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ARTICLE

Effects of combined wet- and dry-aging techniques on the physicochemical and sensory attributes of beef ribeye steaks from grain-fed crossbred Zebu steers[1]

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Abstract: The effects of dry- and wet-aging combinations on the sensory and physicochemical attributes of beef ribeye steaks were investigated. Paired beef ribs ($n = 16$) from eight grain-fed crossbred Zebu steers ($n = 16$) were divided into unaged, 28 d wet, 28 d dry, 14 d wet + 14 d dry, and 14 d dry + 14 d wet. Aging was conducted in a chamber at 2 °C with 73% relative humidity and without airflow. Dry-aged and combined-aged products had greater percentages of total loss compared with wet-aged products during the aging and fabrication, resulting in lower total saleable product ($P < 0.01$). All aging treatments presented a brighter and more vivid red color than unaged samples ($P < 0.05$). Regarding shear force, aged samples presented lower ($P < 0.05$) values when compared with unaged samples, but no significant differences were observed among aging treatments ($P > 0.05$). In addition, all aged samples presented higher proportion of tender steaks (>87%; $P < 0.01$). In this study, trained panelists were unable to identify differences among aging treatments for any of the palatability attributes evaluated ($P > 0.05$). The combination of both aging techniques did not offer any advantage, and the wet-aging process alone appears to be the most efficient strategy for the Brazilian food service to maximize palatability characteristics of beef.

Key words: beef quality, beef tenderness, wet aging, dry aging, sensory profile.

Résumé : Les effets de combinaisons de maturations sèches et humides sur les propriétés sensorielles et physicochimiques de la côte de bœuf ont été étudiés. Les côtes de bœuf jumelées ($n = 16$) provenant de huit bouvillons Zebu croisés nourris au grain ($n = 16$) ont été divisées comme suit : sans maturation; maturation humide de 28 j; maturation sèche de 28 j; maturation humide de 14 j + maturation sèche de 14 j; et maturation sèche de 14 j puis maturation humide de 14 j. La maturation a été effectuée dans une chambre à 2 °C avec humidité relative de 73 % et sans flux d'air. Les produits de maturation sèche et maturations combinées avaient de plus grands pourcentages de pertes totales par comparaison avec les produits à maturation humide pendant la maturation et la fabrication, se soldant par un plus faible produit vendable total ($P < 0,01$). Tous les traitements de maturation présentaient une couleur rouge plus clair et plus vive que les échantillons sans maturation ($P < 0,05$). En ce qui a trait aux forces de cisaillement, les échantillons ayant subi une maturation présentaient de plus faibles ($P < 0,05$) valeur par rapport aux échantillons sans maturation, mais il n'y a pas eu de différences significatives observées parmi les traitements de maturation ($P > 0,05$). De plus, tous les échantillons ayant subi une maturation présentaient une plus grande proportion de steaks tendres (>87 %; $P < 0,01$). Dans la présente étude, des dégustateurs expérimentés étaient incapables de déterminer les différences parmi les traitements de maturation, et ce pour toutes les caractéristiques de palatabilité évaluées ($P > 0,05$). La combinaison des deux techniques de maturation n'offrait aucun avantage, et le processus de maturation humide seul semble être la stratégie la

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plus efficace pour le service alimentaire brésilien afin de maximiser les caractéristiques de palatabilité du bœuf. [Traduit par la Rédaction]

Mots-clés : qualité du bœuf, tendreté du bœuf, maturation humide, maturation sèche, profil sensoriel.

Introduction

Brazilian beef production is based on mature (4 yr average slaughter age), grass-fed cattle consisting of intact males, and is heavily influenced by *Bos taurus indicus* breeds (Nellore), which tend to present lower marbling and leaner carcasses (Ferraz and de Felício 2010). In addition, in Brazil, like other Latin American countries, beef carcasses are marketed within 2–7 d post mortem without the use of any postmortem technology such as electrical stimulation or vacuum-packed aging to improve their palatability (Rodas-González et al. 2009). Consequenly, the beef in domestic markets has excessive variation in palatability, and it is difficult to target desired levels of tenderness and product consistency. Under these production and commercialization conditions, it is difficult to guarantee consumer satisfaction with beef.

