PROJECT SUMMARY
PRODUCT QUALITY

BEEF
RESEARCH

Collaborator I & II – Thermodynamics of Steaks of Different Thickness and USDA Quality Grade Cooked on Grills of Different Temperatures to the Same Internal Temperature

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Background

Beef palatability can be described, altered, and optimized using three major characteristics: tenderness, juiciness, and flavor. The manner in which meat is cooked can affect each of these characteristics. Understanding the thermodynamics that occur during cooking can give important insight into ideal cooking parameters that would allow for optimizing beef palatability. The protein, fat, connective tissue and other materials that constitute beef will react differently depending on the cooking method and affect the transfer of heat which in turn alters the texture, flavor, and juiciness of the product. If a particular set of parameters such as steak thickness or grill surface temperature can be chosen to enhance the palatability of a steak of varying quality grade, then that product could be marketed more effectively and consumed with higher acceptability thus increasing its value.

Objective

The objective of this project was to analyze the thermodynamics and physical properties of beef steaks of different USDA quality grades, thicknesses, and grill surface temperatures cooked to the same internal degree of doneness to determine if a specific set of cooking parameters would create a profound difference in the eating characteristics of a steak.

Methods

Beef steaks of each quality grade (Upper 2/3 Choice and Select) and thickness (38.1mm thick and 17.6mm thin) were cooked on a flat top grill with high (232.2°C) and low (176.7°C) surface temperatures. Steaks were cooked until they reached an internal degree of doneness (IDD) of 35°C and flipped and further cooked until they reached an IDD of 71°C. Once at room temperature (25°C) the steaks underwent a series of tests which measured: cooking loss, change in thickness, percent expressible moisture, thermal conductivity and diffusivity, protein degradation, Warner-Bratzler shear force (WBSF), texture profile analysis (TPA), rheology, and protein degradation. Percent expressible moisture was measured using a centrifugal method, thermal measurements were simultaneously obtained using a Thermal Constant Analyzer (Hot Disk TPS-500), WBSF and TPA were taken on a TSM-Pro fitted with a WBSF blade and parallel plate geometry respectively, rheological measurements were done using an AR-G2 Rheometer, and the protein degradation enthalpies were obtained using a differential scanning calorimeter (DSC).

Findings

It was found that the interactions of quality grade with thickness (conductivity) and thickness with surface temperature (sarcoplasmic and actin enthalpy) indicate that surface temperature impacts thermal behavior, dependent on quality grade, while also influencing major protein structures. The thermal conductivity of steaks cooked with low surface temperature showed a difference between quality grades ($P < 0.05$) while high surface temperature steaks did not.

The elasticity of the surface and centers of the beef steaks were analyzed to determine how the microstructure of the beef responded to applied stress and to support that quality grade is a major effector of thermal behavior due to the change in the microstructure and protein states. Steak center and surface elasticity modulus was influenced by the two-way interactions of quality grade × steak thickness ($P = 0.023$ and 0.012, respectively).

The physical properties in the beef steaks further support through more tangible applications that the composition, thickness, and cooking regiments impact the microstructure and thermal properties of beef and thus final tenderness and texture.

Industry Impact

This project identified that quality grade has an impact on how heat transfers through beef and the microstructure and textural properties are further altered by the cooking surface temperature. Cooking preparation should take into consideration that quality grade, thickness and cooking temperature will affect the textural eating qualities of beef steaks. Choice thick steaks cooked at low surface temperatures were shown to be juicier and more tender then Select thin steaks, but Select steaks cooked at high surface temperatures had comparable characteristics to Choice steaks. Therefore, cooking parameters may be utilized as a mechanism to enhance beef steak palatability.

Graphs/Tables

Figure 1. Conductivity of thick (38.1mm) and thin (17.6mm) beef strip steaks from two quality grades (USDA Choice and Select) cooked with high (232.2°C) and low (176.7°C) grill surface temperatures. Two-way interaction of USDA quality grade × grill surface temperature was observed ($P = 0.048$). Error bars represent pooled (largest) SEM. [ab] Columns lacking a common super script differ ($P < 0.05$).

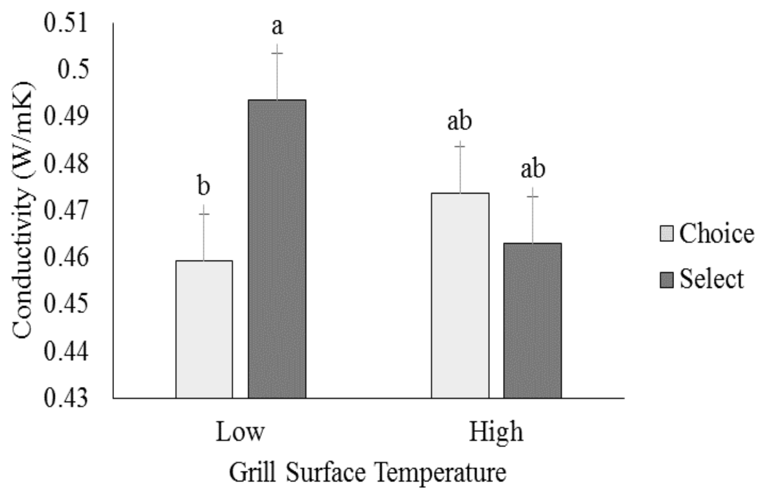

Figure 2. Sarcoplasmic and actin protein degradation of thick (38.1mm) and thin (17.6mm) beef strip steaks from two quality grades (USDA Choice and Select) cooked with high (232.2°C) and low (176.7°C) grill surface temperatures. Two-way interaction of USDA quality grade × thickness was observed ($P = 0.002$). Error bars represent pooled (largest) SEM. [ab] Columns lacking a common super script differ ($P < 0.05$).

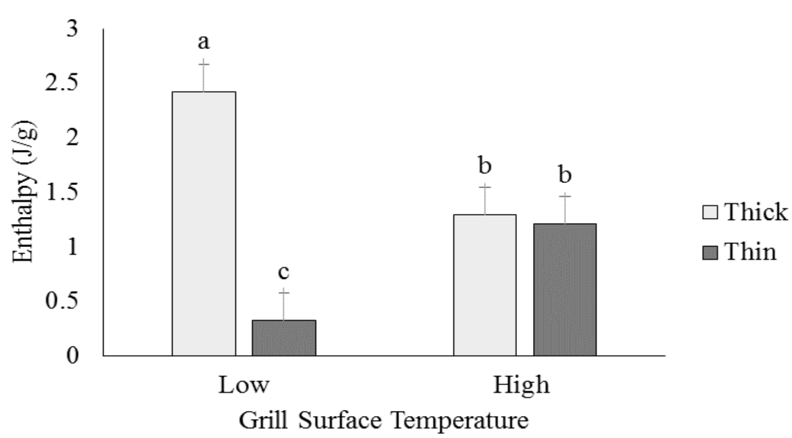

Figure 3. (a) Example of a thermogram plot of sarcoplasmic and actin protein degradation enthalpy from the differential scanning calorimeter, (b) example of how the HotDisk sensor would be placed in a steak sample for determination of thermal conductivity, diffusivity, and heat capacity.