006).

During cooking, the rate of cooking either through changes in cook temperature or cooking method, and the final cook temperature endpoint or degree of doneness affects rate and extent of chemical reactions. Therefore, what flavor compounds may be present in beef are not only affected by what chemical compounds are present in the raw form, but cooking influences what flavor volatiles may or may not develop. It is apparent that beef flavor is complicated and that multiple components contribute to positive and negative flavor attributes.

While much is known about lean flavor development, the combination of the above attributes on specific beef flavor attributes has not been fully examined. It is obvious that multiple components can or may contribute to beef flavor attributes and that varying conditions may result in development of the same flavor or flavor combinations. Our hypothesis is that positive beef flavor attributes are the result of volatile chemical compounds that may be derived from multiple sources or conditions, but the chemical compounds responsible for each defined beef flavor attributes are constant. Understanding what chemical components compose positive beef flavor is imperative to understanding how to manipulate or create conditions for expression of positive beef flavor attributes. Our objectives were to create varying levels of positive beef flavor attributes, measure these with an expert trained meat flavor panel, and measure the volatile compounds using an Aroma-Trax system with a sniff-port to elucidate the chemicals in beef flavor. This will allow use to tie flavors that are expressed with chemicals that are contributing to beef flavor.
Methodology
The study was conducted in 2 phases. In Phase I, steaks (n=98) from the Beef Lexicon study and ground beef patties (n=4) were used to identify steaks with varying levels of beef flavor attributes. The objective was to create differences in beef flavor attributes using cuts and cooking methods from the beef lexicon study. These steaks were used to train the panelists on individual attributes of the beef lexicon and to make sure that variation in lexicon flavor attributes were being presented and scaled by the panelists. Validation of the panel was conducted using these data.

In phase II, high pH, Choice and Select beef top loin steaks, and Choice and Select top sirloin steaks, flat iron steaks and bottom round roasts were obtained. Steaks and roasts were cooked to 58, 70, or 82°C (137, 158 or 176°F) to induce differences in serumy/bloody, liver-like, beefy, and brown/roasted within cuts and to induce differences in Maillard reaction product. Steaks were cooked either on a gas grill or George Foreman grill and roasts were cooked either in a crock pot or roasted in an oven. This design was used to induce differences in Maillard reaction products and heat-induced lipid oxidation.

These steaks and roasts were evaluated by an expert trained flavor descriptive attribute panel with over 23 years of experience that helped develop and validate the beef lexicon. Beef flavor attributes were measured using the attributes from the Beef Flavor Lexicon. Aromas and flavor aromatics were evaluated using the Spectrum® Universal 16-point scale where 0 = none and 15 = extremely intense (Meilgaard et al., 2007).

Volatile were captured from the same steaks or roasts evaluated by the panelists using the AromaTrax System. Individual volatile, aromatic compounds were identified by 2 panelists, each at their own sniff port. Evaluation was within 2 weeks of cooking and sensory evaluation. Raw meat pH, fatty acid composition, myoglobin content, and non-heme iron content were determined on the same samples used for sensory and chemical determinations.

The trained panel descriptive flavor attributes and the volatile compounds were analyzed using Proc Means, Proc Corr, Proc Reg stepwise procedure, Proc GLM and Proc Factor for Principle Component Analysis of SAS (v9.3, SAS Institute, Cary, NC) to understand what chemical attributes drive specific beef flavor attributes. A predetermined alpha of \(P < 0.05\) was used in all analyses. For Analysis of Variance, least squares means were calculated and the pdiff function of SAS was used to determine differences between means.

Findings
Phase I results showed that the trained, flavor descriptive panelists were sufficiently trained to conduct Phase II and were familiar with the Beef Flavor Lexicon. In Phase II, results for chemical data, trained flavor descriptive attributes, and aromatic volatile chemicals varied and were affected by the experimental design to induce differences in beef flavor attributes. These data were sufficient to test the hypothesis that these chemical attributes influence beef sensory descriptive flavor attributes. Aromatic, volatile chemicals defined by the Aroma Trax system and 413 chemicals were used out of over 1,000 identified as volatiles. Within these 413 compounds, 42 aroma descriptors were used to characterize them. Some chemicals were described using more than one aroma descriptor meaning that sometimes an aromatic, volatile chemical, like hexanol, may be detected as beefy, and at a different concentration it may be defined as grassy or buttery. For a chemical to impact beef flavor, it first must have aroma in order to contribute to the flavor of the sample. The 413 chemicals were
used to predict Beef Flavor Lexicon attributes of beef identity, browned/roasted, serumy/bloody, fat-like, metallic, liver-like, umami, overall sweet, and sweet, sour, salty and bitter basic tastes using Stepwise regression. Prediction equations were developed that accounted for 82, 70, 92, 81, 73, 72, 61, 67, 69, 70, 69, 77, and 89 percent of the variability in beef identity, browned/roasted, serumy/bloody, fat-like, metallic, liver-like, umami, overall sweet, and sweet, sour, salty and bitter basic tastes, respectively. Generally, chemical compounds used to predict each sensory attribute included products from the lean and fat components of beef that are the result of heating or cooking. Not one single class of compounds from Strecker degradation, Maillard reactions and lipid oxidation were used to predict any of the flavor descriptive attributes. This means that each flavor attribute, while using different compounds, where the result of reactions in the lean and fat portions of meat.

Principle component analyses were conducted for each of the 13 trained descriptive major flavor attributes. The purpose of this analyses was to take the compounds used in the stepwise regression and see if they would cluster together to show what compounds were related or were accounting for similar variation in the sensory flavor descriptor. These principle component analyses did not account for large amounts of variation and should be interpreted with limited scope. Generally, compounds related to Strecker degradation, Maillard reactions, and lipid oxidation tended to cluster with each other. These analyses may help in reducing the number of compounds used to predict each sensory flavor descriptive attribute in future research. These results indicate that to predict any of the specific sensory flavor attributes, multiple compounds contribute to the flavor descriptor.

**Implications**

Beef flavor is important to consumers. These results provide highly predictive regression equations that identify the compounds responsible for each beef sensory positive flavor attribute. Compounds differed for each sensory attribute which provides an opportunity to select for specific compounds if flavor changes are needed or one specific flavor needs to be enhanced. Additionally, not one single compound was highly predictive of a single beef flavor attribute, but chemical compounds from lean and fat heat denaturation were responsible for specific beef flavor components. It would have been ideal to find one or two chemical compounds that were responsible for each of the 13 positive beef sensory flavor descriptive attributes. We have identified groups of flavor compounds that may help to narrow down what compounds can be used to drive flavor differences. We will use these compounds for the next study where we will be connecting these 13 positive beef flavor attributes, the aromatic, volatile chemicals attributing to the flavor attributes and consumer perceptions and preferences.