VARIATIONS IN TOTAL PIGMENT CONCENTRATION, pH, AND OXIDATION-REDUCTION POTENTIAL OF BREAST MEAT OF BROILERS RAISED IN THAILAND

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Abstract – The objective of this study aimed at investigating the total pigment concentration, pH, and oxidation-reduction potential (ORP) of breast meat of broiler raised in Thailand. Moreover, the color of cooked breast meat was also measured. Breast fillets were obtained from the commercial processing plant, and sorted using the criterion of lightness (L*) values. L*>58 and L*≤58 were set for "light" and "dark" groups, respectively. The experiment was repeated for broiler from two farms, which control feed and raising conditions. The results showed that there was no significant difference (*P*>0.05) in the total pigment concentration (0.45 to 0.51 mg/g sample) and ORP (-56.18 to -70.54 mV) of raw breast, regardless of meat color group and farm. Nevertheless, pH of the light group (pH = 6.00-6.03) was significantly lower than those of the dark group (pH = 6.09-6.10), regardless of farm (*P*<0.05). Moreover, there was no correlation between the color of cooked meat and chemical characteristics of raw meat in terms of total pigment concentration, pH, and ORP. The data presented herein could be beneficial for development in both farming system and manufacturing process.

Key Words – Broiler breast meat, Thailand, Total pigment concentration.

I. INTRODUCTION

Currently, Thailand ranks tenth worldwide in exporting poultry product [1]. In 2015, chicken meat exports of Thailand were 676,000 metric ton [2]. To tremendously raise the export performance, the Thai broiler industry has improved farming system, manufacturing standard, and also product quality. In the product quality aspects, meat color is a critical criterion influencing the consumer's purchase decision for both raw and cooked products. Therefore, there are many researches focusing on meat color chemistry and its corresponding to meat appearance [3-9].

Lightness (L*) of raw meat was suggested to be one of the indicators in the primary breeding program because it allows for detection of a typical meat quality such as pale, soft, and exudative (PSE)-like or dark, firm, and dry (DFD)-like meats [10]. On the other hand, redness (a*) was typically used as an indicator of pink color defect in uncured cooked meat product [11]. It is well-known that the color of meat product depends upon the amount of pigments and their derivatives [12], and also has a strong correlation with muscle pH [13]. For broiler, the total pigment concentration and muscle pH were reported to be in the range of 0.24 to 5.6 mg/g [4-6] and 5.76 to 5.99 [7-8, 13], respectively. These high variations might be due to breeding, rearing environment, and nutrition [3, 8, 14]. Furthermore, Fletcher et al. (2000) reported the linear relationship between raw broiler breast meat pH and L* of its cooked meat [13].

Broiler is currently the important commercial animals of the Thai food industry; although, the basic information of meat quality in the aspect of meat color chemistry for broiler raised in Thailand is rarely reported. The objective of this study aimed, therefore, at investigating the total pigment concentration, pH, and oxidation-reduction potential (ORP) of breast meat of broiler raised in Thailand. Moreover, the color of cooked breast meat was also measured to study the correlation with the raw meat attributes. Breast fillets were obtained from two farms, and primarily sorted by an experienced staff of a factory based on visual appearance and lightness (L*) to be light (L*>58) and dark (L*≤58) groups. The data presented herein could be useful for development in not only farming management such as breeding, feeding, rearing environment, but also in manufacturing process.

II. MATERIALS AND METHODS

Sample Collection

Skinless and boneless breast meats (Abor Acres) were obtained from a slaughter house located in the central region of Thailand. Firstly, broiler breast appearance was visually sorted as "light" and "dark" meats at the deboning line. Subsequently, the samples were packed with ice, and transported to the laboratory on the next day. Based on the lightness (L*) value of the bone side of meat surface, the samples were categorized into light (L*>58) and dark (L*≤58) colors. The samples were then individually packed in a vacuum condition in polyethylene bag, and stored at -18℃ until they were used.