In recent years, some Brazilian cattlemen have been modifying traditional production practices to include feedlot finishing and use of continental or British crossbreeds to offer young steer carcasses with more fat cover and improved meat quality for the market (Ferraz and de Felício 2010). At the same time, some butcher shops, hotels, and restaurant (BHR) companies are interested in applying postmortem aging; particularly postmortem dry aging, to reduce variation in the palatability of Brazilian beef. During the aging process, muscle enzymes break down the proteins and connective tissue, which leads to improved sensory attributes of beef, including tenderness (Dashdorj et al. 2016). In general, there are two techniques for aging beef: wet and dry forms. Wet aging is a process in which the meat is aged in sealed vacuum bags having low permeability to gases and water vapor, whereas dry aging is a traditional method consisting of holding meat without protective packaging at specific refrigeration temperatures, relative humidity (RH), and air flow (Campbell et al. 2001; Ahnström et al. 2006; Dashdorj et al. 2016).

With postmortem aging, specifically dry aging, there is a clear opportunity to fulfill the demand in a small niche market with consumers who prefer these products, which have unique flavor and tenderness. However, this approach represents a serious challenge for Brazilian entrepreneurs because dry aging has a higher processing cost than other conventional processing methods (higher shrinkage, greater trim loss, higher risk of contamination, greater equipment/infracture requirements for aging, and greater labor committment). In addition, the dry-aging process is often applied in beef with higher marbling level (Dashdorj et al. 2016), which could be a limitation for the leaner Brazilian cattle.

Under commercial conditions in Brazil, packing plants ship the carcasses or vacuum-packaged subprimals cuts to BHR companies for further fabrication, and preparation of retail cuts or steak portions occurs within 2–7 d post mortem. The main constraints that prevent BHR companies from adopting dry aging are the lack of sufficient aging space to hold product for prolonged periods, as well as the reluctance to accept weight losses due to shrinkage and trimming. Hence, Brazilian BHR institutions were interested to know if combining aging techniques could yield more efficient use of the aging space and generate less processing loss, but still provide the distinctive flavor and tenderness of dry-aged beef. Testing involved starting with either dry or wet aging for the first half the aging period followed by the second aging option for the remainder of aging compared with only wet or dry aging of the beef subprimals for the entire 28 d. No studies have evaluated the combined effects of dry and wet aging according to the authors' knowledge. Thus, the objective was to investigate the effect of dry and wet aging, as well as their combination on the physicochemical and sensory attributes, of ribeye steaks from grain-fed crossbred Zebu steers.

Material and Methods

The study was conducted according to Brazilian Guidelines for the Care and Use of Animals for Scientific and Educational Purposes of the National Council for Control of Animal Experimentation, which were established in 2013. For sensory evaluation, this project was approved by the Research Ethics Committee of the University of Campinas (UNICAMP; Campinas, Brazil) under protocol 1.242.533.

Procurement and processing of subprimals

A group ($n = 120$) of Nellore-influenced steers (36 mo of age and 75% Angus/Hereford × 25% Nellore) were reared alike (corn-based grain finishing diets for 90 d) and harvested in a commercial slaughter facility located at Lins, São Paulo, Brazil, located about 20 km away from the rearing facility, requiring 0.5 h transport time. Animals were slaughtered the next day, within at least 12 h of their arrival following Brazilian standard procedures (Brasil 1997). At 48 h post mortem, a subset of carcasses ($n = 8$), both sides, was selected based on their weight (≈250 kg), whereas no other carcass evaluation was allowed in the plant. At 72 h post mortem, paired bone-in beef rib subprimals [No. 103; North American Meat Processors Association (NAMP 2007)] were obtained from the carcasses, vacuum packed, and immediately shipped under refrigeration at 4 °C to the Meat Science Laboratory at the UNICAMP.

