PROFILING OF VOLATILE COMPOUNDS IN THIGH MEAT FROM KOREAN NATIVE CHICKENS AND COMMERCIAL BROILERS

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***Abstract*—The objectives of this study are to profile volatile compounds (VC) in thigh meat from KNC and CB and to identify differences in the VC pattern between the two meat sources in multiple stages of growth. Totals of 201 KNC and 200 CB fed commercial broiler diets were used in this study. KNC and CB were killed at 7, 9, 11, 13, and 15, or 3, 4, 5, 10 and 13 weeks of age, respectively. Thigh muscles were obtained from 10 birds of each breed at each stage of growth. VC composition of the thigh muscles was analyzed using Gas Chromatograph/Mass Spectrometry. The triplicate measurements of VC in the samples were averaged and profiled for the different stages of growth. Only compounds that measured at least two stages of growth in KNC or CB were used in the analysis. The relevant VC patterns of each breed were identified using the K-means clustering analysis. The numbers of VC used for profiling were 26 and 37 for KNC and CB, respectively. In both KNC and CB thigh meat, five K-means were sufficient for describing the patterns of VC composition in the stages of growth. The patterns, however, were different. In KNC the cluster containing the largest numbers of VC was K5 (7 compounds), which showed a slow increase up to 11 weeks of age and a rapid increase after then. The major patterns of CB were B3 (peak at 4 weeks and remains at low level after then) and B5 (continuous decreasing); both contain 12 compounds. In conclusion, there is much variation in the VC contents and their patterns at stages of growth in the thigh meat from KNC and CB. The largest number of VC showed a progressive pattern in KNC, while a regressive pattern in CB.**

***Index Terms*— Korean native chicken, profiling, thigh meat, volatile compounds,**

I. INTRODUCTION

Due to relatively low fat, cholesterol and iron contents, chicken meat is well-recognized as a healthy animal food compared to other red meat (Jaturasitha, Srikanchai, Kreuzer, & Wicke, 2008). The chicken meat consumption per capita in Korea has increased 5.4 folds for the last four decades, and the similar trend was also observed in Asian countries including China (Han, Ha, & Lee, 2009).

Most of chicken meat consumed in Korea and other countries are from a few commercialized broiler strains which grow rapidly in intensive fattening systems (Jaturasitha et al., 2008). Recently in Korea, however, there has been an increasing interest of consumers in meat from Korean native chicken (KNC), which shows lower growth rate, feed efficiency and lean muscle gains than the commerical broiler (CB) (Sang et al., 2006).

Compared to the CB meat, the KNC meat is usually darker and redder and contains more essential fatty acids and total collagen (Jeon, Choe, Jung, Kruk, Lim, & Jo, 2010). The KNC meat contains less fat and higher protein than that from CB, which is attractive enough for consumers to pay a 2-3 times higher price than the CB meat (Kong et al., 2006). Threfore, there is a strong rationale for charaterizing chemical properties that is unique to the KNC meat compared to the CB meat. Little data, however, is available for differences in volatile compound (VC) contents of KNC and CB, and there has been no attempt to compare the variations in VC composition of the meat from two breeds at stages of growth.

Recent advances in technology enable us to analyze hundreds compounds simultaneously in a relatively short period of time (Weckwerth, 2003), and the clustering analysis can be successfully used to divide data into groups based on similarity or correlation and identify patterns (MacQueen, 1967). The objectives of this study are thus to profile volatile compounds (VC) in thigh meat from KNC and CB using Gas Chromatograph/Mass Spectrometry (GC/MS) and to identify differences in the VC pattern between the two meat sources in multiple stages of growth.

II. MATERIALS AND METHODS

Animal and experimental design

Two-hundred one-day-old, mixed-sex KNC and 200 CB were obtained from a commercial hatchery. Chickens were randomly assigned to floor pens (20 chickens per pen, 3.0 m × 2.0 m) under the standard condition of temperature, humidity, and ventilation, and 24 h fluorescent lighting for the entire experimental period. Chickens had *ad libitum* accessed to water and diet, and were fed a commercial broiler starter (0-6 days) and grower (7-21 days) and finisher (21-35 and 77 days) diets. The diet contained approximately 20% crude protein, 4% crude fiber, 3,100 ME kcal/kg and was a typical commercial diet produced for broilers (Chunhajeil Feed Co., Daejeon, Korea). Chickens were weighed every week and the similar live weights were determined based on weight: 3, 4, and 5 wk for CB and 7, 9, and 11 wk for KNC, respectively). Chickens were reared over the market weight (approximately 2.0 kg) to see any differences between CB and KNC in the period (10 and 13 wk for CB and 13 and 15 wk for KNC, respectively). The chickens with similar live weights were killed by conventional neck cut, bled for 2 min and removed of feathers and eviscerated. Thigh (*biceps femoris*) muscles were dissected from the carcasses after chilling at 4□ for 24 h. The skin was removed, and the muscles were trimmed of obvious fat and connective tissue. Muscle samples from different age with similar live weight each of 10 birds for each breed (totally 30 birds of each breed) were vacuum packed and were stored in a freezer at -50°C until analysis.

