Project Title: Understanding the Impact of the Presence of Relative Humidity in the Beef Cooking Process on Beef Tenderness, Sensory, Protein Stability, and Appearance

Principle Investigator(s): D. Woerner, J. Martin, J.D. Tatum, R. Delmore, K. Belk and D. Gredell

Institution(s): Colorado State University

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Background

Recent checkoff-funded research has demonstrated that differences in steak thickness, cooking method, cooking temperature, cooking rate, and the inclusion of high levels of humidity influence the overall eating satisfaction of steaks and influences beef flavor (Shubert, 2014). Perhaps the most intriguing discovery of that research was the improvement in the tenderness observed in steaks that were cooked more slowly with 100% added humidity (Shubert, 2014). Additionally, pilot work (unpublished data) in the sensory lab at Colorado State University has demonstrated that increasing the added humidity in the cooking environment significantly increases the tenderness of beef steaks. This finding has led to speculation that the humidity in the cooking environment and/or equipment (e.g., open-hearth grill or char broiler, belt grills, impingement ovens, clamshells, convection ovens) can influence the tenderness results in research trials depending on the type of equipment used to cook steaks and even the environment that the steaks are cooked in. It has been widely demonstrated that increased humidity (moisture) in the cooking process helps to degrade protein, specifically collagen, and thereby improves tenderness. This research is aimed at expanding upon the research idea that rate of cooking and the incorporation of humidity in the cooking environment can be major contributors to steak tenderness and sensory characteristics. Ultimately, the findings of this research will contribute to developing the ideal cooking procedures to maximize the steak eating experience and may also help to explain differences in research findings in previously conducted work related to beef tenderness. The objective of this study was to evaluate the effects of oven temperature and added humidity on the appearance, extent of protein denaturation, and palatability of beef strip loin steaks. The objectives were met by evaluating external and internal cooked steak color, extent of protein denaturation, total collagen, shear force, and using a trained sensory panel to characterize palatability traits.

Methodology

The study was designed as a 2 3 factorial representing two oven treatments [low temperature (LT) and high temperature (HT)] and three levels of added humidity [zero (ZH), mid (MH), and high (HH)], for a total of six individual treatments (Table 1). USDA Choice beef Strip Loins (n = 30) were used for this study. Each Strip Loin was fabricated into six sets of paired steaks, with each steak being 2.54 cm thick. Each set of paired steaks was randomly assigned into one of the treatments, so that each of the six treatments were represented within each individual Strip Loin. Individual steaks were vacuum-packaged, aged for 14 days, then frozen until analysis. Prior to all analyses, steaks were cooked using the prescribed treatments to a final internal temperature of 71°C. Each sample was evaluated by a trained sensory panel to evaluate tenderness, juiciness, and flavor attributes of cooked steaks. Twelve samples were fed per session over 15 panels, each consisting of seven-nine panelists. External and internal cooked color was measured using both instrumental readings (CIE L*a*b*) as well as subjective color evaluations by trained personnel. Differential scanning calorimetry (DSC) was used to measure the amount of energy required to denature any remaining intact proteins after the cooking process. Concentrations of total collagen were measured to evaluate cooking rate and humidity effects on the heat stability of connective tissue. Both slice shear force (SSF) and Warner-Bratzler shear force (WBSF) were used as an objective measurement of tenderness.

Findings

The present study showed that adding humidity to the cooking environment significantly increased cooking rate, which was especially evident at a low oven temperature. When high levels (70-100%) of humidity were added to the cooking environment, sensory panel ratings showed Strip steaks were tougher; however, when only mid-levels (35-50%) of humidity were added at low oven temperature, steaks cooked considerably faster without toughening. Additionally, sensory panel ratings indicated that steaks cooked at lower oven temperatures were found to be more tender than when cooked at higher temperatures. Improvements in tenderness were the result of a slower cooking rate. Adding humidity to the cooking environment restricted surface browning of steaks and the development of desirable meat-like flavors associated with these reactions. It is evident that humidity plays a significant role in sensory development and needs to be controlled in the cooking environment to maximize palatability and the overall eating experience. At both high and low oven temperatures, high levels of humidity were detrimental to palatability and should be avoided. However, at a low oven temperature, a mid level (50%) of humidity-maintained tenderness and increased juiciness, while having minimal effects on flavor attributes.

