Kansas Agricultural Experiment Station Research Reports

Volume 11
Issue 1 *Cattlemen's Day*

Article 15

2025

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Recommended Citation

Prester, Mason J.; Frink, Lauren M.; Witberler, Stephanie L.; Legako, Jerrad F.; Woerner, Dale R.; Miller, Rhonda K.; Kerth, Chris R.; Nair, Mahesh N.; Lancaster, Jessica M.; and O'Quinn, Travis G. (2025) "The Effects of Aging Time on the Eating Quality of Biceps Femoris Steaks," *Kansas Agricultural Experiment Station Research Reports*: Vol. 11: Iss. 1. https://doi.org/10.4148/2378-5977.8674

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Funding Source

This research was coordinated by the National Cattlemen's Beef Association, a contractor to the Beef Checkoff.

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The Effects of Aging Time on the Eating Quality of *Biceps Femoris* Steaks

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Abstract

This study evaluated the sensory, instrumental color, and tenderness characteristics of *biceps femoris* steaks aged over eight periods ranging from 14 to 70 days. Eighty beef sirloin top butt sub-primal cuts were collected from a commercial processing facility and aged at 35.6° and 39.2°F throughout the duration of their aging periods. After aging, the *biceps femoris* and *gluteus medius* muscles were separated, and 1-in thick steaks were fabricated, packaged, frozen at -4°F, and stored for subsequent analysis. The steaks underwent instrumental evaluations for raw and cooked color traits, tenderness, and consumer sensory preferences. Key objective measurements included L^* (lightness), a^* (redness), and b^* (yellowness) color, hue angle, chroma, and the percentages of oxymyoglobin (OMb) and metmyoglobin (MMb) on the steak surface. Steaks were cooked to an internal temperature of 159.8°F and analyzed for cook loss and Warner-Bratzler Shear Force (WBSF) values. Additionally, sensory evaluation was conducted with 96 consumers who assessed the steaks for tenderness, flavor, and juiciness using a 10-point scale, and evaluated the steaks for the acceptability of each trait. There were no differences ($P > 0.05$) in the percentage of samples rated acceptable for flavor, juiciness, tenderness, or overall. Moreover, there were no differences ($P > 0.05$) in flavor, juiciness, tenderness, or overall liking among the different aging periods. Furthermore, no differences ($P > 0.05$) were observed in the percentage of cook loss, WBSF, or cooked color readings among aging treatments. However, raw steaks aged 14 and 28 days had higher ($P < 0.05$) a^* and b^* values than steaks aged 42, 49, or 70 days. Despite these minor differences in raw color, the aging period had minimal impact on overall eating quality, indicating that within the studied range, the aging process has only a minimal effect on the quality traits of *biceps femoris* steaks.

Introduction

The consumer beef-eating experience is primarily reliant on three factors: tenderness, juiciness, and flavor. All three are factors in the overall eating experience for consumers, but the failure of even one of these factors can increase the likelihood of the overall experience being unacceptable to the consumer (O'Quinn et al., 2018). One factor influencing the consumer beef-eating experience is aging and its effect on beef

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(O'Quinn et al., 2024). Although aging is commonly undergone to improve the tenderness of beef, a recent review of factors that can influence beef flavor concluded that wet-aging beef past 35 days can have negative effects on the consumer with off-flavors, odors, and volatile compounds (O'Quinn et al., 2024). Aging has been widely studied across numerous conditions and with multiple muscles. However, few studies have evaluated aging's impact on the *biceps femoris* (Colle et al., 2016). One previous study reported extended aging periods resulted in reduced color characteristics for *biceps femoris* steaks across five different aging periods, but resulted in improved tenderness although that study only evaluated steaks across a comparatively short aging period (Colle et al., 2016).

The current study evaluated the sensory, instrumental color, and tenderness characteristics of *biceps femoris* steaks aged from 14 to 70 days. Understanding the impact of extended aging will provide valuable insights into optimal management practices for *biceps femoris* steaks and help identify the point at which palatability is maximized as well as when any potential negative flavor traits arise for steaks from the *biceps femoris*.