The samples were collected from two farms where feeding and raising conditions were controlled. Moreover, each of the samples was from the male 38 day-old broiler. Two hundred breasts from each farm (100 fillets for each color group) were firstly collected at a processing plant. From each farm and each color group, twenty five fillets were sampled. Thus, there were totally 100 samples.

Experimental

The sample was thawed through running water (25±2℃) for 10 min. After thawing, the color of the meat surface on the bone-side was immediately measured using Hunterlab Labscan spectrocolorimeter (Hunter Associated Laboratories Inc., Virginia, USA). Subsequently, the raw meat and drip-loss after thawing was ground together via pre-cooled mortar. Half of the ground sample was used to determine pH, ORP, and total pigment concentration. Measurement of total pigment concentration was performed according to the method of Warris (1979) [15], and a heme protein molecular weight of 17,000 g/mol was used for calculation of total pigment concentration in terms of mg/g sample.

Approximately 60 g of the other half of ground meat was packed into an aluminum can (Ø50 mm×L30 mm), and covered with a lid prior to cooking. The sample in the holder was steamed in a two-layer steamer until the internal temperature of the sample reached 85℃. The sample was then immediately cooled in the mixture of water and ice for 20 min. The meat sample was half cut along the diameter, and its color was measured.

Statistical analysis

Results were reported as mean values ± standard deviations. The results were evaluated by analysis of variance (ANOVA) and the means are separated by Duncan's multiple comparison tests at 5% level of significance.

III. RESULTS AND DISCUSSION

Table 1 presents the color of the raw broiler breasts in this study. The L* values of the light group were significantly higher than those of the dark group, regardless of farm (P<0.05). Nevertheless, the L* values of the light group (57.64±3.20 for farm A and 57.18±1.75 for farm B) were slightly lower than 58, setting value in sample categorization. This reduction of L* values might be due to the oxidation of myoglobin affecting by freezing and thawing of the samples prior to the experiment. Viriyarattansak et al. (2007) reported that the formation of brown pigment (metmyoglobin) in tuna meat still proceeded even as in storage at -30℃ [16]. There were no significant differences (P>0.05) in the a* and b* values between the light and dark groups, regardless of farm; even though, the dark group of farm B showed the highest of redness (a* value = 7.26±0.90) (P<0.05).

There were the differences in the color intensity between the light and dark groups; although, there were no significant differences (P>0.05) in the total pigment concentration for each sample (Table 1). The disagreement between meat color and the amount of pigments might be explained that the color of meat was contributed by other factors such as the derivatives of pigment or degree of denaturation of muscle protein especially on the meat surface. Furthermore, there was no significant difference (P>0.05) in ORP of raw breast meats for each sample (Table 1). Our broiler breast meats contained 0.45±0.08 to 0.51±0.09 mg/g total pigment concentrations and -56.18±26.55 to -70.54±25.70 mV ORP, regardless of meat colors and farms (Table 1). Cornforth et al. (1986) demonstrated that meat with low ORP (negative value) had a reducing potential, and this allowed heme iron to be in the ferrous state [17]. On the other hand, pH of the light group was significantly lower than those of the dark group, regardless of farm (P<0.05).

In comparison, the color (L*, a*, and b*) intensities of our breast samples were higher than those of the broiler and Thai indigenous chicken breasts previous reported [7-9] (Table 1). Furthermore, the total pigment concentration and pH of broiler breasts in our study (total pigment concentration = 0.45-0.51 mg/g sample; pH = 6.00-6.10) was slightly higher than those of broiler breast previous reported (total pigment concentration = 0.24-0.44 mg/g sample; pH = 5.93-5.99) [4-5,7-8], except for the result of Wattanachant et al. (2004) [6] showing the total pigment concentration of broiler breast to be 5.6 mg/g sample.

