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# Consumer Sensory Acceptance and Value of Wet-Aged and Dry-Aged Beef Steaks

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# Consumer sensory acceptance and value of wet-aged and dry-aged beef steaks[1]

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**ABSTRACT:** To determine sensory preference and value of fresh beef steak differing in aging technique, strip steaks were evaluated by consumers in Denver (n = 132 consumers) and Chicago (n = 141 consumers). Wet-aged Choice strip loins were matched with dry-aged Choice strip loins, whereas wet-aged Prime strip loins were matched with dry-aged Prime strip loins. Dry-aged strip loins were commercially aged in air in a controlled environment for 30 d and vacuum-aged for 7 d during shipping and storage. Wet-aged strip loins were vacuum-packaged and aged for 37 d in a 1°C cooler. Pairs of strip loins were matched to similar Warner-Bratzler shear force values and marbling scores. Twelve sensory evaluation panels (of 12 scheduled panelists each) were conducted over a 3-d period in each city. Individual samples from a pair of steaks were evaluated by the panelists for sensory traits. Bids were placed on the samples after sensory traits were obtained utilizing a variation of the Vickery auction with silent, sealed bids. No significant differences for sensory traits of flavor, juiciness, tenderness, or overall acceptability were detected between wet-aged Choice samples and dry-aged Choice samples. Although wet-aged Choice samples were numerically superior for all sensory traits, consumers placed similar bid values ($P$ = 0.12) on wet- and dry-aged Choice samples ($3.82 per 0.45 kg and $3.57 per 0.45 kg, respectively). Wet-aged Prime samples were rated more desirable ($P < 0.001$) for flavor, tenderness, and overall acceptability than dry-aged Prime samples. Wet-aged Prime samples were valued at $4.02 per 0.45 kg, whereas dry-aged Prime samples brought $3.58 per 0.45 kg ($P = 0.008$). Consumers (29.3%) who preferred the dry-aged Choice samples over the wet-aged Choice samples were willing to pay $1.99/0.45 kg more ($P < 0.001$) for dry-aged samples. The consumers who preferred the wet-aged Choice over the dry-aged Choice samples (39.2%) were willing to pay $1.77/0.45 kg more ($P < 0.0001$). Consumers who preferred wet-aged Prime over dry-aged Prime samples (45.8%) paid $1.92/0.45 kg more ($P < 0.0001$). Consumers who preferred dry-aged Prime samples (27.5%) were willing to pay $1.92/0.45 kg more than for the wet-aged Prime samples. Although more consumers preferred wet-aged samples, markets do exist for dry-aged beef, and consumers are willing to pay a premium for this product.

**Key words:** beef, dry aging, palatability, wet aging

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## INTRODUCTION

Fresh meat is aged to enhance the palatability of the product. Aging meat increases the tenderness over time, as well as the development of flavors. Wet and dry aging are common aging techniques. Meat that is packaged in a sealed barrier film and held at a temperature above the freezing point of the meat is classified as wet-aged. Because most primals are vacuum-packaged before cutting into steaks or roasts, wet aging can occur during shipping and storage. Dry aging is the process of aging unpackaged meat in a cooler, where humidity is controlled. Dry aging can be utilized for entire carcasses or individual subprimal cuts.

Aging, dry or wet, results in flavor development and more tender meat (Warren and Kastner, 1992; Miller et al., 1997; Campbell et al., 2001). Results from studies differ on the magnitude of difference in sensory traits between wet and dry aging. Parrish et al. (1991) showed small, but significant, palatability differences between dry- and wet-aged loins and ribs, aged for 21 d. Juiciness, flavor intensity, and flavor desirability were comparable in wet- and dry-aged treatments. Conversely, Bischoff (1984) reported that significantly more beef flavor, dry-aged flavor, and brown-roasted aromas were perceived for steaks dry-aged for 14 or 21 d compared with steaks wet-aged for 14 d or dry-aged for 7 d. Wet aging strip loins resulted in increased juiciness and flavor scores when strip loins were aged for 21 d compared with unaged loins (Gutowski et al., 1979; Bidner et al., 1985).

