Comparison of Carcass Appearance, Texture Quality, and Sensory Profile of Broilers Chilled by Air, Evaporative Air or Water Immersion

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Introduction

Recently, Air chilling (AC) is gaining in popularity in the United States from both consumers and processors especially after the revision of US federal regulation (USDA, 2001), restricting moisture retention on poultry carcass. Several poultry processors in the United States adopted the AC technology and promoted air-chilled chickens with a premium, natural or organic brand. There are some published data comparing the properties of AC versus water chilling (WC) on meat quality and sensory profiles in the United States (Huezo et al., 2007; McKee, 2001). However, not much research has been conducted for the comparison of three chilling methods (air, water, and evaporative air) on broiler carcass quality and sensory properties. Therefore, the objectives of this research were to: (1) evaluate the effects of scalding/chilling methods on broiler carcass appearance, the amount of moisture pickup (or loss), stability of the absorbed water, and moisture contents at 5 different carcass locations; (2) assess the effects of "scalding/chilling methods" on breast fillet quality, water holding capacity, protein functionality, gel forming ability, sensory profiles and cooking loss.

Materials and Methods

Experiment 1. A total of 99 male birds were traditionally processed at Michigan State University meat laboratory. In each replication, 11 birds were subjected to hard scalding (56.7 °C, 120 sec) for WC, whereas 22 birds received soft scalding (50 °C, 220 sec) for either AC or EAC. After evisceration and washing, carcasses were weighed (prechill weight) and tagged on the wing. The carcasses were then assigned to 1 of 3 chilling treatments: 1) ice slush for WC, 2) air blowing (1.0 m/sec, 0 °C) for AC, and 3) air blowing and cold water spraying (every 5 min) for EAC in a chilling room. After chilling, each carcass was weighed (postchill weight) and surface skin color was instrumentally measured. Visual evaluation was conducted by a 10 -12 trained panel with a 9-point scale. At 5 h after death, all carcasses were fabricated into breasts, thighs, drumsticks, and back. Each part was weighed immediately after-fabrication, 24 h post-fabrication, vacuum-packaged, and frozen for subsequent moisture determination.

Experiment 2*.* A total of 189 male birds were similarly processed under the conditions as described in Experiment 1. At 5 h postmortem, surface color (CIE L*a*b*) were immediately taken on the skinless breast fillets. The following day, pH and moisture, cooking yield, shear force were measured. From cooked gels (breast), moisture content, cooking yield, and torsion values were assed. Panelists (210 consumers) were asked to evaluate cooked breast fillets for flavor, texture, juiciness, overall acceptability on a 9-point hedonic scale (9 = like extremely and 1 = dislike extremely).

Results

Experiment 1**.** During chilling, carcass temperature was most effectively reduced by WC (55 min), followed by EAC (120 min), and AC (155 min) (Fig. 1). After the chilling, both WC and EAC carcasses picked up moisture by 4.6% and 1.0% of their weights, respectively, whereas AC carcasses lost their weight by 1.5% (Table 1). Upon cutting at 5 h postmortem, WC carcasses showed the highest moisture loss (2.6%), the second (0.4%) by EAC, and the least (0.3%) by AC. After 24 h storage, almost 83% of the absorbed water came out as purge in WC carcass parts whereas EAC and AC maintained their weights as close as the pre-chilled weights (Table 1). When moisture contents of 24 h-aged carcass parts (breast, wing, thing, drumsticks, and back) were measured, no significant differences were found on each of 5 parts among the chilling methods (data not shown). In instrumental color and visual evaluations by panelists, AC carcasses showed darker appearance, more yellow color, and surface discoloration than WC or EAC carcasses (Table 2, 3).