Implications

The results of this study help to better understand the implications that oven temperature and added humidity have on beef steak sensory characteristics. It is clear that cooking method plays a significant role in sensory development; therefore, identifying cooking parameters to maximize eating potential is incredibly beneficial to the foodservice industry. As shown by trained sensory results, tenderness advantages of cooking at low oven temperatures can be achieved if juiciness is maintained by adding moderate levels of humidity to the cooking environment.

Table 1. Trained sensory ratings1 for beef LM steaks cooked to 71°C using two oven temperatures and three levels of humidity.

	80°C			204°C				*P* – Value		
Trait	Zero Humidity	Mid Humidity	High Humidity	Zero Humidity	Mid Humidity	High Humidity	SEM [2]	Oven Temp	Added Humidity	OT × RH
Initial Tenderness	67.43^{am}	67.17^{am}	62.77^{an}	62.84^{bm}	63.63^{bm}	60.19^{bn}	1.62	< 0.01	< 0.01	0.44
Sustained Tenderness	64.81^{am}	63.41^{am}	58.60^{an}	59.27^{bm}	59.61^{bm}	54.98^{bn}	1.51	< 0.01	< 0.01	0.47
Overall Tenderness	66.42^{am}	65.53^{am}	60.81^{an}	61.51^{bm}	61.44^{bm}	57.55^{bn}	1.54	< 0.01	< 0.01	0.61
Juiciness	41.04^{z}	60.16^{w}	56.42^{x}	52.72^{y}	52.02^{y}	51.36^{y}	2.09	0.43	< 0.01	< 0.01
Beefy/ Brothy	56.00^{w}	50.45^{xy}	49.32^{y}	52.22^{x}	51.24^{xy}	50.37^{xy}	2.68	0.37	< 0.01	< 0.01
Browned/ Grilled	47.76^{m}	42.34^{n}	40.88^{o}	47.03^{m}	45.81^{n}	42.52^{o}	3.27	0.10	< 0.01	0.16
Buttery/ Fat	22.83^{y}	26.07^{wx}	23.82^{xy}	27.93^{w}	26.85^{w}	22.83^{y}	2.87	0.01	< 0.01	< 0.01
Burnt	6.90^{m}	5.56^{n}	7.09^{m}	7.04^{m}	4.31^{n}	7.46^{m}	1.28	0.72	< 0.01	0.57
Bloody/ Metallic	10.31^{y}	18.20^{w}	15.79^{w}	10.12^{y}	12.82^{x}	12.98^{x}	2.07	< 0.01	< 0.01	0.01
Livery	0.79	0.23	0.39	0.16	0.14	0.63	0.22	0.29	0.18	0.07
Oxidized	0.82	0.69	0.47	0.76	0.91	0.84	0.38	0.31	0.75	0.60

[a-b]Least square means in the same row without a common superscript differ ($P < 0.05$) due to oven temperature

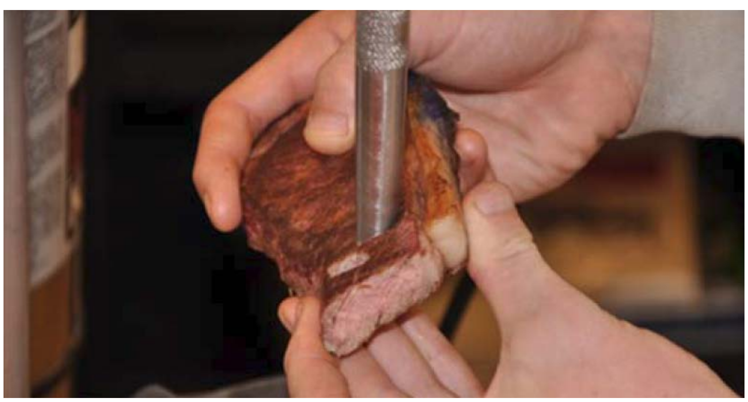
[m-o]Least square means in the same row without a common superscript differ ($P < 0.05$) due to added humidity

[w-z]Least square means in the same row without a common superscript differ ($P < 0.05$) due to an over temperature relative humidity interaction

[1]Attributes were scored using a 100 mm unstructured line scale: 0 = very tough, very dry, and not present; 100 = very tender, very juicy, and very intense

[2]Standard error of the least squares means

Photos



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