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Steam-generation cooking versus dry heat convection of beef roasts differing in connective tissue

Abstract

Foodservice managers strive to control factors that affect yield, serving cost, and palatability of beef. Beef roasts are traditionally roasted at temperatures from 325°F to 350°F for both home and institutional use. Roasts relatively high in connective tissue cooked with moist heat generally are more tender than when cooked with dry heat. Roasts cooked to 150, 160, or 170°F could be expected to have cooking losses ranging from 20% to over 40%. The issue of cooking loss led Winston Industries to develop the CVap Cook and Hold Vapor Oven (Winston Industries, Louisville, KY). CVap technology controls evaporation by creating a moist environment, which creates an opposing vapor pressure that minimizes moisture loss and should improve cooking yields. The objectives of our research were to compare the effects of moist-heat cookery in a CVap oven and dry-heat cookery in a Blodgett forced-air convection oven on cooked yield, cooked color, tenderness, and sensory attributes of beef roasts differing in connective tissue content cooked to different endpoint temperatures.

Keywords

Cattlemen's Day, 2012; Kansas Agricultural Experiment Station contribution; no. 12-231-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1065; Beef Cattle Research, 2012 is known as Cattlemen's Day, 2012; Beef; Steam-generation cooking vs. dry heat convection; Roasts; Connective tissue

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Steam-Generation Cooking Versus Dry Heat Convection of Beef Roasts Differing in Connective Tissue

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Introduction

Foodservice managers strive to control factors that affect yield, serving cost, and palatability of beef. Beef roasts are traditionally roasted at temperatures from 325°F to 350°F for both home and institutional use. Roasts relatively high in connective tissue cooked with moist heat generally are more tender than when cooked with dry heat. Roasts cooked to 150, 160, or 170°F could be expected to have cooking losses ranging from 20% to over 40%. The issue of cooking loss led Winston Industries to develop the CVap Cook and Hold Vapor Oven (Winston Industries, Louisville, KY). CVap technology controls evaporation by creating a moist environment, which creates an opposing vapor pressure that minimizes moisture loss and should improve cooking yields. The objectives of our research were to compare the effects of moist-heat cookery in a CVap oven and dry-heat cookery in a Blodgett forced-air convection oven on cooked yield, cooked color, tenderness, and sensory attributes of beef roasts differing in connective tissue content cooked to different endpoint temperatures.

Experimental Procedures

Vacuum-packaged Choice grade beef outside round-flats, boneless briskets, and boneless strip loins were aged at 1 to 2°F until 28 to 32 days postmortem. Two cooking phases occurred during this project. During cooking phase I, roasts were cooked in a CVap oven following the protocol of Winston Industries, where 8 roasts from each of the 3 subprimals were cooked for approximately 8 hours to a temperature of 160°F with the browning level set at 4. The CVap oven generates a heating curve based on user input for cooking time, desired endpoint temperature, and browning level. The Blodgett forced-air convection oven (G.S. Blodgett Co., Burlington, VT) temperature could not be set as low as for the CVap to duplicate the CVap cooking cycle; therefore, we could directly compare the 2 ovens only by cooking roasts in the CVap for a constant time that matched the average times to reach the 3 temperatures for the 3 muscles in the Blodgett established in preliminary research. Roasts of the 3 muscles were cooked to endpoint temperatures of 150, 160, and 170°F in the Blodgett to determine the average time required to reach those temperatures, which were then used as the cooking times in the CVap. This comparison is referred to as phase II.

Two roasts were cut from each subprimal to evaluate the 2 ovens. Two 4-lb *Biceps femoris* roasts were removed from the center, and 2 3-lb *Deep pectoralis* roasts (point end removed) and 2 4-lb *Longissimus lumborum* roasts were removed from the anterior ends. For direct comparisons between ovens (phase II), 2 roasts from different subprimals were cooked in the Blodgett at 200° F and removed when they reached the target temperatures +/- 2°F. On the same days, 4 roasts were placed in the CVap (2 were from different subprimals, and 2 were from the same subprimal) and cooked for the times determined in the Blodgett. External and internal cooked color was visually evaluated. One-inch-thick sections were cut from the roasts to measure slice shear force and Warner-Bratzler shear force.

After the aging period, 2 4-lb roasts were cut from additional *Biceps femoris* (n = 18) and *Longissimus lumborum* (n = 18) and frozen at −40 °F until sensory panels were conducted. Roasts were then thawed and cooked using the same oven settings as Phase II. Panelists evaluated warm 1 × 0.5 × 0.5-inch samples for myofibrillar tenderness, juiciness, connective tissue amount, beef flavor intensity, overall tenderness, and off-flavors. The scale was 1 = extremely tough, bland, dry, or abundant connective tissue; and 8 = extremely tender, intense, juicy, or no connective tissue. A minimum of 6 trained panelists participated in each sensory panel session.