Solid-Phase Microextraction (SPME) Gas Chromatograph/Mass Spectrometry (GC/MS).

Chicken meat was thawed for 48 hrs in a refrigerator and sample (3 g) was weighed into 20 mL vial and sealed with a silicon/PTFE septum and an open top cap. A solid-phase microextraction (SPME) fiber (Supelco, Bellefonte, Pa., U.S.A.) coated with carboxen/polydimethylsiloxane (Carbboxen/PDMS, 75-㎛ thickness) was used to adsorb headspace volatiles. Before extracting volatiles, the fiber was cleaned at 250ºC for 5 min in the GC injection port and used immediately to prevent possible contamination.

Samples were preheated for 10 min at 40°C in a heating block, and the SPME fiber extracted the headspace volatiles for an additional 50 min; the fiber was then injected into the GC and remained for 5 min for desorption. A Varian Star 3400CX GC with Varian Saturn 2000 MS and HP-5 column (crosslinked 5% diphenyl and 95% dimethylpolysiloxane, 30 m × 0.32 mm, 0.25 ㎛ film thickness) was used to quantify VC. The flow rate of carrier gas (helium) was adjusted to 1 mL/min. The temperature of the injection port was 250°C.

The column was held at 40°C for 2 min and raised to 250°C at 3.5°C /min. The temperature of ion source, manifold, and transfer line in mass spectrometry (MS) were 180, 50, and 180°C, respectively. The VC were identified by a mass spectrum database (WILLY Library (Registry of mass spectral data, 6th edition, USA) or NIST Library (Mass spectral search program, version 4.5, USA), and the total ion counts were presented.

Volatile compounds profiling

The triplicate measurements of VC in the samples were averaged and profiled for the different stages of growth: 3, 4, 5, 10 and 13 wk for CB and 7, 9, 11, 13 and 15 wk for KNC, respectively. Only compounds that measured at least two stages of growth in KNC or CB were used in the subsequent analysis. The values for each VC were standardized to have a mean close to zero and a standard deviation of one. Using the J-Express platform (Dysvik & Jonassen, 2001), K-means clustering analysis (MacQueen, 1967) was conducted separately for the KNC and CB meat in order to identify the differences in pattern of centered VC values in different stages of growth. Pearson's correlation coefficient was used for the distance measure among clusters.

III. RESULTS AND DISCUSSION

The numbers of VC used for profiling were 26 and 37 for KNC and CB, respectively. There was much variation in the VC contents of the thigh meat from KNC and CB (Tables 1 and 2). On average the thigh meat from CB contained higher levels of VC than that from KNC. In both KNC and CB thigh meat, five K-means were sufficient for describing the patterns of VC composition in the stages of growth (Fig. 1 and 2). The patterns, however, are much different. Among 5 clusters in KNC, only K1 cluster showed a similar pattern with B4. In KNC the cluster containing the largest numbers of VC was K5 (7 compounds), which showed a slow increase up to 11 weeks of age and a rapid increase after then. The major patterns of CB were B3 and B5; both contain 12 compounds. One of the remarkable differences between two breeds was that 46% of VC in KNC had a continuous increasing pattern (K2 or K5) which was not seen in CB. In CB, on the contrary, 38% of VC showed a continuous decreasing pattern (B1 or B5). Another unique pattern of CB is the B3 cluster which showed an increase in VC content up to 4 weeks and a sudden decrease after then. This was one of the major clusters in CB.

Several VC that commonly detected in thigh meat showed different patterns in KNC and CB (Tables 1 and 2). For instance, 1-butanol and 1-propene were assigned to the K1 cluster in KNC which had an up-down-up pattern, while they belonged to the B5 cluster in which the content of VC continuously decreased. The content of cyclohexane was progressive in KNC (K5); however, its pattern in CB was regressive (B5).

Since the thigh muscles were sampled at the similar weights between two breeds, there is a possibility that the variations in the patterns of VC content may be due to differences in ages at slaughter. However, this does not seem to be the case in this study. The ages overlapped between two breeds in this study were 10 and 13 weeks of CB and 11 and 13 weeks of KNC. Only B4 in CB showed an increase in VC contents at 10 and 13 weeks, while only K1 in presented a decreasing trend in 11 and 13 weeks. This thus implies that most of the differences in the pattern of VC contents in the thigh meat at the stage of growth resulted not from the variations in age but from species-specific differences. In general, weight is more related with chemical composition of an animal body than age (Fox & Black, 1984).