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In this study, wet-aged and dry-aged strip loins were evaluated for sensory traits and sold by a silent auction. The objective was to quantify sensory differences between wet- and dry-aged strip loins and to determine the value consumers place on their preferred product.

## MATERIALS AND METHODS

Sensory evaluations were conducted in Denver and Chicago. Twelve taste panels were completed in each city with 132 consumers participating in Denver and 141 consumers participating in Chicago. Four panels, with twelve panelists per panel, were scheduled for 3 consecutive days in each city. The data were part of a larger study that included other comparisons (Sitz, 2003). Panelists tasted a total of 4 pairs of beef steak samples.

### *Steak Preparation*

The USDA-graded, fresh strip loins were purchased unfrozen from a commercial packer and from a commercial beef aging facility. The strip loins were stored in a cooler at 1°C. Certified Angus Beef strip loins were dry-aged for 30 d at the aging facility, vacuum-packaged before shipping, and aged for 7 d during shipping and before cutting. Wet-aged strip loins were aged in vacuum bags for 37 d in a 1°C cooler. Steaks were cut from the strip loin to a thickness of 2.54 cm. The steaks were numbered from cranial to caudal, wrapped in white butcher paper, labeled with a random 3-digit number, and frozen in a –20°C freezer.

### *Proximate Analysis*

The first steak from the most cranial end of the strip loin was removed. The marbling score of each strip loin was determined by an experienced evaluator from the freshly cut surface of the steak after a minimum of 15 min of bloom time. The subcutaneous fat and epimysium were removed, and the lean of the LM was cubed, immersed in liquid nitrogen, and homogenized to a powder in a Waring blender (Dynamics Corporation of America, New Hartford, CT). Ash and moisture content were analyzed in duplicate using a Leco thermogravimetric analyzer (Leco Corp., St. Joseph, MI). Lipid content was measured on duplicate samples by the Soxlet method using anhydrous ether (AOAC, 1990). Protein content was calculated by difference (100 – % fat – % moisture – % ash).

### *Warner-Bratzler Shear Force Determination*

The second steak from the cranial end of the loin was used to determine Warner-Bratzler shear force values. After cutting and wrapping the steaks, the steaks were frozen in a –22°C freezer. The steaks were thawed for 24 h in a 4°C refrigerator. The steak was trimmed of external fat and cooked on a Farberware Open Hearth broiler (Farberware Co., Bronx, NY). The steaks were heated to an internal temperature of 35°C, turned, and heated to a final temperature of 70°C. The temperature was measured intermittently at the geometric center of the steak using a digital thermometer and thermocouple (Model 450-ATT; Omega Engineering Inc., Stamford, CT). The steaks were cooled in a 4°C refrigerator for 1 h.

After cooling, 10 to 12 cores (1.27-cm diameter) were sheared from the LM of the steak using a drill press (Delta International Machinery Corp., Pittsburgh, PA) and corer. The cores contained muscle fibers that were parallel to the longitudinal orientation of the muscle fibers and were held at room temperature. The Warner-Bratzler shear force was measured the same day as coring. Shear force was measured on at least 8 cores from each steak using an Instron Universal Testing Machine (Instron Corp., Canton, MA) with a Warner-Bratzler shear force attachment. A 500-kg load cell was utilized with crosshead speed at 250 mm/min.

### *Pairing of Strip Loins*

Two pairs of loins were matched for each taste panel: 1) Choice dry-aged strip loins and Choice wet-aged strip loins, 2) Prime dry-aged strip loins and Prime wet-aged strip loins. Grade was based on the USDA grade classification in which the meat was sold.

The pairs of loins were matched to similar Warner-Bratzler shear values and similar marbling scores. The marbling and tenderness were matched as closely as possible for each pair.

