CONSUMER AND TRAINED SENSORY PANEL EVALUATIONS OF FOUR MUSCLES FROM DRY- AND WET-AGED BEEF RIBEYES AND TOP SIRLOIN BUTTS CUT USING INNOVATIVE MERCHANDISING STYLES

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Abstract – Innovative merchandising methods were used to cut dry-aged and wet-aged beef ribeyes and top sirloin butts for an evaluation of consumer and trained sensory evaluations of four individual muscles: *M. longissimus thoracis*, *M. spinalis thoracis*, *M. gluteobiceps*, and *M. gluteus medius*. Dry aging resulted in less juicy steaks compared to wet aging. The *M. spinalis thoracis* received the highest consumer tenderness and juiciness ratings, whereas the *M. gluteus medius* received among the lowest. Many aging × muscle interactions were observed with lower consumer flavor ratings and more off-flavors observed in the exterior muscles — *M. spinalis thoracis* and *M. gluteobiceps* — from the dry-aged treatments. Employing cutting methods where individual muscles are merchandised may not be the most appropriate way to market dry-aged beef.

Key Words – Dry aging, Wet aging, Beef flavor

I. INTRODUCTION

A challenge facing the U.S. beef industry today is increasing retail/foodservice cut size from the continued increase in the average carcass weight by approximately 1 kg per year [1]. As a potential solution to this problem, West *et al.* [2] used the Beef Alternative Merchandising cutting styles outlined in the SIMPLYBEEF Guide. This study showed that despite increased labor costs and yield losses, these methods do create more uniform portioned products. Research evaluating whether these cutting styles can be used with dry-aging beef is unavailable.

Two common forms of beef aging are dry and wet aging. Smith *et al.* [3] described dry aging as unpackaged meat aged at controlled temperatures and humidity. Wet aging refers to storing meat in vacuum-sealed packages under refrigeration. Since the introduction of vacuum-packaged boxed beef, wet aging has continued to be the most commonly used industry aging system due to its increased ease and flexibility of storage, while still producing tender and consistent products. There are a few establishments preparing dry-aged beef for upscale retail and foodservice markets, despite the additional requirements of a greater amount of space and proper facilities to control temperature, relative humidity, and air-flow.

The objectives of this study were to determine the influence aging method had on consumer acceptance and(or) preference of beef steaks from four different muscles based on aging style, and to better determine the unique flavor profiles specific to dry-aged and wet-aged steaks from subprimals cut using innovative merchandising styles.

II. MATERIALS AND METHODS

Beef carcasses (n = 12) grading Choice with carcass weights averaging 407.8 kg were identified and segregated at a major beef processor at approximately 48 hr postmortem. Both sides from each were fabricated, and Institutional Meat Purchase Specifications Beef Loin, Top Sirloin Butt, Boneless (IMPS 184) and Beef Rib, Ribeye, Lip-On, Boneless (IMPS 112A) subprimals were obtained, labeled, vacuum packaged, and boxed. Boxed subprimals then were shipped via a refrigerated truck to a commercial facility for aging.

Upon arrival, subprimals were separated into one of two treatments, dry or wet aging. Vacuum-packaged subprimals designated for wet aging were placed under refrigeration temperatures (3.0 ± 0.7 ºC). The subprimals

identified for dry aging were removed from their vacuum packages and were placed in a dry-aging cooler (4.0±1.1 ºC; 98.1% Rh) on a perforated, plastic rack. Temperature and relative humidity of the cooler were monitored using a continuous data logging device and probe (Model TM325; Dickson Data, Addison, IL). Fans were used to enhance air circulation, and UV lights were used to inhibit mold growth. Every 3 to 5 days, subprimals were flipped to allow for more uniform drying in accordance with the facility's traditional dry-aging practices. After 35 days of aging, dry-aged subprimals were placed in polyethylene bags and boxed. Both wet-aged and dry-aged subprimals were shipped under refrigeration to the Rosenthal Meat Science and Technology Center at Texas A&M University for fabrication into retail cuts.

