PROJECT SUMMARY
PRODUCT QUALITY

BEEF
RESEARCH

Beef Flavor Kinetics and Thermodynamic Properties of Whole Muscle and Ground Beef

Principal Investigator: Jerrad Legako, PhD

Department of Nutrition, Dietetics and Food Science, Utah State University

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Background

Beef flavor, tenderness and juiciness contribute to overall beef palatability. Beef tenderness is known to be affected by many different biological properties such as sarcomere length, muscle fiber diameter, stromal protein quantity and intramuscular fat content. Furthermore, tenderness is also known to be impacted by cooking as proteins are denatured, fat is melted and moisture is lost.

Flavor development is primarily dependent on two factors: reactant mixture and reaction conditions. Reactant mixture refers to the precursors of flavor (fatty acids, amino acids, reducing-sugars, nucleotides, etc.). Reaction conditions refer to the thermal kinetics as a result of varied time and temperature exposure (cooking). Flavor development, therefore, is highly dependent on both the reactant mixture (precursor compounds) and reaction conditions (cooking).

One common characteristic which may vary in beef steaks is intramuscular fat content. Beef lipid and water percentage are inversely related. Lipids and water are known to differ in thermal conductivity. Therefore, variation in lipid content may affect heat transfer during cooking. As a result, the chemical kinetics of the Maillard reaction and thermal oxidation of lipids may be greatly affected by lipid content, alongside alteration of proteins with cooking. Little information is currently available describing how processing techniques such as grinding impact flavor development. This common alteration of physical properties is of great interest due to the volume of ground beef marketed in the United States.

Objectives

Correlations have been found between palatability, degree of doneness and USDA quality grade. However, possible interactions of varying levels of intramuscular fat and degree of doneness on thermal, physical and chemical properties has not been established in a single study. Therefore, the objective of this study was to determine effects of quality grade and degree of doneness on thermal, physical and flavor-related compounds resulting from beef steaks. Furthermore, it was an objective of this study to determine the effect of quality grade and degree of doneness on flavor related compounds in ground beef.

Methods

Paired Strip Loins (n = 8 per quality grade treatment) of each quality grade (USDA Prime, Low Choice and Standard) were collected, aged 21 days and fabricated into 1 inch thick steaks. Steaks were randomly assigned to thermal treatment (4°C, 25°C, 55°C, 60°C, 71°C and 77°C). Furthermore, six steaks from each pair of Strip Loins were randomly assigned for grinding to produce beef patties. Thermal and physical measurements were evaluated for beef steaks along with chemical measures. Patties were evaluated by chemical measures only.

Thermal tests were conducted using a Hot Disk and Kaplan sensor. Protein degradation was evaluated using Differential Scanning Calorimetry. Rheology measurements were taken using a Rheometer. Expressible moisture (%) and water holding capacity were conducted using centrifugation. Texture analysis (adhesiveness, chewiness, cohesiveness, hardness and springiness) and Warner Bratzler Shear Force (WBSF) were conducted using a TSM-Pro with specialized attachments. Neutral and polar lipid fatty acids were determined by gas chromatography. Free-amino acids, total amino acids, reducing sugars and volatile compounds were determined by a gas chromatography-mass spectrometer.

Important findings

Protein degradation of myosin and sarcoplasmic proteins taken from the center of the steaks were determined to interact between quality grade and degree of doneness. At refrigerated temperatures, steaks did not differ in shear force values. However, variation in protein enthalpy (heat transferred during a constant pressure process) was

determined, where Standard steaks required less energy for degradation of myosin. These results imply that compositional differences in protein components other than just intra-muscular fat content are responsible for differences in enthalpy between quality grades.

As expected from previous studies, degree of doneness had a significant impact on all textural properties. Adhesion, chewiness, cohesiveness, hardness and resilience were each affected by degree of doneness. Cohesiveness was the only property to also be affected by quality grade. Regardless of quality grade, steaks gained a less favorable value for cohesiveness as degree of doneness increased. This suggests that degree of doneness had an influence on all textural properties and that marbling had an influence on cohesiveness. Prime steaks, regardless of degree of doneness had more tender values than Standard steaks that were cooked to 60°C, 71°C and 77°C, and more tender values than Choice steaks cooked to 71°C and 77°C. This data, along with the observed interactions between quality grade and degree of doneness for measures of protein degradation indicate that factors beyond intramuscular fat content influence tenderness, such as differences in protein degradation.

An interaction between quality grade and degree of doneness was determined for compounds of both the Maillard reaction and lipid degradation pathways. Generally, products of the Maillard reaction associated with cooked beef were greater in Prime steaks at a greater degree of doneness. Numerous other interactions were determined for flavor contributing compounds, including fatty acids and amino acids. The combination of degradation with heating and cook loss contributed to final quantities of these flavor contributing compounds.

Implications

These data revealed numerous impacts of quality grade and degree of doneness on thermal, physical and chemical properties. Both quality grade and degree of doneness affect tenderness and development of flavor compounds. While this was expected, no previous studies have collected data relevant to tenderness and flavor development in such completeness. This data may now be utilized to develop kinetic models which account for both physical and chemical traits of cooked steaks. Ultimately these models may be utilized to pattern tenderness and flavor development.

Figure 1. Displays the effect of degree of doneness and quality grade on shear force. [a, b, c, d, e, f, g] means bars lacking a common superscript differ ($P < 0.05$) for the interaction of Quality Grade x Degree of doneness.

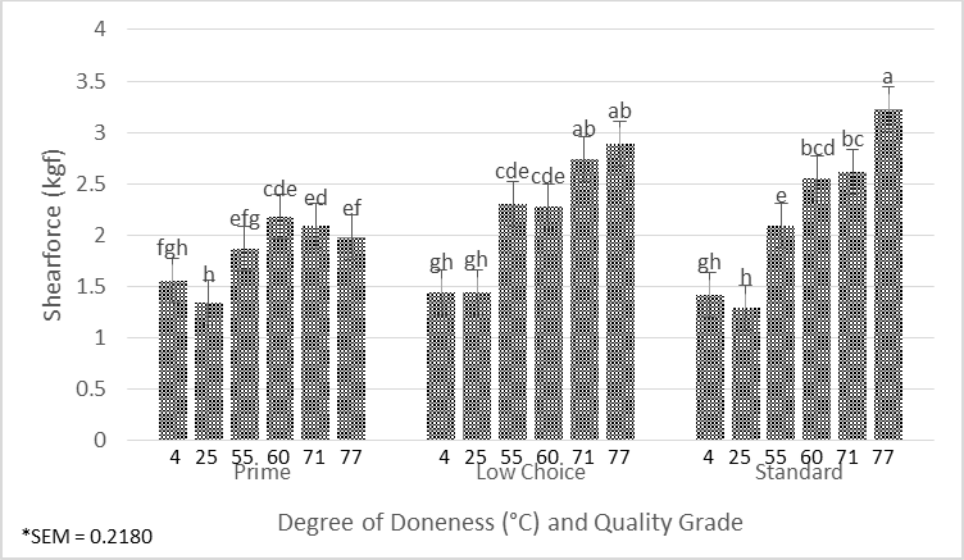

Figure 2. Displays the effect of degree of doneness and quality grade on center enthalpy of myosin and sarcoplasmic proteins. [a, b, c, d, e, f, g] means bars lacking a common superscript differ (P < 0.05) for the interaction of Quality Grade x Degree of doneness.