Effects of Relative Humidity on Meat Quality in Dry Aged Beef

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Summary with Implications

During dry-aging, water is transferred from the interior to the meat surface and is subsequently evaporated to the surrounding environment. There is a common belief in the meat industry that rapid drying creates a hard crust on the meat surface, which would act as a protective barrier against moisture loss, holding moisture on the inside of the product. This phenomenon is called case hardening. If this hypothesis is correct, drying at low relative humidity would be recommended in order to get case hardening and avoid excessive yield loss. This study was conducted to evaluate the effects of relative humidity on moisture loss and flavor in dry-aged beef. No case hardening effects occurred, even at 50% relative humidity. Results suggest lower relative humidity results in more rapid moisture loss at the beginning of the aging process without significantly affecting the total amount of moisture loss. Lower relative humidity tended to associate with more desirable flavor notes.

Introduction

Although enhanced flavor has been extensively used to promote dry-aged beef, evidence that dry aging benefits flavor is still unclear. During dry aging, water is evaporated and flavor compounds are concentrated, making the beef flavor stronger. However, not all studies have found improved flavor for dry-aged beef. These conflicting results may be associated with inconsistent environmental conditions applied during the dry aging process.

Relative humidity (RH) is important because it can affect the water evaporation rate. If RH is too low, excess product shrinkage and crust formation occur due to rapid evaporation of water. Conversely, if RH is too high, spoilage bacteria can grow and result in off-flavors. The objective of this research was to evaluate the impact of low RH during dry aging on moisture and trim loss, tenderness, and flavor. The working hypothesis was rapid drying would create a hard crust on the meat surface that could reduce moisture release over time, thereby reducing weight loss, enhancing tenderness (by retaining more water), and altering flavor when compared with dry aging at higher RH.

Procedure

Sixteen USDA low Choice boneless strip loins were assigned to 1 of 4 aging treatments: vacuum (Wet), dry-aging at 50% RH (RH50), dry-aging at 70% RH (RH70), or dry-aging at 85% RH (RH85). Loins were placed in individual dry aging chambers and aged for 42 days at 35°F and 2200 revolutions per minute (RPM) fan speed. Wet-aged loins were stored in vacuum packages in the same cooler for 42 days. After aging, loins were trimmed of dehydrated lean/fat, fabricated into steaks and evaluated for trim loss, yield, tenderness via Warner-Bratzler shear force (WBSF), and sensory analysis.

A computerized dry aging system was designed and built capable of measuring and precisely controlling RH (± 1 %), temperature (± 0.9 °F), and air velocity (± 50 RPM). The chambers have built-in weighing scales that can continuously monitor weight loss (± 5 g). All measured data can be saved on the connected computer in intervals of 1 second. The percentage daily water loss for dry-aged loins was calculated as the difference between the prior day weight and current weight divided by the prior day weight. The percentage total water loss for dry-aged loins was calculated as the difference between initial weight and final weight divided by the initial weight. The dry-aged loins were then further processed by trimming dried surfaces and non-edible fat, and reweighed to calculate the yield (%) after aging and trimming. The processing weight loss for the wet-aged loins during aging was calculated as the difference between initial weight and purge loss.

Steak internal temperature and weight were recorded prior to cooking. Fresh (never frozen) steaks (1 inch thick) were cooked to a target temperature of 160°F on a Belt Grill. After cooking, internal temperature and weight were recorded. Then, steaks (n = 16) were individually bagged and stored overnight at 36°F for further WBSF analysis. The following day, six (½ inch diameter) cores were removed with a drill press parallel to the orientation of the muscle fibers. Cores were sheared using a Food Texture Analyzer with a Warner-Bratzler blade. Peak WBSF values from each steak were averaged for statistical purposes.

Triangle tests were conducted in two sessions with 32 consumers each. In the first session, panelists were served samples from the RH50% and RH85% treatments to compare the extremes in dry aging conditions. In the second session, panelists were served samples from the Wet and RH70% treatments to compare wet aging to dry aging. Each panelist received three, 3-digit blind coded samples (½ inch × ½ inch × 1 in thickness) cut by avoiding the edges and fat kernels of the steaks. Two of these samples were identical and one was different. Panelists were asked to circle the number of the sample they perceived to be different in flavor.