For the statistical analysis, the primary focus was to compare ovens and evaluate their consistency across 3 temperatures for the 3 muscles. Statistical analyses for muscle responses were conducted separately for each muscle. Simple-effect pairwise comparisons were made to compare oven types within temperatures when the temperature × oven interaction was significant. More roasts were cooked in the CVap (n = 72) than were cooked in the Blodgett (n = 36) for all treatment combinations. When a temperature × oven interaction was significant, ovens within a temperature were compared with each other rather than making all possible comparisons. Pairwise comparisons of sensory data on the temperature main effect and temperature × oven interaction were conducted.

Results and Discussion

Phase II cooking yield main effect means × endpoint temperature and oven for *Biceps femoris* roasts cooked to 150°F had the highest ($P < 0.05$) cooking yield at 84.6%, whereas roasts cooked to 160 and 170°F had the lowest ($P < 0.05$) yields at 70.4% and 66.5%, respectively. When averaged across temperatures, there was no difference ($P > 0.05$) between ovens (69.0% in the CVap versus 66.0% in the Blodgett). When cooking *Deep pectoralis* roasts to 150°F, roasts cooked in the CVap had a higher ($P < 0.05$) mean percentage cooking yield at 84.0% than roasts cooked in the Blodgett (77.4%). In contrast, when cooking *Deep pectoralis* roasts to 170°F, those cooked in the CVap had a lower ($P < 0.05$) cooking yield (62.7%) than those cooked in the Blodgett (68.6%) (statistical interaction). Cooking yields of *Deep pectoralis* roasts generally decreased with increasing temperatures at a faster rate in the CVap than in the Blodgett. *Longissimus lumborum* roasts cooked to the lowest endpoint temperature also had the highest ($P < 0.05$) cooking yields (82.6%); roasts cooked to 170°F had the lowest ($P < 0.05$) cooking yield (66.6%). No difference ($P > 0.05$) was measured in cooking yields between ovens.

Results from roasts cooked according to the protocol of Winston Industries during phase I cannot be statistically compared with cooking in phase II because of differences in cooking protocols. *Biceps femoris* roasts cooked to 160°F in the CVap according to the phase I protocol had a mean cooking yield of 72.5%, whereas those cooked in the CVap or Blodgett for phase II had mean cooking yields of 69.0% and 66.0%, respectively. *Deep pectoralis* roasts cooked to 160°F in phase I had a cooking yield 61.8%, whereas using phase II protocols, *Deep pectoralis* roasts has a mean cooking yield of 73.6% in the CVap and 76.3% in the Blodgett oven. Therefore, cooking *Deep pectoralis* roasts to 160°F according the protocol of Winston Industries appears detrimental to cooking yield when compared with using the phase II cooking protocol for the Blodgett or CVap ovens. *Longissimus lumborum* roasts cooked to to 160°F in phase I had a mean cooking yield of 73.6%. Using the phase II cooking protocol, *Longissimus lumborum* roasts had a mean cooking yield of 74.6% in the CVap and 72.9% in the Blodgett; therefore, cooking *Longissimus lumborum* roasts according to the protocol of Winston Industries in the CVap oven did not offer a cooking yield advantage.

Roasts cooked in the CVap in phase II were tan in color with more moisture on the external surface. In contrast, roasts cooked in the Blodgett were a dark, mahogany-red color with a more caramelized, drier surface. External fat color from the CVap cooked roasts was whiter, whereas the color was more yellow for roasts cooked in the Blodgett. Internal cooked color was not different between ovens.

In phase II, neither endpoint temperature nor oven type affected ($P > 0.10$) slice shear force or Warner-Bratzler shear force of *Biceps femoris* roasts (Table 1). Cooking *Deep pectoralis* roasts in the Blodgett to 170°F resulted in higher ($P < 0.05$) Warner-Bratzler shear force than cooking in the CVap. In addition, *Deep pectoralis* slice shear force values in the CVap decreased considerably from 150 to 170°F (92.0 lb versus 38.1 lb), suggesting that the moist environment in the CVap is advantageous as temperature increases for *Deep pectoralis* roasts, which have a high collagen content, but in the dry environment of the Blodgett, optimum tenderness appears to occur at 160°F. Slice shear force increased in *Deep pectoralis* roasts cooked in the CVap as temperature increased. Collagen solubilization also might be optimum for the *Deep pectoralis* at 160°F in the Blodgett, but myofibrillar toughening likely occurs after that temperature.

