Aging Method, USDA Quality Grade, and Endpoint Temperature Affect Eating Quality of Beef *Longissimus lumborum* Steaks

M.E. Dikeman, E. Obuz, V. Gok, and L. Akaya

Introduction

Tenderness is one of the most important factors affecting consumers' perceptions and acceptance of palatability. Tenderness is affected by both myofibrillar proteins and connective tissue content and quality. Both marbling and carcass maturity can have a significant effect on beef palatability, with higher consumer sensory scores generally given to USDA Choice loin steaks than to Select steaks for tenderness, juiciness, and overall palatability. Endpoint temperature can also have a significant effect, with higher endpoint temperatures generally decreasing palatability.

Aging beef is a common practice in the meat industry because it increases tenderness and flavor development. The meat industry generally utilizes two types of aging, vacuum and dry aging. Vacuum aging, in which meat is aged in a sealed barrier package at refrigerated temperatures, is the most widely used practice. Dry aging refers to aging meat without packaging, and requires greater environmental control to achieve consistent product quality. Vacuum-aged beef has a sourer and stronger bloody/serumy flavor, whereas dry-aged beef has a more beefy, brown-roasted flavor. Dry aging generally results in greater aged flavor of steaks with no advantage for tenderness, and it is a costly procedure because of decreased yields due to greater weight and trim losses than vacuum aging. Flavor benefits of dry aging and distinct yield advantages of vacuum aging stimulated researchers to develop a "special bag" with a very high water vapor transmission rate and very low oxygen transmission rate to decrease shrink and trim loss but create a dry-aged flavor.

Although some studies have compared the effects of vacuum and dry aging and dry and "special bag" aging, no study has compared all three aging methods. Therefore, the objectives of our study were to determine the effects of vacuum, dry, and special bag aging of USDA Choice and Select grade boneless strip loin steaks cooked to endpoint temperatures of 145°F or 160°F on yield, physical properties, chemical properties, instrumental tenderness, instrumental color, visual cooked color, and sensory properties of beef steaks.

Experimental Procedures

Beef boneless strip loins from USDA Choice (n = 9) and USDA Select (n = 9) carcasses were purchased from a commercial processor. Each loin was cut into halves and randomly assigned to 1 of 3 aging treatments (vacuum aging, dry aging, or aging in a special bag; VAC, DRY, or SB, respectively). Loin sections allocated to VAC aging were packaged in bags (Cryovac Sealed Air Corporation, Duncan, SC). Loin sections destined for DRY aging were aged unpackaged with direct exposure to air in the cooler. Loin sections assigned to the SB treatment were vacuum packaged in dry-aging bags (MacPak, LLC, Wayzata, MN). Loin sections were aged from the time they were received at 8 days postmortem for 21 days at 4°F on wire racks, with the subcutaneous fat surface down. On day 21 of aging, 4 1-inch-thick steaks were removed from the anterior end and randomly assigned to 1 of 2 endpoint cooking temperatures (145 or 160°F) for Warner-Bratzler shear force determination and sensory analysis. A sample was also taken for fat and moisture analyses. For DRY and SB aging, loin sections were trimmed after aging to remove dried and discolored portions. Vacuum-aged loins were blotted with dry paper towels. Samples of *longissimus lumborum* tissue were prepared for moisture and fat analyses.

Color measurements on raw steaks were taken before and after aging with a Hunter colorimeter as well as on the cooked steaks. Visual color was evaluated on a 6-point scale with 1 = raw red center, pink border, tan edge (medium rare); 3 = pinkish red center, pink to light brown/tan to outer surface; and 6 = dry, brown throughout (well done). Steaks were cooked in a Blodgett gas-fired, forced-air-convection oven at 325°F until the center temperature reached 145 or 160°F. After cooking, steaks were overwrapped in polyvinyl chloride film and cooled for 24 hours at 4°F, then 6 round 1/2-inch cores per steak were removed parallel to the long axis of the muscle fibers and sheared once through the center using a Warner-Bratzler shear attachment (V-notch blade). Shear-force steaks were also used to determine cooking losses.

Six steaks for trained sensory evaluation were cooked at a session in the same way as for Warner-Bratzler shear force testing. Each steak was cut into 1/2 × 1/2 × 1-inch pieces for serving. Trained panelists (n = 6) evaluated palatability attributes on an 8-point scale for myofibrillar tenderness, juiciness, flavor, off-flavor, connective tissue, and overall tenderness (1 = extremely tough, dry, bland, intense, tough, and abundant; 8 = extremely tender, juicy, intense, none, tender, and none) for each sample.

The overall treatment structure was a split-split plot design with the incomplete assignment of the treatment combinations to the experimental units. The whole plot treatment was quality grade (USDA Select or Choice), the sub-plot treatment was aging method (DRY, VAC, or SB), and the sub-sub-plot treatment was endpoint temperature (145 or 160°F). Random effects included loin within quality grade and aging method × loin within quality grade. The treatment combinations were replicated 6 times. Data were analyzed using the PROC MIXED procedure of SAS (2009; SAS Inc., Cary, NC). Least squares means for all significant effects were calculated and separated when significant ($P < 0.05$). Least significant differences for all significant factors were calculated and presented for ease of mean separation.

