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The Influence of Cooking Rate and Holding Time on Beef Flavor

Jennie M. James
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Summary

Seven muscles from 10 beef carcasses were cooked quickly or slowly and held 0 or 1 hour to explore the influence of cooking rate and holding time on beef flavor. Off-flavor intensity was lowest when beef was cooked slowly (on a 300°F grill instead of a 480°F grill) and when it was held for 1 hour prior to sensory evaluation. The infraspinatus (flat iron) had the least intense off-flavor and the vastus intermedius (knuckle bottom) had the most intense off-flavor. Slow cooking or holding for 1 hour prior to consumption reduced the intensity of off-flavor in value cuts.

Introduction

The food-service industry has begun to use various steaks obtained from the chuck and the round. Managers in this industry report an increasing number of complaints about off-flavors in some of the value cuts. Some of the typical off-flavors are described as liver-like, fatty, sour, and metallic. Flavor is a combination of aroma and taste. As a result, some of the compounds that are part of the normal beef flavor may be concentrated or lost due to cooking. In the food-service industry, meat is cooked and then traditionally held for a time before being served.

The objectives of this research were to determine the effects of cooking rate and holding time on the flavor of steaks obtained from muscles in the chuck and the round.

Procedure

Seven muscles (*M. infraspinatus* -INF, flat iron; *M. teres major*- TER, shoulder tender; *M. triceps brachii*- TRI, clod heart; *M. rectus femoris*- REC, knuckle center; *M. vastus lateralis*-VAL, knuckle side; *M. vastus medialis*-VAM, knuckle bottom; and the *M. vastus intermedius*- VAI, knuckle bottom) located in the clod (IMPS #114) and knuckle (IMPS #167) from 10 animals (5=Choice and 5=Select) were separated and trimmed of external fat after aging 7 days postharvest. The thick band of connective tissue in the INF was removed. The TRI, REC, and VAL were cut into 1-inch steaks. The top and bottom portions of the INF were cut in half to make 4 steaks. The TER, VAM, and VAI were cut in half. Steaks were wrapped and frozen (3°F) until sensory evaluation was conducted.

Four steaks from one USDA Choice and four steaks from one USDA Select muscle type were randomly served during every taste panel session. Serving order of muscles was randomized. Steaks were thawed 24 hours prior to cooking for sensory evaluation. One steak from each muscle was cooked quickly (FAST) with a grill temperature of 480°-500°F to an internal temperature of 145°F and brought to 150°F during a 1 hour hold in a commercial food-service warming oven (Precision RS-201, Metal Products, Inc, Miami, Fla.) kept at approximately 165°F. A second steak from the muscle was slow cooked (SLOW) with a grill temperature of 300°F to an internal temperature of 145°F and held for 1 hour to a final internal temperature of 150°F. The remaining 2 steaks from each muscle were cooked SLOW and FAST, respectively, to an internal temperature of 150°F and served with no holding time (0 hour). Steaks to be served with no holding time were timed to finish cooking near the end of the 1 hour holding period of the other two steaks. Weight losses from cooking and holding were determined.

Panelists for this study were selected and trained according to the guidelines and procedures outlined by the American Meat Science Association. In order to prevent bias, panelists were seated in individual booths equipped with red fluorescent lights and partitioned to reduce possible collaboration between panelists and eliminate visual differences. Each panelist was served distilled water and unsalted, saltine crackers and given three minutes between samples to cleanse their palates. The panel evaluated the 0.5 inch x 0.5 inch x 1 inch pieces of the eight steaks each session for tenderness, connective tissue, juiciness, and off-flavor intensity on an 8-point hedonic scale with 1=extremely tough, extreme connective tissue, extremely dry, and extreme off-flavor and 8=extremely tender, no connective tissue, extremely juicy, and no off-flavor. Panelists were trained to identify the presence of specific off-flavors (liver-like, metallic, sour, charred, oxidized, rancid, or other) contributing to the off-flavor score for the steak.

Table 1. Least squares means for off-flavor intensity of four muscles from the chuck and round[1].