### *Preparation of Taste Panel Samples*

Taste panel samples were prepared as the panelists arrived at the host facility. The third and fourth steak from the cranial end of the strip loin were used as taste panel samples. The steaks were shipped frozen to the host facilities. The steaks were thawed for 24 h before taste panels in a 4°C refrigerator. The steaks were trimmed of excess fat and cooked to an internal temperature of 70°C as described for Warner-Bratzler shear force determination. After cooking, steaks were removed from the broilers and wrapped in aluminum foil for 5 min or less. The steaks were cut into 1 × 2-cm cubes, wrapped in aluminum packets, labeled with the appropriate identification number, and placed into a double broiler. Samples were held at 40 to 50°C for 20 min or less until served (Caporoso, 1978). A single piece of steak was placed onto a plate, labeled with the identification number, and served to the panelist. Water and saltine crackers (unsalted tops) were provided to the panelists to cleanse their palates between samples.

### *Screening of Panelists*

Panelists were screened by employees of the host facilities via telephone or through a written document. To qualify for the taste panel, the consumers had to be

the primary grocery shopper of the household, between the ages of 19 to 59, with no food allergies, and willing to consume beef. Consumers were disqualified if they or their immediate family worked for the meat or cattle industry, marketing, or advertising agencies. A survey of demographic information, eating preferences, purchasing behavior, and a consent form were mailed to each panelist to be completed before the taste panel.

Upon arrival at the host facility, the panelists were asked to complete a meat knowledge survey, as well as finish any incomplete paperwork. Panelists were assigned random 3-digit numbers for identification. Panelists were paid $50 for participation in the taste panel upon arrival, so they would have money to use for steak purchase, should they win an auction.

### *Auction Procedures*

The panelists were seated in a conference room. The moderator read a written dialogue explaining the auction procedure. Steaks the panelists bought were taken from the same strip loin as the sample tasted. A reference price of $7 per pound was given to panelists for a Choice strip loin steak before conducting 3 nonbinding practice auctions. The panelists were not required to bid; however, if a panelist chose to bid and won a nonpractice auction, the panelist would pay for the auction from the $50 participation payment. One steak from each pair would be a binding auction, although the panelists did not know which steaks were to be sold. The panelists tasted a pair of samples and then submitted silent, sealed bids on both steaks.

A variation of the Vickery (uniform-price) auction, in which the second highest bid determines the purchase price, was utilized (Vickery, 1961). The variation of the Vickery auction was called an nth price auction, in which the number of winners per auction was randomly assigned. The nth price auction determined the purchase price, or the amount the winner(s) paid, for the auction (n = 2, 3, or 4). In a second price auction, the second highest bid was the purchase price the highest bidder paid for the steak. For a third price auction, the third highest bid set the purchase price for the steak, whereas the highest and second highest bidder would only pay the price of the third highest bid. The fourth price auction resulted in 3 winners.

Because the winners of the auctions did not pay the amount they bid, it was in the best interest of the consumer to bid the exact amount they were willing to pay for a sample (Vickery, 1961). Consumers who underbid risked the chance of losing the auction, whereas consumers who overbid risked overpaying for the item. The best strategy was therefore to bid the highest value they were willing to pay for the item (Menkhaus et al., 1990).

Three practice auctions were conducted to familiarize the panelists with the auction procedure. Coppinger et al. (1980) reported that bids in Vickery auctions stabilize over several bidding sequences. The panelists placed hypothetical bids after visually evaluating packages of beef strip steaks containing different amounts of labeling information (results reported in a separate paper; Umberger et al., 2003). The third practice auction was a warm-up sensory sample to familiarize the panelists with the sensory evaluation process and flavor, juiciness, and tenderness traits. If a panelist chose to bid $0 for a sample, the panelist was asked to provide a written explanation of why they chose not to bid.

### *Tasting and Bidding on Samples*

Panelists were placed into individual tasting booths or tables to evaluate sensory traits of the samples. The first sample of the pair was served on a 15-cm paper plate identified with the sample number. The panelists evaluated the first sample for sensory traits using an 8-point hedonic scale, in which 1 = extremely undesirable and 8 = extremely desirable. The second sample of the pair was served on a 15-cm paper plate labeled with the sample identification number and was evaluated for sensory traits.