Experiment 2**.** No significant difference was found among the chilling methods in moisture content, cooking yield, and shear force of deskined breast fillets stored overnight (Table 4). However, the pH (5.6) of 24 h-stored fillets was higher in WC than in AC (5.5) and EAC (5.5). In surface color of skinless breasts, WC showed a higher CIE L* value than AC or EAC, whereas AC exhibited more red (higher CIE a*) and yellow (higher CIE b*) than other two chilling methods (Table 4). When raw breast meat was made into gels, there was no significant difference in cooking loss, moisture content, shear stress, and shear strain, regardless of chilling methods (Table 5). In consumer sensory evaluations, AC breasts showed a higher juiciness score than WC and EAC breasts, but no significant difference was found for flavor, texture, and overall acceptability (Table 6).

Discussion

Up to today, water chill has been a common chilling method in the United States mainly due to chilling efficacy and no weight loss. Currently, the generic advantages of WC are challenged by water shortage, cost of waste management, and revised USDA rules. WC appears to have some up-front advantages during chilling, however AC possesses more potential advantages after-the-chilling such as water saving, reduced waste management, and juicier product. Additional information for the overall benefits of three chilling methods are required to compare not just for a poultry chilling step but for the entire processing, including value added products and environmentally friendly processing for the future.

References

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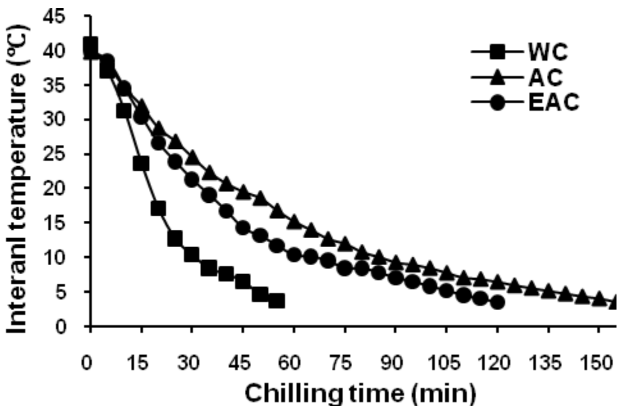

Fig. 1. Temperature change profiles of broiler breast fillets during WC, AC, or EAC. ■: water chilling, ▲: air chilling, ●: evaporative air chilling.

Table 1. Chilling yield, fabrication yield, and 24-h purge loss of broiler carcasses chilled by one of three chilling methods

Chilling[1]	Chilling yield[2] (%)	Fabrication yield[3] (%)	Purge loss of each part (%)[4]					
			Breast	Wing	Thigh	Drumstick	Back	Average
WC	104.6[a]	102.1[a]	1.5[a]	1.1[a]	1.3[a]	0.7[a]	1.4[a]	1.3[a]
AC	98.5[c]	98.2[c]	0.8[b]	0.4[b]	0.2[b]	0.2[b]	0.3[b]	0.5[b]
EAC	101.0[b]	100.5[b]	0.8[b]	0.5[b]	0.2[b]	0.3[b]	0.4[b]	0.5[b]

[a-c]Means within a columm with unlike superscripts are different ($P < 0.05$).
[1]WC = water chilling; AC = air chilling; EAC = evaporative air chilling.
[2]Measured immediately after chilling (The number of observations in each chilling, n = 30).
[3]Measured after cutting at 5 h postmortem (The number of observations in each chilling, n = 30).
[4]Measured after overnight storage (The number of observations in each chilling, n = 30).

Table 2. The surface skin color[1] in 5 different locations of broiler carcasses chilled by one of three chilling methods

Traits	Chilling[2]	Breast	Wing	Thigh	Drumstick	Back
CIE *L**	WC	64.9[a]	68.9[a]	68.5[a]	61.5[a]	70.9[a]
	AC	63.1[b]	67.2[b]	67.0[b]	59.6[b]	68.9[c]
	EAC	63.3[b]	69.3[a]	67.1[b]	61.1[a]	70.2[b]
CIE *a**	WC	3.2[a]	4.1[a]	3.4[a]	4.0[a]	4.6[a]
	AC	2.1[b]	3.2[b]	2.7[b]	3.1[b]	3.3[b]
	EAC	1.8[b]	2.7[c]	2.2[c]	2.7[c]	2.8[c]
CIE *b**	WC	4.7[a]	4.6[c]	2.8[c]	0.9[c]	4.7[c]
	AC	4.3[ab]	7.0[a]	6.8[a]	2.1[a]	7.7[a]
	EAC	3.8[b]	6.0[b]	5.0[b]	1.5[b]	6.5[b]

[a-c]Means within a color trait and columm with unlike superscripts are different ($P < 0.05$).
[1]The number of observations in each chilling for each part and color trait, n = 180.
[2]WC = water chilling; AC = air chilling; EAC = evaporative air chilling.