All subprimals were cut in accordance with the Beef Alternative Merchandising (BAM) cutting styles outlined in the SIMPLYBEEF Guide for ribeyes [4] and top sirloin butts [5], following the procedures used by West *et al.* [2]. Four individual muscles were obtained — *M. spinalis thoracis* and *M. longissimus thoracis* from the ribeye, and *M. gluteobiceps* and *M. gluteus medius* from the top sirloin — and were cut into steaks. Steaks were vacuum packaged, labeled, and frozen (–23 °C) for subsequent analyses.

Consumer panelists (*n*=107) were recruited from the Bryan-College Station metropolitan area using an existing consumer database. Steaks selected for sensory evaluation were removed from the freezer and thawed in the cooler (~2 °C) for 48 hr. Steaks were cooked on indoor electric grills (Hamilton Beach Indoor/Outdoor Grill, Hamilton Beach/Proctor Silex, Inc., Southern Pines, NC), and temperatures were monitored continuously using Omega trendicators (Omega Engineering, Inc., Stamford, CT) fitted with type-T thermocouples. Steaks were cooked to an internal temperature of 35 °C, flipped, and cooked to a final temperature of 70 °C. Two 1.27 cm^3 samples from steaks representing individual subprimals were served randomly to panelists seated in individual sensory booths equipped with red lights.

Panelists evaluated eight samples using 9-point scales for overall like (**OLIKE**; 1=dislike extremely; 9=like extremely), flavor like (**FLAV**; 1=dislike extremely; 9=like extremely), level of flavor (**FLEVEL**; 1=extremely bland or no flavor; 9=extremely flavorful or intense), beef flavor like (**BEEFLIKE**; 1=dislike extremely; 9=like extremely), level of beef flavor (**FLVBF**; 1=extremely bland or no flavor; 9=extremely flavorful or intense), tenderness like (**TEND**; 1=dislike extremely; 9=like extremely), level of tenderness (**LEVTEND**; 1=extremely tough; 9=extremely tender), juiciness like (**JUIC**; 1= dislike extremely; 9=like extremely), and level of juiciness (**LEVJUIC**; 1=extremely dry; 9=extremely juicy). Consumers were given a monetary award of US$20 for their participation in this study.

A 5-member expert meat and flavor descriptive attribute panel trained using AMSA [6] and Meilgaard, Civille, and Carr [7] was used. Panelists were familiarized for 2 days with extra samples from the study. They were seated in individual booths equipped with red lights, and received cooked, unseasoned, wet-aged beef top loin steak cubes as warm-up samples. Sensory analyses were performed for 8 days.

Cooked sections were cut into 1.27 cm^3 samples, placed in plastic weigh boats, and served immediately. Each day, panelists evaluated 12 samples, each served 5 min apart, during 2 sessions (7 samples per session) with a 15 min break between sessions. Panelists cleansed their palate between samples with double-distilled deionized water and whole milk ricotta cheese.

Trained panelists evaluated these beef flavor identities: brown/roasted, serumy/bloody, fat-like, metallic, liver-like, unami, overall sweet, sweet, sour, salty, bitter, sour aromatics, green-haylike; aromatics: barnyard, animal hair, burnt, heated oil, chemical, apricot, asparagus, cumin, floral, beet, chocolate, green-grass, musty-earthy/humus, medicinal, petroleum like, smokey charcoal, smokey wood, spoiled-putrid, dairy, buttery, cooked milk, sour milk/dairy, refrigerator stale, warmed-over, soapy, painty, fishy, and cardboard; and aftertastes: barnyard,

bitter, musty-earthy, sour, and metallic using 16-point scales (0 = none; 15 = extremely intense).

The effects of aging treatment (dry and wet), muscle type (*M. longissimus thoracis, M. spinalis thoracis, M. gluteus medius,* and *M. gluteobiceps*), and aging treatment × muscle type were analyzed using JMP® Software (JMP®, Version 9.0.0, SAS Institute Inc., Cary, NC, 1989-2010). Interactions not significant were removed from the model. The p-diff option at $P < 0.05$ was used to separate means when significant differences occurred. Box-Cox transformation was used to ensure normal distribution for analysis of consumer data.