A beef flavor attribute panel was trained to scale ten basic flavors from the beef lexicon on a 16-point intensity scale (0 = none and 15 = extremely intense). For sample testing, panelists (n = 6) were served two random cubes (½ inch × ½ inch × 1 in thickness) assigned a 3-digit blind code, avoiding the edges and fat kernels of the

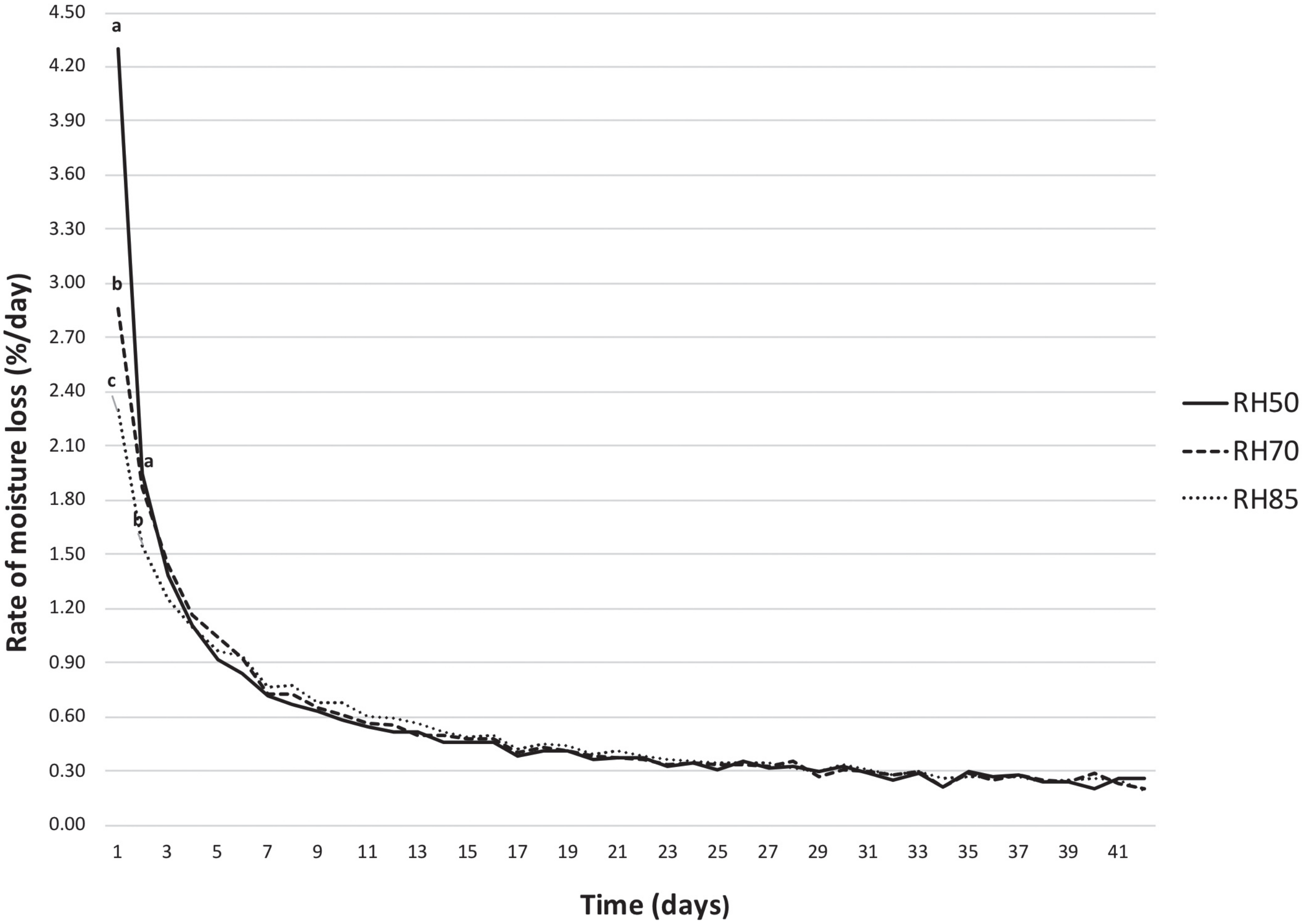

Figure 1. Rate of moisture loss (%/day) of strip loins dry aged for 42 days at 50, 70 or 85% relative humidity (RH).