At 96 h post mortem, the shipment arrived at the meat laboratory. Immediately, bone-in beef rib subprimals were pair matched according to carcass origin, removed from vacuum packaging, back fat thickness was measured at the beef rib posterior end [United States Department of Agriculture (USDA 1997)], and a 2.5 cm thick bone-in steak was cut with a butcher saw (Weston Butcher Saw having a 62.5 cm stainless steel blade). This steak was packaged in a multi-laminar, thermo-shrinkable bag (Cryovac® BB 2620, Cryovac Brazil Ltd., 50 μm thick, oxygen permeability of 20 cm^3 m^{-2}, 24 h, at 23 °C, and 75% RH; and maximum carbon dioxide permeability of 100 cm^3 m^{-2}, 24 h, at 23 °C, and 75% RH) by use of a Selovac vacuum-packaging machine (model CV60, São Paulo, Brazil), and frozen for subsequent fat content analysis.

Two additional bone-in 2.5 cm steaks were obtained with the butcher saw from the central portion of the beef rib and assigned to the unaged treatment of each subprimal. The pH and objective color evaluation were performed 1 h after obtaining the steaks at 4 °C and then it was frozen for later shear force analysis. Consequently, equally sized pieces were obtained from a rib pair. Each piece was then randomly assigned to one of the four aging treatments by alternating cranial and caudal portions to avoid position effects. The following treatments were performed: 28 d dry aging (DRY), 28 d wet aging (WET), 14 d dry aging + 14d wet aging (DRY + WET), and 14 d wet aging + 14 d dry aging (WET + DRY). Each carcass was represented equally among aging treatments.

Aging treatments, fabrication, and sampling

Subprimal portions assigned to the DRY and DRY + WET (initial 14 d dry aging) treatments were weighed, placed on stainless steel racks and stored in the aging chamber with subcutaneous fat upward for 28 or 14 d, respectively. Aging was performed in a refrigeration chamber at 2 ± 0.5 °C at an uncontrolled but daily monitored RH of ≈73%, with no airflow. Once the DRY + WET portions completed the first 14 d of dry aging, they were weighed, vacuum packed (Cryovac® BB 2620, Cryovac Brazil Ltd., Jaguariúna, Brazil) and wet aged for an additional 14 d on a stainless steel rack in a cooler at 2 ± 0.5 °C.

The subprimals assigned to the WET and WET + DRY treatments were weighed, vacuum packed and wet aged for 28 or 14 d as described above, respectively. Once the WET + DRY samples completed the first 14 d of wet aging, they were removed from their bags, dried with absorbent paper, weighed, and dry aged for an additional 14 d as described above.

At the end of 28 d aging, samples from different treatments were weighed, except for those from WET and DRY + WET treatments, which were dried before being weighed. Fabrication of portions was performed by experienced meat cutters, and individual weights of bone and dried surfaces or crust were recorded and computed as percent of the sample. After aging, the boneless ribeye samples, 2.5 cm thick steaks were cut from them for measurement of pH, instrumental color, instrumental tenderness, and sensory analysis. Except for pH and instrumental color tests, all samples were frozen immediately at −20 °C and stored until analysis.

pH

Steak pH was measured by inserting in the center the tip of a nonglass pH meter probe (Mettler Toledo MP125, Schwerzenbach, Uster, Switzerland) previously calibrated using buffers at pH 4 and 7. Two measurements per steak were taken, and results were averaged prior to statistical analysis.

Instrumental color

Color measurements were performed on the freshly cut surface of one of the steaks exposed at 4 °C for 1 h using a portable colorimeter (CM 508-d, HunterLab MiniScan™ XE, Reston, VA, USA). The parameters L^* (brightness), a^* (intensity of red/green), and b^* (intensity of yellow/blue) were determined in the CIELAB system, using the following parameters: specular component included, illuminant D65, viewing angle of 8°, and observer angle of 10°, according to the specifications of the Commission Internationale de l'Eclairage (CIE 1978).