After both samples were tasted, the panelists bid on the samples. The value of each steak was placed on an individual bid sheet labeled with the sample's identification number. The panelists' bids were collected, and the purchase prices of the samples were determined. Slips announced the purchase price, potential winners (1 sample auction was binding, the other sample was not sold), or whether the panelists did not win an auction. The procedure was repeated for the second pair of samples.

To avoid biasing the bids, the auctions that were binding were announced after all the samples had been tasted and slips had been distributed to the panelists. Any panelists who did not win any auction were announced, and these panelists were free to leave. The panelists who had won auctions stayed to purchase their steaks. Change was given if needed, and the panelists received their steaks and a receipt for their purchase.

### *Statistical Analysis*

All 273 panelists were contained in the sensory evaluation portion of the analysis. If a panelist bid $0 per pound for all 8 samples, the panelist was removed from the auction portion of the analysis. Forty panelists were deleted from the data set, leaving 233 panelists for the auction portion of the analysis.

Differences in sensory panel evaluation and auction data were analyzed using the Proc Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). The experimental design for the aged Choice and aged Prime pairs was a split-plot with grade (Choice or Prime) as the whole-plot factor and aging technique (wet-aged or dry-aged) as the split-plot factor. The factors for the ANOVA were city (C), evaluation session (S), panelist (P), grade (G), and aging technique (T). All factors were considered

**Table 1.** Taste panel evaluation ratings and bids for wet-aged and dry-aged strip steaks matched by shear force and marbling[1,2]

| Pair | Flavor | Juiciness | Tenderness | Overall acceptability | Bid ($/0.45 kg) |
|---|---|---|---|---|---|
| Dry-aged Choice | 5.77 | 5.30 | 5.59 | 5.56 | 3.57 |
| Wet-aged Choice | 5.91 | 5.39 | 5.68 | 5.72 | 3.82 |
| SE | 0.076 | 0.078 | 0.080 | 0.077 | 0.151 |
| *P*-value | 0.175 | 0.374 | 0.379 | 0.095 | 0.125 |
| Dry-aged Prime | 5.70 | 5.66 | 5.61 | 5.55 | 3.58 |
| Wet-aged Prime | 6.08 | 5.82 | 6.00 | 5.94 | 4.02 |
| SE | 0.076 | 0.078 | 0.080 | 0.077 | 0.151 |
| *P*-value | 0.001 | 0.096 | 0.001 | 0.001 | 0.009 |

[1]Taste panel scores (n = 273) were based on an 8-point hedonic scale, where 1 = extremely undesirable, 2 = very undesirable, 3 = moderately undesirable, 4 = slightly undesirable, 5 = slightly desirable, 6 = moderately desirable, 7 = very desirable, and 8 = extremely desirable.
[2]Consumers (n = 40) who bid $0 for all samples were removed from the bid data set, leaving n = 233.

fixed except for panelist, which was considered random. The model contained the sources: C S(C) P(S×C) G G×C G×S(C) G×P(S×C) T T×C T×S(C) T×P(S×C) T×G T×G×C T×G×S(C) T×G×P(S×C).

Overall acceptability ratings were used to categorize the consumers into 3 groups: 1) consumers who preferred wet-aged samples in a pair, 2) consumers who preferred dry-aged samples in a pair, or 3) consumers who were indifferent in their preference. Auction data were analyzed as a split-plot with acceptability group as the whole-plot and sample (wet-aged or dry-aged) as the split-plot. All factors were considered fixed except panelist and evaluation session, which were considered random. Factors included in the model were city (C), evaluation session (S), panelist (P), acceptability group (G), and sample (B). Sources in the ANOVA were C S(C) P(S×C) G G×C B B×C B×G B×G×C. For all analyses, differences between pairs of means were tested using LS means comparisons.