Table 1. Total moisture loss, trim loss, yield, and Warner-Bratzler shear force values of strip loins wet or dry aged for 42 days at 50, 70 or 85% relative humidity.

	Treatment				
	Wet	RH50%	RH70%	RH85%	*P*-value
Moisture loss (%)	1.14[a]	23.87[b]	23.20[b]	22.64[b]	< 0.05
Trim loss (%)	0.0[a]	14.86[b]	14.58[b]	14.99[b]	< 0.05
Yield (%)	98.86[a]	61.27[b]	62.22[b]	62.37[b]	< 0.05
WBSF (kg)	2.62	2.56	2.29	2.27	0.66

[a,b] Means in the same row with different superscripts differ ($P < 0.05$).

steak, in a plastic cup while in a breadbox style booth under red lighting. Salt-free crackers and double-distilled, deionized water were offered as palette cleansers.

Rate of moisture loss was analyzed as a complete randomized design with day of aging as the repeated measure. Trained panel results were analyzed using principal component analysis (PCA). All the other data were analyzed as a completely randomized design. Chamber (loin) was considered the experimental unit (n = 16; 4/treatment). Data were analyzed using the PROC GLIMMIX procedure of SAS with α = 0.05.

Results

Wet-aged samples had lower moisture loss, trim loss and higher yield than all dry-aged treatments ($P < 0.05$, Table 1). The rate of moisture loss for dry-aged treatments is presented in Figure 1. The RH50 treatment had a faster rate of moisture loss than RH85 on the first day of aging ($P < 0.05$), while RH70 was intermediate. The RH50 and RH70 treatments had faster rates of moisture loss than RH85 on days 2 and 3 of aging ($P < 0.05$). From day 4 onward, no differences in rate of moisture loss among RH treatments were found ($P > 0.05$). There were no differences among RH treatments for total moisture loss, trim loss, and yield ($P > 0.05$). There is a commonly-held belief in the meat industry that rapid drying creates a protective crust on the meat surface, thereby locking in moisture. However, this research showed the protective crust concept is incorrect. The lower RH resulted in more rapid moisture loss (days 1 to 3) without significantly affecting the total amount of moisture loss after 42 days. This suggests RH has relatively little effect on weight loss.