III. RESULTS AND DISCUSSION

Main effect (aging and muscle) consumer sensory ratings are shown in Table 1. Only JUIC was affected by aging, with dry-aged steaks less juicy than wet-aged steaks. Smith *et al.* [3] found that wet-aged steaks were perceived as more favorable from a juiciness standpoint than wet-aged steaks. The *M. spinalis thoracis* received the highest FLVBF, TEND, LEVTEND, JUIC, and LEVJUIC ratings among the four muscles. In addition, the *M. gluteus medius* had the lowest ratings for TEND, LEVTEND, JUIC, and LEVJUIC.

Four significant interactions between aging treatment × muscle were found for OLIKE, FLAV, FLEVEL, and BEEFLIKE (Table 2). Clearly, consumers rated the wet-aged, *M. spinalis thoracis* highest in each of the previously stated attributes. Within each muscle type, wet-aged steaks were numerically higher for each attribute when compared to dry-aged steaks. Generally speaking, steaks generated from the ribeye had higher ratings than did steaks fabricated from the top sirloin butt, whether wet or dry.

Table 1 Least squares means for consumer sensory responses (n = 107 consumers) of steaks stratified by aging treatment and muscle

Main effects	Level of beef flavor[a]	Tenderness like[b]	Level of tenderness	Juiciness Like[b]	Level of juiciness[d]
Aging Treatment					
Dry-aged	6.2	6.9	6.9	6.2b	6.1
Wet-aged	6.2	7.1	7.0	6.5a	6.2
$P > F$	0.937	0.090	0.259	0.038	0.233
Muscle					
M. spinalis thoracis	6.6a	8.1a	8.1a	7.4a	7.3a
M. longissimus thoracis	5.9c	6.7b	6.8b	6.0c	5.8c
M. gluteobiceps	6.3ab	6.9b	6.9b	6.5b	6.4b
M. gluteus medius	6.1bc	6.1c	5.9c	5.5d	5.1d
$P > F$	0.004	<0.001	<0.001	<0.001	<0.001
RMSE	3.8	4.5	4.3	3.5	3.2

a-d Means within the same column lacking a common letter differ ($P < 0.05$).
[a] 9=Extremely flavorful or intense; 1=extremely bland or no flavor.
[b] 9=Like extremely; 1=dislike extremely.
[c] 9=Extremely tender; 1=extremely tough.
[d] 9=Extremely juicy; 1=extremely dry.

For the trained sensory panel ratings (Table 3), aging period had a significant effect on metallic flavor, with dry-aged steaks receiving higher metallic flavor ratings compared to their wet-aged counterparts. There was a significant difference in both fat and metallic flavors between muscles. Fat-like aromatics followed the trend to be greater in fattier cuts, or those cuts more exposed to the external surface. Muscles from the ribeye roll were less metallic than those from the top sirloin butt. This was to

be expected because the sirloin is generally associated with metallic aromatics [8].

Table 2 Least squares means for consumer sensory responses (n = 107 consumers) of steaks stratified by aging treatment × muscle.

Interaction effects	Overall like[a]	Flavor like[a]	Level of flavor[b]	Beef flavor like[a]
Aging treatment ×muscl				
Dry-aged, *M. spinalis thoracis*	6.4b	6.0b	6.4b	6.2b
Wet-aged, *M. spinalis thoracis*	7.4a	7.1a	7.0a	7.1a
Dry-aged, *M. longissimus thoracis*	6.0bcd	6.0b	5.9bc	6.1b
Wet-aged, *M. longissimus thoracis*	6.2bc	6.0b	5.7c	6.1b
Dry-aged, *M. gluteobiceps*	5.6d	5.3c	6.0bc	5.5c
Wet-aged, *M. gluteobiceps*	6.3b	5.9b	6.1bc	6.2b
Dry-aged, *M. gluteus medius*	5.6d	5.6bc	6.2bc	5.8bc
Wet-aged, *M. gluteus medius*	5.7cd	5.7bc	5.6c	5.9bc
$P > F$	0.032	0.022	0.025	0.040
RMSE	3.5	3.3	3.9	3.9

a-d Means within the same column lacking a common letter differ ($P < 0.05$).
[a] 9=Like extremely; 1=dislike extremely.
[b] 9=Extremely flavorful or intense; 1=extremely bland or no flavor.