Experimental Procedures

Beef sirloin top butt sub-primal cuts (n = 80) were collected from a commercial beef processing facility. Subprimal cuts were then aged for eight aging periods: 14, 28, 35, 42, 49, 56, 63, or 70 days at 35.6°F and 39.2°F. Once the aging period concluded, the *biceps femoris* and *gluteus medius* were separated, and 1-in thick steaks were fabricated, packaged, frozen at -4°F, and stored for further analysis. Steaks were analyzed for instrumental raw and cooked color traits, tenderness, and consumer sensory taste panels. Steaks assigned for instrumental tenderness and raw and cooked color traits were thawed for 24 hours at 33.8 - 39.2°F. Once packages were opened, steaks underwent a 30-minute bloom period at ambient temperature prior to color evaluation using a Hunter Lab Miniscan Spectrum photometer (Illuminant A, 2.54 cm aperture, 10° observer, Hunter Lab Associates Laboratory, Reston, VA). L^*(lightness), a^* (redness), and b^* (yellowness) readings and spectral data were used to calculate hue angle, chroma, and percentage of oxymyoglobin (OMb) and metmyoglobin (MMb) according to the American Meat Science Association Meat Color Measurement Guidelines (King et al., 2023). Steaks were cooked to an internal temperature of 154.4°F on a flat top griddle with a surface temperature of 375.8°F, then pulled and allowed to rise to a peak temperature of 159.4°F, with temperatures monitored using a thermocouple connected to a Doric MiniTrend 205. Once steaks reached peak temperature, they were sliced at a 45° angle, perpendicular to the outer cooked surface, in the medial section of the steak, and after a 3-minute bloom period, L^*, a^*, b^* readings, spectral, and cook loss data were collected as a measure of cooked color. After chilling steaks at 33.8 – 39.2°F for 24 hours, Warner Bratzler Shear Force (WBSF) was measured using an Instron. For sensory analysis, steaks assigned for consumer sensory taste panels were divided into equal thirds, and consumers were provided an approximately 2-in^2 sample for evaluation. Consumers evaluated five samples representing different aging periods. Consumers (n = 96) evaluated overall tenderness, flavor, and juiciness liking on 10-point line scales and determined if the sample was acceptable for each trait (yes/no). Data were analyzed using a completely randomized design with an aging period as a fixed effect.

Results and Discussion
Consumers found no differences ($P > 0.05$) among aging treatments for overall liking, flavor liking, juiciness liking, or tenderness liking (Table 1). Moreover, the percentage of samples rated acceptable for *biceps femoris* steaks did not differ ($P > 0.05$) among the aging treatments, with more than 90% of samples from each aging period rated acceptable overall (Table 2). However, instrumental color readings for raw steaks changed throughout aging with a^* and b^* values decreasing (Table 3). The 14- and 28-day-aged steaks had the highest ($P < 0.05$) values for a^* and b^* measures, and the 42- and 49-day-aged steaks had the lowest ($P < 0.05$). Similarly, 14- and 28-day aged steaks had the lowest ($P < 0.05$) OMb percentage of all aging periods, while 70-day aged steaks had the highest ($P < 0.05$) OMb percentage following blooming. Additionally, there was no difference ($P > 0.05$) in cooking loss, WBSF, and cooked color among the evaluated aging periods (Table 4).

Implications
The aging period, ranging from 14 to 70 days, has minimal impact on the overall quality traits of *biceps femoris* steaks, with over 90% of samples rated as acceptable overall by consumers regardless of the aging duration. This indicates that key sensory attributes like flavor, tenderness, juiciness, and instrumental measurements of cooked color and tenderness remain consistent across aging periods. For industry and consumers, aging within this range does not significantly affect eating quality, allowing for more flexible and potentially cost-effective aging practices without compromising consumer satisfaction.

Acknowledgments
This research was coordinated by the National Cattlemen's Beef Association, a contractor to the Beef Checkoff.

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Table 1. Least-squares means for consumer (n = 96) panel palatability ratings[1] for *biceps femoris* steaks across eight aging treatments

Aging period (days)	Overall liking	Flavor liking	Juiciness liking	Tenderness liking
14	6.6	6.0	6.6	6.2
28	6.7	6.5	6.8	7.0
35	6.8	6.3	6.7	6.4
42	6.9	6.3	7.3	7.1
49	6.0	5.7	6.6	6.1
56	7.0	6.6	7.5	7.2
63	6.5	5.9	6.7	6.6
70	6.3	5.4	6.4	6.1
SEM[2]	0.30	0.33	0.35	0.35
P-value	0.21	0.09	0.36	0.14

[1]Sensory score: 1 = extremely dislike; 5 = neither like nor dislike; 10 = extremely like.
[2]Standard error of the mean (largest) of the least square means.