Intramuscular fat

Nonaged samples were characterized for intramuscular fat. Steaks were thawed at 4 °C for 24 h prior to analysis. The analysis was performed according to Bligh and Dyer (1959). After removing external fat, the grounded wet tissue was homogenized with a mixture of chloroform and methanol. Dilution with chloroform and water separates the homogenate into two layers, the chloroform layer containing all the lipids and the methanolic layer containing all the nonlipids. A purified lipid extract was obtained merely by isolating the chloroform layer.

Cooking for analysis of instrumental tenderness and sensory characterization

Steaks were thawed at 5 °C for 24 h prior to shear force or sensory evaluation. Sample preparation and cooking procedures were followed according to guidelines described by the American Meat Science Association (AMSA 2016). The steaks were cooked on a clamshell cooking apparatus (George Foreman, Salton, Brazil Ltd., GBZ38220V, China) with a grill-plate temperature set at 180 °C. Steaks were cooked to an internal temperature of 35 °C, flipped, and cooked to a final temperature of 71 °C. Steaks were weighed before and after cooking to calculate cooking losses.

Instrumental tenderness

After cooking, the steaks were cooled (5 °C) for 12 h. Six cores of 1.27 cm diameter were obtained parallel to the longitudinal muscle fiber direction using a coring

Table 1. Means ± standard error of the mean (SEM) ($n = 32$) percent water loss[a] and fabrication yield[a] of beef rib subprimal stratified by aging treatment.

	Aging treatment					
Variable	WET ($n = 8$)	DRY ($n = 8$)	DRY + WET ($n = 8$)	WET + DRY ($n = 8$)	SEM	$P > F$
Rib portion initial weight (kg)	3.86	3.70	3.87	3.94	0.20	0.85
Purge (%)	3.36a	0.00b	0.63b	0.58b	0.36	<0.01
Cooler shrink (%)	0.00d	7.65a	3.49c	4.85b	0.22	<0.01
Total losses during aging[b] (%)	3.36c	7.65a	4.13c	5.43b	0.42	<0.01
Bone (%)	22.00	21.19	23.60	23.59	1.01	0.23
Trimming (crust) (%)	0.00c	9.16a	7.82b	7.41b	0.45	<0.01
Total losses during fabrication[c] (%)	22.00b	30.35a	31.41a	31.00a	0.91	< 0.01
Total losses (aging + fabrication) (%)	25.35b	38.00a	35.54a	36.43a	0.96	<0.01
Total saleable yield (%)	74.64a	62.00b	64.46b	63.57b	1.45	<0.01

Note: Means within a line not sharing a lowercase letter differ significantly at the $P < 0.05$ level. WET, 28 d wet aging; DRY, 28 d dry aging; DRY + WET, 14 d dry aging + 14 d wet aging; WET + DRY, 14 d wet aging + 14 d dry aging.

[a]Percentage of initial subprimal net weight.

[b]Purge + cooler shrink.

[c]Bone + trimming.

cutter. The cylinders were immediately tested by shearing in a TA-XT 2i texture analyzer (Texture Technologies Corp./Stable Micro Systems, UK), equipped with a 1 mm thick Warner-Bratzler blade (AMSA 2016). The Warner-Bratzler shear force (WBSF) values were recorded in kilogram, and the values from the six were averaged for statistical analysis.

Sensory evaluation

The sensory panel used for this study was comprised of eight, highly trained judges. The selection and training were performed according to Cadena et al. (2013) and Damásio and Costell (1991), respectively.