Table 1 Total pigment concentration, pH, and ORP of chicken breast meats

Chicken type	Total pigment (mg/g sample)	pH	ORP (mV)	Color of raw meat[1]			Reference
				L*	a*	b*	
Broiler	0.32-0.44						[4]
	0.24±0.04						[5]
	5.6						[6]
		5.99±0.14		49.20±1.40	1.40±0.40	10.30±1.30	[7]
		5.93±0.10		38.79±1.46	-0.09±0.45	3.62±1.03	[8]
Spent hen	3.47±0.06	5.78±0.11		52.26±1.29	-2.86±0.46	7.19±2.60	[9]
Thai indigenous chicken		5.72±0.15		42.33±5.01	-0.06±0.75	4.75±1.28	[8]
Broiler							
Light; Farm A	0.45±0.08	6.00±0.12[b]	-56.18±26.55	57.64±3.20[a]	5.86±0.70[b]	16.46±1.87	This study
Light; Farm B	0.49±0.09	6.03±0.11[ab]	-65.34±21.54	57.18±1.75[a]	6.13±1.13[b]	16.09±1.01	This study
Dark; Farm A	0.50±0.10	6.10±0.11[a]	-60.17±23.82	55.07±2.64[b]	6.21±1.00[b]	15.83±1.37	This study
Dark; Farm B	0.51±0.09	6.09±0.14[a]	-70.54±25.70	53.86±1.48[b]	7.26±0.90[a]	16.85±1.22	This study
Probability	>0.05	<0.05	>0.05	<0.05	<0.05	>0.05	

[1]The sample was frozen and thawed. [a-c]Means within an effect in the same column with no common superscripts differ significantly (P<0.05).

For cooked meat, the light and dark group from farm A showed the lowest and the highest a* values (P<0.05). The lowest a* values of the light group from farm A is in agreement with the results of low total pigment concentration, low pH, and high ORP. Nevertheless, there was no correlation between the color of cooked meat and chemical characteristics of raw meat such as total pigment concentration, pH, and ORP, regardless of color groups and farms. These results were in disagreement with those of Fletcher et al. (2000) [13] who reported that cooked L* had significant correlations with pH of raw broiler breast.

Table 2 Color of cooked broiler breast for different color groups and farms

Sample	L*	a*	b*
Light; Farm A	81.84±0.97[a]	2.03±0.21[c]	15.57±0.78[a]
Light; Farm B	81.00±0.97[b]	2.46±0.35[ab]	14.94±0.50[b]
Dark; Farm A	81.39±1.06[ab]	2.58±0.25[a]	15.31±0.61[ab]
Dark; Farm B	81.15±0.77[ab]	2.36±0.24[b]	15.14±0.60[ab]
Probability	<0.05	<0.05	<0.05

[a-c]Means within an effect in the same column with no common superscripts differ significantly (P<0.05).

IV. CONCLUSION

This paper presented the inherent factors affecting meat color of breast fillets of broiler raised in Thailand. Breast fillets were obtained from two farms, and sorted by base on visual appearance and lightness (L*) to be light (L*>58) and dark (L*≤58) groups. The results showed that there were the differences in the color intensity of raw meat between the light and dark groups; although, there were no significant differences (*P*>0.05) in the total pigment concentration and ORP for each sample. Our broiler breast meats contained 0.45±0.08 to 0.51±0.09 mg/g total pigment concentrations and -56.18±26.55 to -70.54±25.70 mV ORP. The disagreement between meat color and the amount of pigments might be explained that the color of raw meat should be contributed by other factors such as the derivatives of pigment or degree of denaturation of muscle protein especially at the meat surface. On the other hand, pH of the light group (pH = 6.00-6.03) was significantly lower than those of the dark group (pH = 6.09-6.10), regardless of farm (*P*<0.05). Moreover, the present results indicated that there was no correlation between the color of cooked meat and chemical characteristics of raw meat such as total pigment concentration, pH, and ORP. Factors affecting variations in both raw and cooked meat color should be more identified in the further study.

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