



The Thermophysical Properties of Beef Steaks of Varying Quality Grade and Thickness Cooked on Low and High Grill Surface Temperatures

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Objectives

The ability of an anisotropic (directionally dependent)-multi-component material, such as beef, to conduct heat is highly dependent on protein states, fat content, water content and other variables. It is also widely known that beef composition greatly impacts overall palatability described by juiciness, tenderness, and flavor. Analysis of these properties in beef steaks of varying USDA quality grades and thicknesses cooked on low and high grill surface temperatures will help to elucidate their importance and how they are affected by cooking.

Materials and Methods

Beef steaks of USDA Upper 2/3 Choice and Select quality grades were sliced into thick (38.1 mm) and thin (12.7 mm) steaks and cooked until an internal degree of doneness of 71°C was reached on a commercial flat top grill at low (167°C) and high (232°C) surface temperatures. Thermal conductivity and diffusivity were measured simultaneously using a Thermal Constant Analyzer (Hot Disk TPS 500). Viscoelasticity was measured using a rheometer and textural properties were measured using a Textural Profile Analysis instrument.

Results

The conductivity of Select steaks was found to be greater ($P = 0.048$) than Upper 2/3 Choice steaks cooked at low heat as compared to there being no difference ($P > 0.05$) between quality grades when cooked at high heat. Furthermore, enthalpies of sarcoplasmic and actin protein denaturation differed ($P = 0.002$) between thick and thin steaks cooked at low heat, as compared to no enthalpy change ($P > 0.05$)

between the thicknesses at high heat. These 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 viscoelastic behaviors, elasticity (G') and viscosity (G''), of the surface and centers of the beef steaks were analyzed to determine how the microstructure of the beef responded to applied stress. The elastic behavior of steak surface and center samples differed due to quality grade dependent on thickness (surface; $P = 0.012$, center; $P = 0.023$). The viscous behavior of steak center samples was determined to differ between thicknesses and surface temperatures, dependent on quality grade ($P = 0.005$). These thermal and physical properties may be further explained through instrumental texture profile analysis described by hardness, resilience, adhesion, cohesiveness, springiness and Warner-Bratzler shear force. Hardness, resilience, and chewiness were influenced by grill surface temperature and thickness, dependent on quality grade ($P = 0.007$; $P = 0.033$; $P = 0.015$, respectively). Thin steaks possessed greater cohesiveness ($P = 0.038$) and shear force ($P = 0.007$) values. Meanwhile, thin steaks exhibited lower springiness ($P = 0.002$). Statistical analysis was performed using ANOVA for a split plot design using USDA Quality Grade as the main plot and steak thickness and grill surface temperature factors in the split plot with 5 replications.

Conclusion

The measured changes in thermal and physical properties in the beef steaks suggest that the composition, thickness, and cooking parameters impact the microstructure of beef. These findings were confirmed through textural measurements. Future work will explore relationships between these factors and consumer sensory responses.