After cooking the steaks, the fat cover and connective tissue were removed and cubes of 1 cm per side were sampled. The cubes were placed in glass containers, covered with plastic tops and held in a Euro-Cuisine digital yogurt maker (model YMX650, Los Angeles, CA, USA) at 40 °C until sensory evaluation. The sensory evaluation was performed in individual booths. Samples were served in disposable plastic containers encoded with random three digit numbers, and water and crackers were provided between samples to avoid residual carry-over effects. A 9 cm unstructured linear scale was used for each descriptor, anchored at the extremes with the terms "little", "absent," or "dry" on the left, and "very" or "wet" on the right (Meilgaard et al. 2007; Stone et al. 2012).

Four samples representing each treatment were served in a monadic manner and the order of presentation was balanced to avoid bias. A total of eight sessions were performed with four samples per session, one from each treatment. Thus, there were four samples for eight assessors and eight replicates.

Statistical analysis

Data were analyzed as a completely randomized design using the MIXED model procedures of SAS version 9.4 (SAS Institute Inc., Cary, NC, USA; SAS 2012) with the aging treatment as a single independent variable. Carcass within treatment was used as the random effect. Least-square means were separated (F test, $P < 0.05$) using least significant differences generated through the PDIFF option. The degrees of freedom in the denominator were adjusted using the Satterthwaite procedure. The covariance effect of back fat thickness (9 ± 1.3 mm) and intramuscular fat (4.5% ± 1.11%) content in the rib muscle was explored, but neither factor influenced any of the dependent variables among treatments.

In addition, χ^2 analysis (Fisher's exact test) was used to examine differences among frequencies for aging treatments to describe the proportion of tender steaks [WBSF value ≤40.13 N (4.09 kg)] using threshold values for tenderness classes described by Rodas-González et al. (2009).

Results and Discussion

Processing yield

Processing yield values by aging treatments are presented in Table 1. Except for initial net weight and bone ($P > 0.05$), aging treatment affected various components associated with aging and fabrication process ($P < 0.01$). In this study, there were no differences in initial net weight and bone of each rib portion because all carcasses were within the targeted 250 kg carcass weight, had similar back fat thickness and beef ribs were divided into equal weight portions, reducing the potential confounding effects on aging and fabrication yield evaluations.

The total moisture weight loss (purge plus cooler shrink) was higher in DRY, followed by WET + DRY, then DRY + WET and WET ($P < 0.05$) because cooler shrink was the highest in DRY, followed by WET + DRY. Although aging treatment had a significant effect on purge, the magnitudes of losses were relatively low among aging

Table 2. Means ± standard error of the mean (SEM) ($n = 32$) of quality characteristics of beef rib steaks stratified by aging treatment.

	Aging treatment						
Variable	Control	WET ($n = 8$)	DRY ($n = 8$)	DRY + WET ($n = 8$)	WET + DRY ($n = 8$)	SEM	$P > F$
pH	5.46b	5.65a	5.66a	5.66a	5.67a	0.01	<0.01
L^*	37.07b	40.06a	38.46b	39.06a	38.79ab	0.90	<0.01
a^*	22.77b	24.42a	24.25a	25.67a	24.64a	0.65	<0.01
b^*	19.71c	21.65b	21.26b	22.88a	21.14b	0.52	<0.01
Chroma	30.11c	32.65ab	32.27b	34.40a	32.49b	0.80	<0.01
Hue	40.89b	41.63ab	41.22ab	41.74a	40.64a	0.38	<0.01
CL (%)	13.97	15.32	16.18	15.84	17.53	1.11	0.25
WBSF (N)	4.67a	3.23b	3.36b	3.29b	3.26b	0.27	<0.01
Tender steaks[a] (%) (n)	50 (4)	87.50 (7)	100 (8)	100 (8)	100 (8)	—	<0.01

Note: Means within a line not sharing a lowercase letter differ significantly at the $P < 0.05$ level. WET, 28 d wet aging; DRY, 28 d dry aging; DRY + WET, 14 d dry aging + 14 d wet aging; WET + DRY, 14 d wet aging + 14 d dry aging. L^*, brightness; a^*, intensity of red/green; b^*, intensity of yellow/blue; CL, cooking loss; WBSF, Warner-Bratzler shear force.