In phase II, neither endpoint temperature nor oven type affected ($P > 0.10$) slice shear force or Warner-Bratzler shear force of *Longissimus lumborum* roasts (Table 1). The differences in Warner-Bratzler shear force among the 3 temperatures for the *Longissimus lumborum* were much lower than for the other 2 muscles. *Longissimus lumborum* roasts had slice shear force values that were about half as high as those for the *Deep pectoralis* and *Biceps femoris*. When roasts were cooked according to the phase I protocol of Winston Industries, *Biceps femoris* roasts had a mean slice shear force value of 35.8 lb, which is more tender than roasts cooked in the Blodgett with a slice shear force value of 67.1 lb using the phase II cooking protocol. It was also more tender than roasts cooked in the CVap during phase II, with a slice shear force value of 64.2 lb. Therefore, cooking *Biceps femoris* roasts according to the phase I protocol of Winston Industries provides an advantage in slice shear force tenderness. *Deep pectoralis* roasts cooked using the phase I protocol had a slice shear force of 26.4 lb, which was dramatically lower than roasts cooked using the phase II protocol, which had shear slice force of 64.5 lb for roasts cooked in the Blodgett and 68.4 lb when cooked in the CVap. For *Longissimus lumborum* roasts, there was no slice shear force advantage using the CVap, likely because of its low connective tissue content.

Biceps femoris roasts cooked according to phase I protocol had a mean Warner-Bratzler shear force value of 7.5 lb, which is lower than roasts cooked in the Blodgett or CVap using the phase II protocol, which had Warner-Bratzler shear force values of 9.0 lb and 9.5 lb, respectivley. *Deep pectoralis* roasts cooked using the phase I protocol had a low mean Warner-Bratzler shear force value of 5.5 lb, whereas those cooked using the phase II protocol in the Blodgett or CVap had a mean Warner-Bratzler shear force of 10.8 lb and 9.5 lb, respectively. In contrast to the *Biceps femoris* and *Deep pectoralis*, cooking the *Longissimus lumborum* according to the phase I protocol offered no Warner-Bratzler shear force tenderness advantage.

Sensory panels conducted on *Biceps femoris* roasts cooked in the CVap and Blodgett ovens using the phase II protocol to target temperatures of 160 and 170°F found no differences among endpoint temperatures or ovens for beef flavor intensity and off-flavors. Roasts cooked to 170°F in the Blodgett had lower ($P < 0.05$) myofibrillar tenderness scores (5.8) than those cooked in the CVap (6.7). In a similar pattern, overall tenderness score was lower ($P < 0.05$) for roasts cooked to 170ºF in the Blodgett than those cooked in the CV (5.5 versus 6.5). Therefore, cooking *Biceps femoris* roasts in the CVap oven at the higher temperature, but not at the lower temperature, appears to bestow tenderness advantage.

No oven effect ($P > 0.10$) was detected for sensory scores of *Longissimus lumborum* roasts. As expected, roasts cooked to an internal endpoint temperature of 160°F had a higher ($P < 0.05$) mean juiciness score (4.2) than roasts cooked to an endpoint temperature of 170°F (3.7).

Implications

Cooking *Biceps femoris* and *deep pectoralis* roasts in a CVap steam-generation oven according to the protocol of Winston Industries provides some advantages over a dry-heat convection oven for cooking yields and/or tenderness but no advantages for *Longissimus lumborum* roasts.

Table 1. Oven means for slice shear force (SSF) and Warner-Bratzler shear force (WBSF) within endpoint temperatures for *Biceps femoris* (BF), *Deep pectoralis* (DP), and *Longissimus lumborum* (LL) roasts cooked to 3 endpoint temperatures in a Blodgett (B) or CVap oven using 2 cooking protocols

		Phase I		Phase II								
		160°F		150°F			160°F			170°F		
		CVap	SE[1]	B	CVap	SE[1]	B	CVap	SE[1]	B	CVap	SE[1]
BF	SSF	39.4	2.6	64.5	64.7	6.4	62.7	67.3	6.4	74.4	60.7	6.4
	WBSF	7.5	0.3	8.4	9.7	0.7	8.1	8.4	0.8	10.6	10.1	0.7
DP	SSF	26.4	1.5	71.3	92.0	6.7	61.8	75.2	6.7	60.3	38.1	6.7
	WBSF	5.5	0.1	12.8	12.5	0.4	8.8	9.9	0.4	11.0[a]	6.8[b]	0.4
LL	SSF	32.8	1.9	35.9	34.8	2.1	25.1	29.0	2.1	26.8	26.0	2.1
	WBSF	7.3	0.3	5.7	5.1	0.3	6.2	5.5	0.3	6.4	4.4	0.3

[ab] Oven means within 170ºF endpoint temperature with different superscripts differ ($P < 0.05$). Oven means within 150 and 160 °F endpoint temperatures did not differ ($P > 0.05$).
[1] SE = standard error.