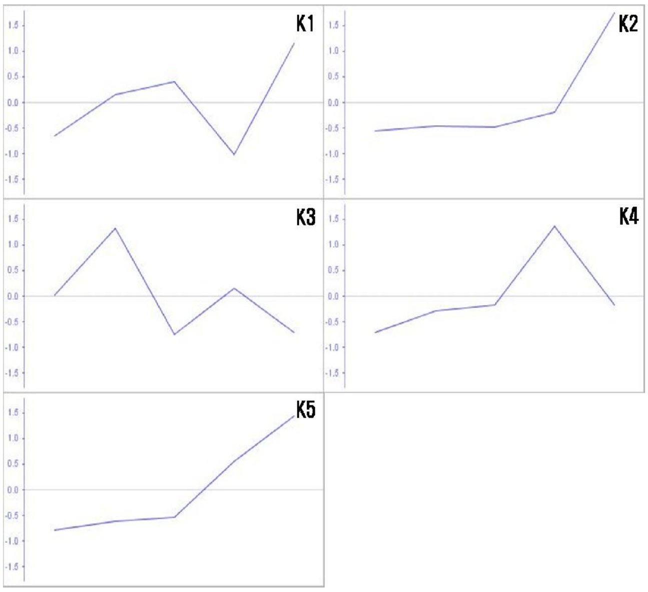

Fig. 1. K-mean clusters of volatile compound contents in chicken meat from Korean native breed at 7, 9, 11, 13 and 15 weeks of age

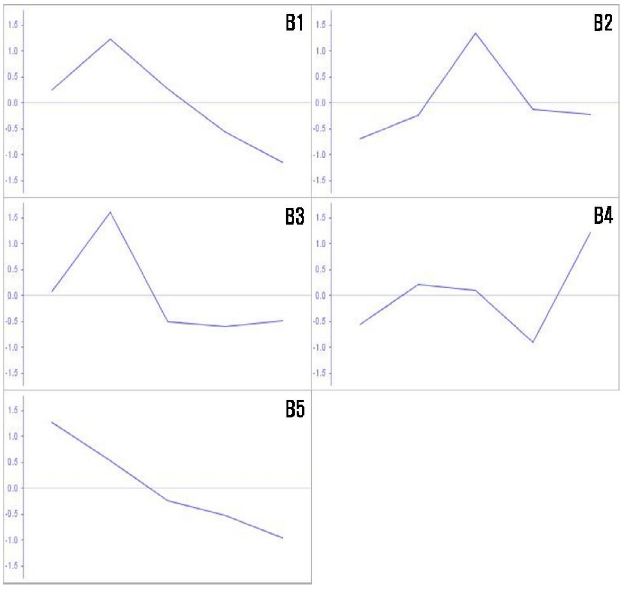

Fig. 2. K-mean clusters of volatile compound contents in chicken meat from commercial broilers at 3, 4, 5, 10 and 13 weeks of age

Table 1. The area and cluster of selected volatile compounds in the stages of growth of Korean native chickens

Volatile compound	Weeks					cluster
	7	9	11	13	15	
1-Butanol	152,084	1,265,384	601,681	-	936,640	K1
Carbon disulfide	4,019,012	6,160,111	3,925,542	3,836,264	2,696,560	K3
Chloroform	450,531	492,642	493,289	883,688	712,175	K4
Cyclohexane	467,865	700,847	558,569	875,310	1,185,859	K5
1H-Indole	-	674,552	126,563	212,537	187,713	K3
Phenol	69,882	589,646	527,466	587,070	521,578	K4
1-Propene	-	-	1,584,423	-	2,781,001	K1
Octa-Sulfur	40,754	72,067	104,792	966,528	7,900,489	K2

IV. CONCLUSION

There is much variation in the VC contents of the thigh meat from KNC and CB. Moreover, we observed much difference in the patterns of VC contents at the stages of growth between two breeds. The largest number of VC showed a progressive pattern in KNC, while a regressive pattern in CB. Profiling of VC contents in meat successfully distinguish KNC from CB.

Table 2. The area and cluster of selected volatile compounds in the stages of growth of commercial broilers

Volatile compound	Weeks					cluster
	3	4	5	10	13	
1-Butanol	1,812,196	830,562	652,613	-	-	B5
Carbon disulfide	1,788,316	1,240,551	1,948,613	1,264,480	1,446,927	B2
Chloroform	1,743,858	4,226,774	1,079,890	961,313	1,022,881	B3
Cyclohexane	1,539,796	1,509,973	1,314,225	1,253,262	1,042,270	B5
1H-Indole	963,170	1,452,233	1,513,727	1,171,369	5,103,129	B4
Phenol	3,247,908	498,205	2,015,169	1,923,289	250,328	B5
1-Propene	5,947,727	4,778,713	4,707,325	3,647,299	2,658,183	B5
Octa-Sulfur	16,588,967	25,892,624	4,251,704	3,509,376	2,779,372	B3

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