EFFECT OF HIGH HYDROSTATIC PRESSURE ON MICROBIAL AND PHYSICOCHEMICAL PROPERTIES OF AGED DUCK BREAST MEAT

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Abstract – The aim of this study was to examine the effect of high hydrostatic pressure (HHP) on microbial and physicochemical characteristics of duck breast meat with different aging methods. Twelve birds of 8-wk-old *Woorimatori*™, Korean native duck, were slaughtered and breast meat was obtained. The vacuum-packed breast meat was pressurized at 400 MPa and aged by dry- and wet-aging methods. For dry-aging, a specific dry-aging bag was used. Microbial analysis, cooking loss and color were determined. HHP decreased the number of total aerobic bacteria by 3-4 log CFU/g. Dry-aged duck did not show any significant difference in the L*-value regardless of HHP treatment while the a*-value was significantly lower in dry-aged duck and had no difference by HHP treatment. Based on the result, HHP treatment at 400 MPa can enhance microbial safety of duck breast meat during aging. It may be more useful for dry-aging for aging method as it did not cause any changes in color.

Key Words – Dry-aging, High pressure, *Woorimatori*™

I. INTRODUCTION

With recent increases in consumption of meat, consumers prefer to higher-quality and new meat product such as aged-meat. The aging can increase eating quality attributes of meat such as flavor, juiciness and/or tenderness by activation of endogenous enzymes [1, 2]. There are two types of aging: dry- and wet-aging. Wet-aging can develop tasty meat product in a short time and dry-aging can make unique flavor.

Recently, duck meat consumption has been increased in the world as duck meat is considered as healthier meat source due to higher unsaturated fatty acid, low-cholesterol, and high-protein contents [3]. Moreover, it contains 70 to 90% oxidative red muscle, resulting in closer flavor to red meat, therefore, there may be a possibility for application of aging for duck meat [4, 5].

Microbial safety of duck meat and duck meat products is a major concern and dry-aging are more prone to microbial contamination. Thus, a certain method should be applied to maintain microbial safety of duck meat products during aging. High hydrostatic pressure (HHP) has been introduced as non-thermal method which can secure microbial safety effectively while minimizing destruction of nutrients [6].

Therefore, the aim of this study was to examine the effect of HHP on microbial and physicochemical characteristics of duck breast meat during 3 weeks of aging.

II. MATERIALS AND METHODS

Sample preparation

Twelve birds of 8-wk-old *Woorimatori*™, newly developed Korean native duck, were purchased from a local farm, slaughtered, and deboned in the laboratory. The obtained breasts were packaged in a sterilized oxygen-impermeable nylon bag (2 mL O_2/m^2/24 h at 0°C, 0.09 mm thickness; Sunkyung Co. Ltd., Seoul, Korea), transported to Korea Food Research Institute (Seongnam, Korea) in a cooled container, and immediately subjected to HHP at 400 MPa for 5 min with the initial temperature of the pressure vessel set at 15±3°C. The level of HHP was selected based on the result of preliminary study [7]. The dry- and wet-aged groups were packed in the nylon bag and bag for specifically dry-aging (Drybagsteak LLC, Minneapolis, MN, USA), respectively. Both groups were aged at 1-4°C and 75% of humidity for 3 weeks.

Total aerobic bacterial counts

The samples (5 g) were blended with sterile saline (45 mL, 0.85% NaCl) for 2 min using the Stomacher BagMixer® 400 (Interscience Co., St Nom, France) and then serially diluted in sterile saline. Each diluent (100 μL) was spread on the tryptic soy agar (Difco Laboratories, Detroit, MI, USA) and the agar plates were incubated at 37 °C for 48 h. The microbial counts were expressed as log CFU/g.

Cooking loss

Meat samples (30 g) were vacuum packed (HFV-600L, Hankook Fujee Co., Ltd., Korea), heated in a water bath at 90°C for 15 min until a core temperature of 72°C was reached, and cooled in iced water. After recording the final weight, cooking loss was calculated as the percentage weight loss of each meat sample after cooking.

Surface color

The meat color value of each breast was measured on the surface of the breast meat sample using a spectrophotometer (CM-5, Minolta Co., Ltd., Osaka, Japan). L* (lightness) and a* (redness) values were determined.

Statistical analysis

Statistical analysis was performed using one-way analysis of variance (ANOVA) and the significant differences between the mean values were identified with Tukey's multiple range test using SAS software at a confidence level of $P<0.05$ (SAS 9.3, SAS Institute Inc., Cary, NC, USA).

III. RESULTS AND DISCUSSION

Number of Total aerobic bacteria (TAB)

TAB in HHP-treated groups was significantly decreased, except for dry-aged group at 3 week (Table 1). TAB in wet-aged group without HHP exceeded the 7 log CFU/g which is the point of spoilage, however, HHP significantly decreased TAB by 3-4 log CFU/g. HHP treatment can cause alterations of genetic material, osmotic changes, and other changes to microbial cellular membranes, resulting in cell death [6, 8].