Significant interactions between aging treatment × muscle (Table 4) were associated with attributes of beef flavor, brown roasted, bloody/serumy, musty, putrid, and warmed-over flavor (no other flavor attributes were impacted by the treatment combinations). Differences in beef flavor seemed to trend towards being higher for wet-aged steaks versus those that were dry-aged in addition to being higher in the more internal muscles of the *M. longissimus thoracis* and the *M. gluteus medius*. Similarly, brown/roasted flavor was generally higher with the same trend. Bloody/serumy attributes were highest for the wet-aged *M. spinalis thoracis* and *M. gluteus medius*. Generally speaking, bloody/serumy tended to be lower for wet-aged steaks than dry-aged steaks, which opposes findings from Warren and Kastner [9]. Musty and putrid flavors both were higher for dry-aged steaks, especially from muscles closer to the exterior surface of the subprimal. These surfaces would be more physically exposed to drying and mold growth during the dry-aging process. In both aging styles, the exterior muscles were closer to the larger fat depots within the subprimals. Warmed over flavor, although significantly different, lacked an evidenced trend to explain differences based on aging and muscle type. Perhaps further research could explain these differences.

IV. CONCLUSION

Using innovative styles to cut beef ribeyes and top sirloin butts may allow for greater merchandising options, especially for subprimals from heavier carcasses. However, when combined with dry-aging where the exterior muscles — *M. spinalis thoracis* and *M. gluteobiceps* — are more exposed to extreme drying and possible mold growth, these conditions may result in the development of undesirable flavor characteristics that may be more pronounced than if the muscles are merchandised in their more traditional form.

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Table 3 Least squares means for trained sensory responses of steaks stratified by aging treatment and muscle (0 = none; 15 = extremely intense).

Main effects	Fat-like	Metallic
Aging Treatment		
Dry-aged	2.22	3.14a
Wet-aged	2.35	2.94b
P > F	0.180	0.025
Muscle		
M. spinalis thoracis	3.40a	2.75b
M. longissimus thoracis	1.98b	2.89b
M. gluteobiceps	2.13b	3.15a
M. gluteus medius	1.63c	3.35a
P > F	<0.001	<0.001
RMSE	0.21	0.17

a-d Means within the same column lacking a common letter differ ($P < 0.05$).

Table 4 Least squares means for trained sensory responses of steaks stratified by aging treatment × muscle (0 = none; 15 = extremely intense).

Interaction effects	Beef Flavor	Brown Roasted	Bloody/ Serumy	Musty	Putrid	Warmed Over Flavor
Aging treatment ×muscle						
Dry-aged, *M. spinalis thoracis*	5.32c	2.15d	2.27b	3.01a	3.56a	0.01cd
Wet-aged, *M. spinalis thoracis*	7.05b	2.75b	2.98a	0.65d	0.36c	0.24ab
Dry-aged, *M. longissimus thoracis*	6.51b	2.71bc	2.36b	1.67bc	1.55b	0.26a
Wet-aged, *M. longissimus thoracis*	7.85a	3.42a	2.47b	0.42d	0.11c	0.07bcd
Dry-aged, *M. gluteobiceps*	5.45c	2.25cd	2.65ab	2.09b	2.81a	0.08bcd
Wet-aged, *M. gluteobiceps*	6.76b	2.87b	2.51b	0.74d	0.21c	0.00d
Dry-aged, *M. gluteus medius*	6.73b	2.92b	2.38b	1.26c	1.25b	0.04cd
Wet-aged, *M. gluteus medius*	7.20a	2.72bc	2.99a	0.31d	0.10c	0.17abc
P > F	0.037	0.036	0.031	0.005	0.001	0.004
RMSE	0.59	0.37	0.32	0.49	0.95	0.05

a-d Means within the same column lacking a common letter differ ($P < 0.05$).