[a]The proportion of tender steaks was calculated using a threshold value for tenderness classes [WBSF value ≤ 40.13 N (4.09 kg)] as described by Rodas-González et al. (2009).

treatments; however, WET resulted in the highest purge losses ($P < 0.05$). In addition, DRY, DRY + WET, and WET + DRY required a greater percentage of trimming compared with WET product during the fabrication, resulting in lower total saleable product ($P < 0.01$).

In agreement with our results, several authors have found that cooler shrink and trim represent the major losses associated with dry aging of beef (Warren and Kastner 1992; Laster et al. 2008; Smith et al. 2008; Dikeman et al. 2013; Li et al. 2014; Kim et al. 2016). It was hypothesized that combining dry with wet aging would reduce the shrink and trim; however, it was not proved and total losses in the combined aging treatments were similar to those in the DRY treatment.

Quality characteristics

Aging increased the pH of steaks (from 5.46 to 5.67; $P < 0.05$); however, no significant differences were observed in pH values among aging treatments ($P > 0.05$; Table 2). These results are in agreement with other studies on dry-aged versus unaged and wet-aged beef (Parrish et al. 1991; Boakye and Mittal 1993; Li et al. 2014; Stenström et al. 2014; Kim et al. 2016). This effect is probably due to the action of proteolytic enzymes, which cause cellular membrane leakage and produce ion migration raising the net protein charge (Boakye and Mittal 1993). However, some authors have found lower pH values in wet-aged samples (Dikeman et al. 2013; Li et al. 2014). Higher lactic acid bacteria numbers in wet-aged samples may reduce the pH of wet-aged samples due to the production of lactic acid during storage (Bañón et al. 2012; Li et al. 2014); however, this was not found in this study.

Changes in the instrumental color coordinates were observed during aging (Table 2). The aged samples presented higher L^*, a^*, b^*, chroma and hue values (lightness and vividness of red color) with respect to control samples ($P < 0.05$). No differences ($P > 0.05$) in instrumental color parameters were observed among treatments, except for b^*, chroma and hue values, where DRY + WET achieved the highest values. In agreement with the current study results, several researchers have reported an increase in L^*, a^* (Marino et al. 2014; Kim et al. 2016), and b^* coordinates (Boakye and Mittal 1996) in aged meat. Although aging may reduce the ability to bloom and subsequent color stabilitiy of meat vacuum packaged (Robertson et al. 2007), blooming of meat depends on oxygen availability, oxygen diffusion into the meat, and oxygen consumption rate. This latter factor will be decreased at the end of the aging period (inactivation of oxygen-utilising enzymes); therefore, in fresh meat blooming occurs more rapidly (Joseph and Connolly 1977; Ledward 1992), because increased penetration of oxygen creates a deeper layer of oxymyoglobin, providing a redder and more desirable color (MacDougall 1972). In addition, greater water loss in dry aging, can lead to greater light reflection from the meat surface making it appear pale (Kim and Hunt 2011; Kim et al. 2016). In contrast, Li et al. (2014) found no differences between the instrumental color of dry-aged and wet-aged samples.

No significant differences were observed for cooking loss between the unaged and aged samples (Table 2), which was also observed by other authors (Warren and Kastner 1992; Dikeman et al. 2013; Stenström et al. 2014). Regarding WBSF, aged samples presented lower ($P < 0.05$) values when compared with unaged samples, but no significant differences were observed among aging treatments (Table 2). In addition, the assignment of cooked steaks into tenderness levels indicated that aged samples (wet/dry aging, whether combined or not) presented the highest proportion of tender steaks (>87%; $P < 0.01$). These results are in agreement with those of other researchers (Smith et al. 2008; Dikeman et al. 2013). However, Laster et al. (2008)

Table 3. Means ± standard error of the mean (SEM) ($n = 32$) of sensory descriptors of beef rib steaks stratified by aging treatment.