Muscle[x]	Fast[y] 0 h	Fast[y] 1 h	Slow[y] 0 h	Slow[y] 1 h
INF	5.83	5.94	5.62	5.93
TRI	4.86[a]	5.70[b]	5.82[b]	6.02[b]
REC	5.70	5.75	5.75	6.17
VAL	4.28[a]	5.57[b]	5.65[b]	5.57[b]
Pooled SEM		0.3632		

[1]8-point hedonic scale used to evaluate off-flavor with 1=extreme off-flavor; 8=no off-flavor
[a,b] Means in the same row without a common superscript are different ($P < 0.05$)
[x]INF=*infraspinatus* (flat iron), TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side).
[y]Grill Temperature: Fast= 480-500°F; Slow=300°F.

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Table 2. Least squares means for off-flavor intensity scores for seven muscles.

Treatment[w]	Off-flavor Intensity[x]	*P*-value
HOLDING TIME		0.0237
0 h Hold	5.31[a]	
1 h Hold	5.78[b]	
SEM= 0.0881		
MUSCLES[y]		<0.0001
INF	6.27[d]	
TRI	5.67[b,c,d]	
TER	5.38[b,c]	
REC	6.11[c,d]	
VAL	5.31[b]	
VAI	4.41[a]	
VAM	5.65[b,c,d]	
SEM= 0.1649		

[a,b,c,d]Means within group without common superscript are different ($P<0.05$).
[w]Grill Temperature: Fast= 480-500°F.
[x]8-point hedonic scale used to evaluate off-flavor with 1=extreme off-flavor; 8=no off-flavor
[y]INF=*infraspinatus* (flat iron), TER= *teres major* (shoulder tender) TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side), VAI=*vastus intermedius* (knuckle bottom), and VAM=*vastus medialis* (knuckle bottom).

Table 3. Weight loss percentage after cooking, holding, and total loss

Muscle[w]	Cook Loss %[x]	Hold Loss %[y]	Total Loss %[z]
Fast Cook- 0 h Hold	26.71[a,b]	—	26.71[a]
Fast Cook- 1 h Hold	21.98[a]	11.75[b]	31.14[b]
Slow Cook- 0 h Hold	28.76[b]	—	28.76[a,b]
Slow Cook- 1 h Hold	25.89[a,b]	7.95[a]	31.79[b]
ER			
Fast Cook- 0 h Hold	25.95	—	25.95[a]
Fast Cook- 1 h Hold	22.54	9.46	29.92[b]
TRI			
Fast Cook- 0 h Hold	23.59[a]	—	23.59[a]
Fast Cook- 1 h Hold	19.23[a]	18.74	34.39[c]
Slow Cook- 0 h Hold	28.46[b]	—	28.46[b]
Slow Cook- 1 h Hold	21.82[a]	16.09	34.55[c]
REC			
Fast Cook- 0 h Hold	23.29	—	23.29[a]
Fast Cook- 1 h Hold	27.87	6.81	31.13[b]
Slow Cook- 0 h Hold	28.12	—	28.12[b]
Slow Cook- 1 h Hold	27.04	3.93	28.71[b]
VAL			
Fast Cook- 0 h Hold	25.12[a,b]	—	25.12[a]
Fast Cook- 1 h Hold	21.44[a]	18.20[b]	36.10[c]
Slow Cook- 0 h Hold	26.66[b]	—	26.66[b]
Slow Cook- 1 h Hold	26.57[b]	10.30[a]	34.28[c]
VAI			
Fast Cook- 0 h Hold	24.59[b]	—	24.59[a]
Fast Cook- 1 h Hold	19.61[a]	15.30	31.83[b]
VAM			
Fast Cook- 0 h Hold	24.29	—	24.59[a]
Fast Cook- 1 h Hold	21.97	15.36	33.93[b]

[a,b,c]Means within columns for each treatment with different letters are significantly different ($P < 0.05$).
[w]INF=*infraspinatus* (flat iron), TER= *teres major* (shoulder tender) TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side), VAI=*vastus intermedius* (knuckle bottom), and VAM=*vastus medialis* (knuckle bottom).
[x]Cook loss %= (Raw weight-Cooked weight)/Raw weight *100.
[y]Hold loss %= (Cooked weight-Hold weight)/Cooked weight*100; Hold loss % only includes steaks that had a 1 h hold time.
[z]Total loss %= (Raw weight-Cooked weight-Hold weight)/Raw weight *100.