Table 3. The mean values[1] of visual appearances evaluated by trained panelists of broiler carcasses chilled by one of three chilling methods

Chilling[2]	Intensity of yellow color	Intensity of white color	Appearance defects 1 (dark-spot)	Appearance defects 2 (bleach-like spot)	Surface moisture (dryness/ wetness)
WC	1.7[c]	4.0[ab]	1.6[c]	1.9[b]	7.4[a]
AC	3.8[a]	3.8[b]	4.2[a]	3.8[a]	2.4[c]
EAC	3.1[b]	4.3[a]	1.9[b]	4.0[a]	5.5[b]

[a-c]Means within a columm with unlike superscripts are different ($P < 0.05$).
[1]The number of observations in each chilling for each attribute, n = 360; Based on a 9-point scale (9 = most yellow, most white, extremely defected and extremely wet, and 1 = least yellow, least white, none and extremely dry).
[2]WC = water chilling; AC = air chilling; EAC = evaporative air chilling.

Table 4. Effects of chilling methods on the properties of raw and cooked broiler breast fillets

Properties[1]	Water	Air	Evaporative-air
pH	5.6[a]	5.5[b]	5.5[b]
Moisture (%)	75.1[a]	75.4[a]	75.6[a]
Cooking yield (%)	75.9[a]	74.4[a]	75.5[a]
Shear force (N)	13.7[a]	12.0[a]	11.4[a]
CIE *L**	53.4[a]	49.6[c]	51.1[b]
CIE *a**	2.9[b]	3.4[a]	3.0[b]
CIE *b**	2.6[b]	3.4[a]	3.0[ab]

[a-c]Means within a row with unlike superscripts are different ($P < 0.05$).
[1]pH, moisture, cooking yield, and shear force values were measured after 24 h postmortem, and CIE $L^*a^*b^*$ values were measured immediately after chilling and being skinned. Number of observations in each chilling, n = 60 (pH); 10 (moisture); 30 (cooking yield); 60 (shear force); 360 ($L^*a^*b^*$, each).

Table 5. Effect of chilling methods on moisture content, cooking yield, and functional properties of gels made from broiler breast meat

Properties[1]	Water	Air	Evaporative-air
Moisture (%)	78.8[a]	78.8[a]	78.7[a]
Cooking yield (%)	85.8[a]	85.3[a]	86.5[a]
Shear stress (kPa)	25.6[a]	25.8[a]	25.7[a]
Shear strain	1.3[a]	1.3[a]	1.4[a]

[a]Means within a row with unlike superscripts are different ($P < 0.05$).
[1]All values were measured from the cooked and 24 h stored gels. Number of observations in each chilling, n = 10 (moisture); 15 (cooking yield); 30 (shear stress/strain).

Table 6. Effect of chilling methods on consumer sensory attributes of cooked broiler breasts after 24 h of storage

Attributes[1]	Water	Air	Evaporative-air
Flavor	6.4[a]	6.4[a]	6.5[a]
Texture	6.4[a]	6.7[a]	6.4[a]
Juiciness	6.2[b]	6.6[a]	6.0[b]
Overall acceptability	6.3[a]	6.2[a]	6.5[a]

[a,b]Means within a row with unlike superscripts are different ($P < 0.05$).
[1]All values were measured from the central portions of cooked breasts. Scores based on 9-point hedonic scale, where 9 = like extremely and 1 = dislike extremely. n = 210 (each attribute).