## RESULTS AND DISCUSSION

No significant differences for flavor, juiciness, tenderness, and overall acceptability were detected between dry-aged Choice strip loins and wet-aged Choice strip loins (Table 1). These results agree with a study by Parrish et al. (1991), in which minute differences in juiciness, flavor intensity, and flavor desirability were detected between dry- and wet-aged loins and ribs that were aged for 21 d. Tenderness and overall palatability were significantly greater for wet-aged steaks than dry-aged steaks when evaluated by consumer and trained panels (Parrish et al., 1991). In the present study, Choice wet-aged samples were numerically greater for all sensory traits than Choice dry-aged samples. Flavor differences could possibly be due to greater fat content (1.35%) of the wet-aged samples (Table 2). However, Killinger et al. (2004) reported flavor differences of a similar magnitude when marbling differed by 2 full marbling scores (slight vs. modest or greater). The differences in intramuscular fat reported here, though significant, are unlikely to be of sufficient magnitude to cause the flavor differences. Consumer tenderness scores favored wet-aged Choice steaks, although Warner-Bratzler shear values were similar (Table 3).

Consumers valued the wet-aged Choice steaks numerically but not significantly ($P = 0.12$) over the dry-aged Choice steaks by $0.25 per 0.45 kg (Table 1). When consumers were grouped according to their preference (sample in the pair with the greatest overall acceptability score), 39.2% of consumers preferred wet-aged Choice samples, 29.3% preferred dry-aged Choice samples, and 31.5% of the consumers had no preference. Consumers who preferred the dry-aged Choice steaks were willing to bid a $2.02/0.45 kg premium ($P < 0.001$) for their preference, whereas consumers with a preference toward wet-aged Choice steaks were willing to bid $1.76/0.45 kg more ($P < 0.001$) for wet-aged Choice samples (Table 4).

Wet-aged Prime strip loins were rated higher ($P < 0.001$) for flavor, tenderness, and overall acceptability than dry-aged Prime strip loins (Table 1). However, no significant differences ($P = 0.14$) were detected between wet-aged Prime samples or dry-aged Prime samples for tenderness utilizing Warner-Bratzler shear force values (Table 3). Greater juiciness and flavor scores also occurred in wet-aged strip loins in other studies when compared with dry-aged loins (Bidner et al., 1985; Miller et al., 1997). Even though quality grades for wet-

**Table 2.** Proximate analysis of raw taste panel steaks

| Pair | Ash (%) | Moisture (%) | Fat (%) | Protein (%) |
|---|---|---|---|---|
| Dry-aged Choice | 1.23 | 62.67 | 10.44 | 25.66 |
| Wet-aged Choice | 1.05 | 67.85 | 11.79 | 19.30 |
| SE | 0.042 | 0.475 | 0.481 | 0.463 |
| *P*-value[1] | 0.004 | 0.001 | 0.053 | 0.001 |
| Dry-aged Prime | 1.30 | 59.51 | 11.56 | 27.63 |
| Wet-aged Prime | 1.02 | 64.54 | 16.16 | 18.28 |
| SE | 0.042 | 0.475 | 0.482 | 0.463 |
| *P*-value[1] | 0.001 | 0.001 | 0.001 | 0.001 |

[1]*P*-value for the difference between dry-aged and wet-aged Choice or Prime steaks (n = 48).

**Table 3.** Warner-Bratzler shear force (WBSF) values, marbling scores, and quality grade for dry-aged Choice, wet-aged Choice, dry-aged Prime, and wet-aged Prime samples[1,2]

| Pair | WBSF, kg | Marbling | USDA quality grade |
|---|---|---|---|
| Dry-aged Choice | 2.96 | 605 | 4.50 |
| Wet-aged Choice | 2.93 | 581 | 4.29 |
| SE | 0.022 | 10.36 | 0.092 |
| *P*-value[3] | 0.10 | 0.32 | 0.12 |
| Dry-aged Prime | 2.67 | 808 | 6.63 |
| Wet-aged Prime | 2.63 | 809 | 6.63 |
| SE | 0.022 | 10.36 | 0.092 |
| *P*-value[3] | 0.14 | 0.93 | 1.00 |

[1]Marbling scores were converted to a numerical scale, where Slight 00 = 300, Small 00 = 400, Modest 00 = 500, Moderate 00 = 600, Slightly Abundant 00 = 700, Moderately Abundant 00 = 800, and Abundant 00 = 900.