	Aging treatment					
Descriptor	WET ($n = 8$)	DRY ($n = 8$)	DRY + WET ($n = 8$)	WET + DRY ($n = 8$)	SEM	$P > F$
Dry/humid aspect	4.15	4.97	4.85	4.23	0.34	0.22
Blood aroma	1.87	1.97	2.22	1.78	0.27	0.52
Roast beef aroma	5.94	6.05	5.80	6.16	0.25	0.72
Off-aroma	0.44	0.11	0.26	0.22	0.16	0.26
Initial tenderness	6.78	6.56	6.47	6.68	0.28	0.86
Sustained tenderness	6.44	6.37	6.44	6.68	0.29	0.88
Juiciness	4.09	4.68	4.16	4.23	0.33	0.55
Roast beef flavor	5.92	6.09	5.97	6.13	0.26	0.91
Umami flavor	1.70	1.46	1.59	1.57	0.15	0.71
Blood flavor	1.88	1.95	1.96	1.81	0.28	0.95
Acidity flavor	0.89	0.67	0.63	0.78	0.16	0.48
Off-flavor	0.25	0.25	0.19	0.34	0.06	0.30

Note: WET, 28 d wet aging; DRY, 28 d dry aging; DRY + WET, 14 d dry aging + 14 d wet aging; WET + DRY, 14 d wet aging + 14 d dry aging.

indicated that WBSF values were lower in wet-aged than in dry-aged ribeye.

Sensory analysis

In this study, trained panelists were unable to identify differences among aging treatments for any of the attributes evaluated ($P > 0.05$; Table 3).

Other authors observed different findings regarding the sensory characteristics between wet- and dry-aged meats. Parrish et al. (1991), using trained panelists reported that wet-aged samples showed higher scores for tenderness and overall palatability, but not for flavor intensity. However, other authors have reported no difference in tenderness, but they found higher flavor intensity in dry-aged products when compared with those wet aged, detecting umami, butter-fried meat flavor, or beefy and roasted flavor (Warren and Kastner 1992; Li et al. 2014). On the other hand, Li et al. (2014) reported more noticeable metallic odor in wet-aged samples when compared with dry-aged samples as assessed by trained panelists.

Evaluation performed by consumer, Sitz et al. (2006) reported higher scores for overall acceptance, tenderness, and flavor in wet-aged US Prime top loin when compared with equivalent dry-aged steaks; however, differences between aging techniques were not detected with US Choice loins. Laster et al. (2008) reported that wet-aged ribeye steaks were considered just more tender by consumers when compared with dry-aged steaks. In contrast, other researchers have reported that consumers considered the dry-aged samples more tender (Li et al. 2014) or more flavorful (having intense flavor) and overall were preferred over wet-aged loins (Kim et al. 2016). Some authors found no sensory differences between dry- and wet-aged samples using either consumers (Smith et al. 2008) or trained panelists (Dikeman et al. 2013).

It is considered that dry aging develops unique and distinct flavors, facilitates oxidative changes in lipids, enhances formation of volatile compounds, and moisture loss [through purge and (or) cooler shrink] during aging, which may contribute to the development of more pronounced meat flavor resulting from the concentration of meat flavor compounds in dry-aged meats (DeGeer et al. 2009). The latter assessment was not supported in this study. In this sense, in all aging treatments off-aroma, off-flavor, and the development of their descriptors (e.g., blood and acidity) obtained lower score than pleasant ones (e.g., roast beef).

Conclusion

Trained panelists were not able to detect any difference in palatability characteristics among aging treatments. In addition, products from dry aging alone or combined treatments generated higher processing losses and lower saleable yields when compared with wet aging. According to the present observations, the combination of both aging techniques would not be a suitable alternative for the development of dry-aged products when there are not palatability differences sufficient to justify increasing the price to compensate for the processing loss. The wet-aging process alone appears to be a valuable strategy for Brazilian BHR institutions to more consistently maximize palatability characteristics of beef without incurring higher processing losses and fulfill the demand in the market of consumers eager for an exceptional eating experience.

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