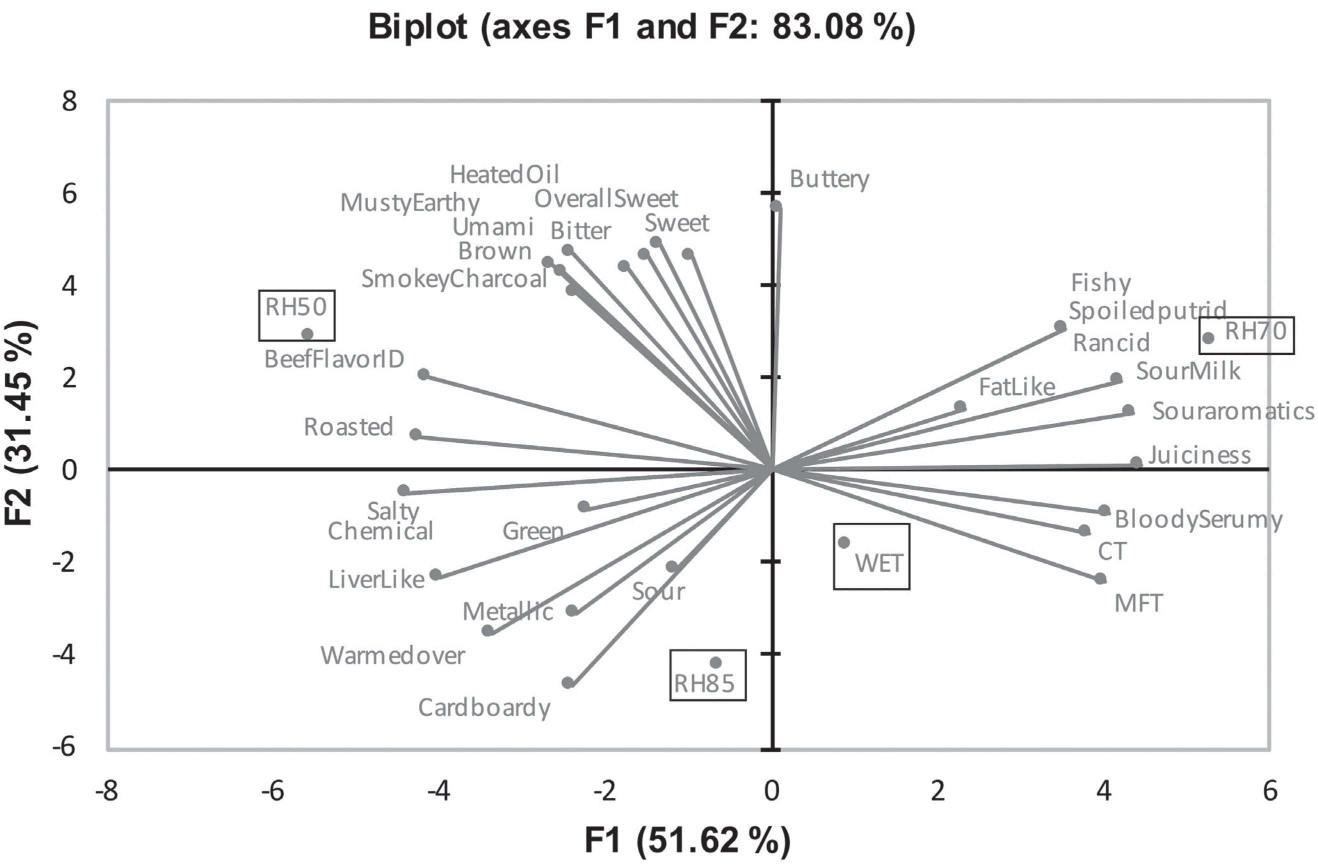

Figure 2. Principal component biplot of sensory attributes where RH50 = dry aged loins at 50% relative humidity (RH), RH70 = dry aged loins at 70% RH, RH85 = dry aged loins at 85% RH, and WET = wet aged loins for trained sensory panel.

No differences among treatments for WBSF were found (*P* = 0.66; Table 1). Improvements in tenderness through the aging process occur regardless of the aging method used (wet or dry) as the mechanism of beef tenderization (proteolysis) is independent of oxygen. Although dry aging improves beef tenderness, this aging method has not been used to promote a tenderness advantage in comparison to wet aging; instead, dry aging is mainly used for intensifying flavors.

Results from the triangle test indicated consumers detected a difference in flavor between Wet and RH70 (*P* = 0.02). However, consumers did not detect flavor differences between RH50 and RH85 (*P* = 0.14). No differences among treatments were found for flavor notes using analysis of variance. Using PCA, two factors explained 83% of the variation in sensory attributes (Figure 2). The RH50 treatment tended to be associated with relatively positive flavor notes, including beef flavor identity, roasted, umami, smoky/charcoal, heated oil, bitter, and brown flavor. The RH70 treatment tended to associate with sour milk, sour aromatics, rancid, and fishy flavor, while RH85 tended to associate with oxidized flavors like cardboard, warmed-over, metallic, green, liver-like and sour flavor notes. Wet aged steaks were fairly neutral in flavor notes. The lower RH results in more rapid moisture loss at the beginning of the aging process without significantly affecting the total amount of moisture loss. Trim loss, yield, and tenderness were not affect by RH during dry aging. These results suggest speed of moisture loss does not impact the quality of dry-aged beef.

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