[2]Quality grades were converted to a numerical scale, where Select$^-$ = 1, Select$^+$= 2, Choice$^-$ = 3, Choice$^\circ$ = 4, Choice$^+$ = 5, Prime$^-$ = 6, Prime$^\circ$ = 7, and Prime$^+$ = 8.

[3]*P*-value for the difference between dry-aged and wet-aged Choice or Prime steaks (n = 48).

aged Prime and dry-aged Prime steaks were similar (both low Prime; Table 3), the fat content of the wet-aged Prime steaks was significantly greater ($P < 0.001$) than dry-aged Prime steaks (Table 2). The 4.6% greater fat content in the wet-aged Prime steaks could account for greater flavor ratings, although juiciness ratings were similar. These samples were aged for 37 d, suggesting undesirable flavors may develop during dry aging. Campbell et al. (2001) observed significantly more beef flavor, dry-aged flavor, and brown, roasted aromas for steaks dry-aged for 14 or 21 d than steaks wet-aged for 7 or 14 d. Although consumers rated wet-aged Prime samples numerically greater for tenderness, no significant differences for tenderness were detected between wet- or dry-aged Prime samples, suggesting differences in overall acceptability were more a reflection of flavor differences.

**Table 4.** Consumers' bids ($/0.45 kg) based on overall preference placed on wet-aged or dry-aged strip steaks

| | Preference | | |
|---|---|---|---|
| Pair | Dry-aged | Wet-aged | No preference |
| Choice Dry-aged | 4.81 | 2.91 | 3.35 |
| Choice Wet-aged | 2.79 | 4.67 | 3.55 |
| SE | 0.268 | 0.222 | 0.245 |
| *P*-value[1] | 0.001 | 0.001 | 0.366 |
| n[2] | 80 | 107 | 86 |
| n[3] | 67 | 92 | 74 |
| Prime Dry-aged | 4.34 | 2.98 | 4.12 |
| Prime Wet-aged | 2.41 | 4.92 | 4.02 |
| SE | 0.291 | 0.222 | 0.290 |
| *P*-value[1] | 0.001 | 0.001 | 0.687 |
| n[2] | 75 | 125 | 73 |
| n[3] | 66 | 106 | 61 |

[1]*P*-value for the difference between dry-aged and wet-aged steaks of the same grade.

[2]Consumers (n = 273) who evaluated samples for sensory traits.

[3]Consumers (n = 40) who bid $0 for all samples were removed from the bid data set, leaving n = 233.

Consumers in this panel valued wet-aged Prime strip loins significantly higher than dry-aged Prime strip loins (Table 1). The significantly greater sensory scores for the wet-aged Prime samples contributed to the greater value placed on the wet-aged Prime samples. When consumers were grouped according to their preference, consumers were willing to pay significantly more ($P < 0.001$) for their preference (Table 4). Consumers paid $1.93/0.45 kg more for their wet-aged preference and $1.94/0.45 kg more for their dry-aged preference (Table 4). Although more consumers preferred wet-aged Prime steaks (45.8%), 27.5% of the consumers preferred the dry-aged Prime steaks, and 26.7% did not indicate a preference in the pair of steaks. Even though more consumers prefer wet-aged Prime samples, others are willing to pay for the advantages of dry-aged beef.

## IMPLICATIONS

Dry aging beef is an expensive method, requiring extra storage time and yield loss due to evaporation. To compensate for these losses, dry-aged beef is more expensive. Results from this study indicate consumers who prefer dry-aged beef are willing to pay more for the dry-aged samples. Because wet-aged beef is consumed more by the average consumer, consumers may not be accustomed to the unique flavor profile of dry-aged beef. A greater percentage of consumers favored wet-aged samples, indicating that high quality beef can be wet-aged with desirable palatability results.

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