Table 1. Effect of high hydrostatic pressure (HHP) on total aerobic bacteria (log CFU/g) of duck breast during storage at 4°C

Storage (week)	Aging method	Pressure (MPa)		SEM[1)]
		0.1	400	
0	-	4.68	4.29	0.132
1	Dry	5.69^{ay}	3.33^{by}	0.019
	Wet	7.41^{ax}	3.55^{bx}	0.108
	SEM[2)]	0.103	0.038	
2	Dry	6.19^{ay}	4.50^{b}	0.286
	Wet	7.90^{ax}	4.40^{b}	0.060
	SEM[2)]	0.288	0.055	
3	Dry	5.35^{y}	5.87	0.274
	Wet	9.13^{ax}	5.43^{b}	0.599
	SEM[2)]	0.286	0.594	

[1)]Standard error of means (n=6), [2)](n=6).
[a,b]Different letters within the same row differ significantly ($P<0.05$).
[x,y]Different letters within the same column during the same week differ significantly ($P<0.05$).

Cooking loss

The cooking loss was significantly increased in HHP-treated groups after 1 week storage (Table 2). This increase is possibly due to more severe shrinkage and myofibrillar changes by HHP treatment [9]. However, no significant differences were found at 2 and 3 week and this result is considered as the consequence of large decrease of water content at 1 week (data not shown).

Table 2. Effect of high hydrostatic pressure (HHP) on cooking loss (%) of duck breast during storage at 4°C

Storage (Week)	Aging method	Pressure (MPa)		SEM[1)]
		0.1	400	
0	-	29.19	33.86	1.508
1	Dry	10.01^{b}	34.75^{a}	1.982
	Wet	15.75^{b}	35.01^{a}	2.344
	SEM[2)]	2.806	1.245	
2	Dry	4.11^{y}	5.62^{y}	1.566
	Wet	35.35^{x}	35.48^{x}	1.461
	SEM[2)]	1.188	1.783	
3	Dry	3.46^{y}	2.95^{y}	1.412
	Wet	36.22^{x}	34.62^{x}	0.913
	SEM[2)]	1.348	1.006	

[1)]Standard error of means (n=6), [2)](n=6).
[a,b]Different letters within the same row differ significantly ($P<0.05$).
[x,y]Different letters within the same column during the same week differ significantly ($P<0.05$).

Surface color

Table 3 shows effect of HHP treatment on L* and a*values of duck breast with different aging methods. The L^*-value of wet-aged duck breast was increased with HHP treatment due to the whitening effect, the well-known phenomenon caused by high expressible moisture from HHP treatment at high level [9, 10]. However, dry-aged duck breast did not show any difference in the L^*-value regardless of HHP treatment, while the a^*-value was significantly lower in dry-aged duck and had no difference according to HHP treatment. The extraordinary tendency in L^*- and a^*-values of dry-aged duck may be due to water evaporation. The a^*-value is related with water content of meat surface. In the case of dry-aged meat, it has lower water-content on its surface which causes high absorption of the light, resulting in low a^*-value and dark-red color of dried surface [2]; therefore, low expressible moisture of dry-aging may minimize the adverse changes in surface color by whitening effect.

Table 3. Effect of high hydrostatic pressure (HHP) on L^* and a^*values of duck breast during storage at 4°C

	Storage (Week)	Aging method	Pressure (MPa)		SEM[1)]
			0.1	400	
L^*-value	0	-	45.26^{b}	59.96^{a}	1.783
	1	Dry	43.30	43.33	0.151
		Wet	38.47	42.92	2.821
		SEM[2)]	2.771	0.552	
	2	Dry	43.59	2.92^{y}	0.511
		Wet	45.72^{b}	57.79^{ax}	0.916
		SEM[2)]	0.843	0.624	
	3	Dry	43.26^{y}	44.08^{y}	0.373
		Wet	45.36^{bx}	58.81^{ax}	0.331
		SEM[2)]	0.273	0.416	
a^*-value	0	-	14.79	14.56	0.568
	1	Dry	4.40^{y}	4.66^{y}	0.286
		Wet	14.72^{x}	14.72^{x}	0.452
		SEM[2)]	0.392	0.364	
	2	Dry	2.40^{y}	2.69^{y}	0.371
		Wet	13.98^{x}	14.75^{x}	0.422
		SEM[2)]	0.264	0.496	
	3	Dry	1.94^{y}	2.17^{y}	0.167
		Wet	13.92^{x}	13.57^{x}	0.220
		SEM[2)]	0.147	0.235	

[1)]Standard error of means (n=6), [2)](n=6).
[a,b]Different letters within the same row differ significantly ($P<0.05$).
[x,y]Different letters within the same column during the same week differ significantly ($P<0.05$).

IV. CONCLUSION

HHP treatment at 400 MPa can enhance microbial safety of duck meat during aging. Dry-aging may have merit due to less color change than wet-aging. Further research in the changes of flavor compounds and sensory evaluation is desired for better understanding of HHP treatment on dry-aged duck.

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