Data were analyzed as a randomized complete block design by analysis of variance (ANOVA) using the MIXED procedure of SAS with a predetermined significance level of $P \leq 0.05$. Animal served as the experimental unit and was considered a random effect. The Kenward-Roger option was used to determine denominator degrees of freedom. Main effects of muscle, cooking rate, and holding time and their two-way and three-way interactions were included in the model. When significance was indicated by ANOVA, means separations were performed using the LSMEANS and PDIFF function of SAS.

Results

The TER, VAI, and VAM were too small to obtain four steaks from the muscle so only the fast cooking rate was used for these muscles. Off-flavor intensity scores for the remaining four muscles were different between cooking rate (P=0.0007), holding time (P=0.0002), the muscle*cooking rate interaction (P=0.0237), and the three way interaction of muscle*cooking rate*holding time (P=0.0121). The FAST cook rate and held for 0 h had the poorest scores for off-flavor intensity for the TRI and VAL muscles. The INF and the REC were not significantly different ($P > 0.05$) among the treatments (Table 1). When cooking rate was not included in the model and all seven muscles were analyzed, the same trend was observed with both muscle and holding time being significant, but the interaction was not (Table 2). Slow cooking and holding for 1 hour resulted in the least intense off-flavor ratings.

Total weight losses during the cooking and holding were always less for the steaks that were fast cooked with a 0 hour hold for all muscles (Table 3). Perhaps the increased weight loss is improving the off-flavor intensity ratings as shown in Table 1. This suggests off-flavor compounds are volatile and likely water-soluble. The off-flavors slightly dissipate when

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Table 4. Average percentage of panelists that observed an off-flavor.

Muscle[z]	Liver-like	Metallic	Sour	Charred	Oxidized	Rancid	Fatty	Other	None
INF	16.88	7.25[a]	17.12[a]	23.48[b]	0.59[a]	3.13[a]	9.55[c]	0.92[a]	17.35[b]
TRI	19.06	12.05[b,c]	39.37[b]	23.65[b]	15.66[b]	3.96[a]	1.94[a]	4.51[b]	11.67[a]
REC	18.96	8.33[a,b]	20.42[a]	12.85[a]	1.53[a]	3.51[a]	5.56[b]	5.31[b]	11.67[a]
VAL	15.86	12.75[c]	36.99[b]	31.47[b]	20.67[c]	7.63[b]	1.85[a]	2.79[a]	7.49[a]

[a,b,c]Means in same column without common superscripts are different ($P<0.05$).
[z]INF=*infraspinatus* (flat iron), TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center); VAL=*vastus lateralis* (knuckle side).

there is greater cooking and holding loss. It is known that water soluble compounds contribute to meat flavor.

Table 4 illustrates that all muscles had the same incidence of liver-like flavors. Panelists found sourness at a higher frequency in the TRI and the VAL. The INF was found to have the highest response of no off-flavors in the samples tested. The INF has been found to have desirable flavor in several other studies.

Neither cooking rate nor holding time affected the percentage of panelists perceiving liver-like, metallic, oxidized, and rancid flavors. The percentage of panelists perceiving sourness was significantly different (P=0.0363) for FAST (25.61%) and SLOW (31.35%) cooking rate as well as charred ($P < 0.0001$) and fatty (P=0.0003) flavor. The charred flavor was probably affected by the high cooking temperatures (36.90% for FAST versus 8.82% for SLOW) where more external browning would have formed. The fatty flavor was probably perceived more often due to increased cook loss in the SLOW cooked steaks which concentrated the fat flavor components (SLOW 7.05% versus FAST 2.38%).

Implications

Cooking rate and holding time play a role in the intensity of off-flavor perceived in muscles from the chuck and round, especially when the steaks are cooked quickly and served immediately. The slower cooking or the longer hold time create more total loss in weight and reduce intensity of off-flavor.

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