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Use of Predictive Modeling to Determine Safe Cooking Times of Mechanically Tenderized Beef Steaks

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Objectives

Microbial food safety issues related to mechanically tenderized beef products are on the rise, evident from 6 outbreak reports from CDC identifying them as the leading cause of contamination. Mandatory labelling requirements, by the USDA-FSIS, for cooking instructions of mechanically tenderized beef products requires validation of safe cooking time. However, determination of safe cooking times and degree of doneness for individual steak cuts of different sizes and weights is tedious. At the same time, cooking validation studies involving multiple factors is costly and time consuming. Predictive modeling, using statistical approach, is a powerful and concise way to simulate real-time scenarios without undergoing repeatability of costly experimentation. Predictive modeling in meat processing can provide quick and inexpensive testing of "what if" scenarios, reducing operation and production costs. The objective of the study was to utilize predictive modeling techniques to determine safe cooking times for a variety of mechanically tenderized steak cuts.

Materials and Methods

A total of 288 steak cuts of various types ($n = 4$ each): Top Round, Knuckle, Top Sirloin, Sirloin Cap, Flap, Tri-Tip, Flank, and Ribeye, with 3 thicknesses: 1.27, 2.54 and 3.81 cm, were used. The weight of the steaks ranged from 117 to 567 g. Samples were tenderized and fabricated, vacuum-packaged and stored at 5 to 7°C until cooking (< 7-d storage). The dimensions (width, thickness, and length) of the steaks were measured prior to each cooking experiment. Before cooking the steaks, a thermocouple, attached to a temperature data logger, was inserted into the probable geometrical center of the sample and temperature logged every 10 s. Temperature profiles obtained during cooking were used to determine cooking rate. Samples were cooked on a preheated (185°C) flat-top grill until they reached an internal temperature of 70 to 71°C. Samples were flipped when the first side reached 35 to 40°C and the end-point temperature was used as a measure of doneness.

Data generated through the experiment was used for model development. Model building started with correlation of factors that could determine cooking time. A Pearson's correlation statistics was performed to identify variables governing cooking time. Factors (length, width, thickness, weight, and cooking rate) with a 60% or higher correlation with cooking time ($P < 0.01$) were selected to build the multivariable regression model. Values were checked for multicollinearity. Each experiment was repeated 3 times and data analyzed and modeled using PROC REG at a significance level of $P < 0.01$.

Results

A high correlation (> 70%) between cooking time and the thickness, weight, and cooking rate of the steaks was observed. The length and width of the steaks did not affect the time it took to cook the steaks. No significant differences ($P < 0.01$) were found between experimental and predicted values of cooking time. A regression coefficient (r2) of 0.80 indicated that the model was successful in determining cooking time for different steak products with 80% accuracy.

Conclusion

This method for predicting cooking time will help the food industry (specifically at processing, retail and in food-service sectors) formulate safe cooking times of various steak cuts, without repeatability of cooking validation studies. Its application could help eliminate use of thermocouples.