Table 2. Least-squares means (n = 10/aging treatment) for the percentage of consumers who rated each palatability trait as acceptable (yes/no) for *biceps femoris* steaks

Aging period (days)	Overall acceptability	Flavor acceptability	Juiciness acceptability	Tenderness acceptability
14	93.8	94.2	96.1	89.5
28	95.2	95.1	89.1	95.2
35	92.6	89.9	92.7	91.6
42	95.6	93.6	98.8	91.1
49	92.5	87.5	89.7	86.0
56	95.1	96.8	96.3	95.4
63	91.0	90.6	92.5	91.0
70	93.3	84.2	94.4	92.2
SEM[1]	3.8	5.2	4.7	5.0
P-value	0.98	0.36	0.36	0.71

[1]Standard error of the mean (largest) of the least square means.

Table 3. Least-squares means for L*, a*, and b*, percentage of myoglobin content, chroma, hue angle for raw *biceps femoris* steaks

Aging period (days)	L*	a*	b*	MMb[1]	OMb[2]	Chroma	Hue angle
14	38.99[d]	26.79[a]	20.59[a]	7.14	23.52[d]	38.79[a]	0.65[ab]
28	41.40[cd]	26.36[a]	20.01[a]	6.55	24.32[d]	33.10[ab]	0.65[abc]
35	41.89[bcd]	24.93[ab]	18.82[ab]	7.72	25.39[cd]	31.25[ab]	0.64[bc]
42	44.53[ab]	21.54[c]	15.67[c]	9.26	28.80[bc]	26.66[c]	0.62[c]
49	45.65[a]	21.48[c]	15.52[c]	7.66	28.48[bc]	26.50[c]	0.62[c]
56	41.92[bc]	25.47[ab]	19.71[a]	7.30	25.49[cd]	32.22[ab]	0.66[ab]
63	40.95[cd]	23.44[bc]	18.40[ab]	9.49	30.54[b]	29.82[bc]	0.67[ab]
70	40.32[cd]	21.37[c]	17.04[bc]	8.42	34.84[a]	27.35[c]	0.67[a]
SEM[3]	1.04	0.91	0.82	0.72	1.45	1.20	0.01
P-value	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01

[abcd] Least square means within the same column lacking a common superscript differ ($P < 0.05$).
[1]Metmyoglobin.
[2]Oxymyoglobin.
[3]Standard error of the mean (largest) of the least square means.

Table 4. Least-squares means for L*, a*, and b*, percentage of myoglobin content, chroma, hue angle, cook loss, and Warner-Bratzler Shear Force (WBSF) for cooked *biceps femoris* steaks

Aging period (days)	Cook loss	WBSF	L*	a*	b*	MMb[1]	OMb[2]	Chroma	Hue angle
14	25.74	3.85	48.56	19.17	28.17	1.01	39.69	26.98	0.78
28	23.96	3.13	47.31	20.73	23.98	1.50	37.50	29.01	0.78
35	23.01	3.35	49.95	19.48	23.03	1.16	37.85	26.85	0.75
42	22.26	3.35	48.67	20.51	22.21	0.57	38.18	28.01	0.75
49	25.21	3.31	48.81	19.07	25.27	0.20	40.99	26.80	0.78
56	21.93	3.33	49.53	17.81	24.98	0.19	40.13	24.68	0.77
63	23.18	3.53	47.62	19.19	23.24	1.35	38.64	27.20	0.78
70	24.18	3.68	48.25	17.55	27.26	0.58	40.27	25.01	0.80
SEM[3]	1.38	0.25	0.96	1.13	2.23	0.53	1.67	1.42	0.02
P-value	0.46	0.52	0.54	0.44	0.53	0.50	0.75	0.43	0.48

[1]Metmyoglobin.
[2]Oxymyoglobin.
[3]Standard error of the mean (largest) of the least square means.