Results and Discussion

USDA Select loins had higher ($P < 0.05$) weight loss during aging than Choice loins (Table 1, 11.37% for Select and 9.92% for Choice), likely because of higher initial moisture content ($P < 0.05$) of Select loins (72.56% versus 71.43%). VAC-aged loins had dramatically less ($P < 0.0001$) weight loss during aging than both DRY and SB aging methods (2.90% versus 15.56% and 13.48%, respectively). Both DRY and SB aging methods resulted in higher ($P < 0.0001$) trim loss than VAC aging, and SB aging resulted in greater ($P < 0.05$) trim loss than DRY aging (26.55% versus 24.05%; Table 1). Both DRY and SB aging resulted in similar combined losses, but combined losses were dramatically lower for VAC aging. Therefore, aging in the SB does not offer advantages over DRY aging as far as trim and combined losses are concerned.

After aging, VAC loins had the highest moisture content and DRY aged loins had higher ($P < 0.05$) fat content than SB aged loins (5.53 versus 4.37%, Table 2). Fat content was lowest ($P < 0.05$) for SB aging after cooking. As expected, higher endpoint temperature resulted in lower ($P < 0.0001$) moisture content (Table 2). VAC aging resulted in higher L* (lighter color) values than DRY or SB aging. A decrease ($P < 0.05$) in a* values (decreased redness) with increased endpoint temperature was less pronounced in DRY aged steaks than it was in VAC-aged or SB-aged steaks. Steaks from SB-aged loins were considerably redder for Select than for Choice. The mean visual color scores of steaks cooked to 145°F and 160°F were 3.14 and 4.67 (3 = pinkish red center, pink to light brown/tan to outer surface; 5 = tan/brown center and edges, no evidence of pink; $P < 0.01$), respectively.

Neither quality grade nor aging method had an effect ($P > 0.05$) on Warner-Bratzler shear force of steaks (Table 2); however, Warner-Bratzler shear force increased ($P < 0.0001$) from 6.42 to 7.44 lb as endpoint temperature increased. Quality grade was not a factor ($P > 0.05$) for cooking loss (Table 2). Cooking loss for steaks cooked to 160°F was about 5% higher ($P < 0.0001$) than for steaks cooked to 145°F (Table 2).

Quality grade and aging method did not affect ($P > 0.05$) juiciness, but, as expected, steaks cooked to 145°F were juicier ($P < 0.05$) than those cooked to 160°F (data not presented). Neither quality grade nor aging method affected ($P > 0.05$) myofibrillar tenderness, connective tissue amount, overall tenderness, or off-flavor intensity (data not presented), but VAC-aged loins cooked to 160ºF had the lowest ($P < 0.05$) myofibrillar tenderness score. In addition, there was a three-way quality grade × aging method × endpoint temperature interaction ($P < 0.01$) for beef flavor intensity in which Select, DRY-aged steaks had higher beef flavor intensity than VAC- or SB-aged steaks, but the small difference (0.3) might not be detectable by consumers. Choice, VAC-aged steaks cooked to 145°F had higher ($P < 0.01$) beef flavor intensity than those cooked to 160°F.

In summary, DRY and SB aging resulted in excessive trim loss and required extensive labor. Our trained sensory panel revealed few, if any, differences among DRY, VAC, and SB aging.

Implications

VAC aging remains an economical and practical aging method to optimize the palatability of strip loins.

Table 1. Least squares means of quality grade and aging methods on weight loss (%), trim loss (%), and combined loss (%) for *Longissimus lumborum* muscles

Source of variance	Weight loss, %	Trim loss, %	Combined loss, %
Quality grade			
Select	11.37	18.04	26.81
Choice	9.92	18.05	25.66
P-value	0.01	0.99	0.28
SEM[1]	0.52	--	--
LSD[2]	1.10	--	--
Aging method			
Dry	15.56	24.05	35.98
Vacuum	2.90	3.53	6.32
Special bag	13.48	26.55	36.41
P-value	<0.0001	<0.0001	<0.0001
SEM	0.60	1.03	0.95
LSD	1.22	2.10	1.96

[1] SEM: Standard error of mean.
[2] LSD: Least significant difference ($\alpha = 0.05$).

Table 2. Least squares means of quality grade, aging methods and endpoint temperature on Warner-Bratzler shear force (WBSF) values and cook loss (%) of *Longissimus lumborum* steaks

Source of variance	WBSF, lb	Cook loss, %
Quality grade		
Select	7.16	20.37
Choice	6.70	19.88
P-value	0.39	0.42
SEM1	--	--
LSD2	--	--
Aging method		
Dry	6.90	18.75
Vacuum	6.94	20.24
Special bag	6.93	21.38
P-value	0.99	0.01
SEM	--	0.79
LSD	--	1.70
Endpoint temperature, °F		
145	6.42	17.81
160	7.44	22.43
P-value	<0.0001	<0.0001
SEM[1]	0.08	0.62
LSD[2]	0.17	1.26

[1] SEM: Standard error of mean.
[2] LSD: Least significant difference ($\alpha = 0.05$).