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Effects of Different Grain Sources in Both Maternal and Offspring Diets on Pigmentation and Growth Performance in Yellow-Skinned Chickens

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This study aims at investigating the effects of different grain sources during pre-hatch (from diet of the breeders) and post-hatch (from the diet of broilers) on coloration (Roche color fan scores; L*, lightness; a*, redness; and b*, yellowness) as well as the growth performance in yellow-skinned chickens at market age (42 days old). In this experiment, six thousand yellow-skinned broiler breeders at 27 weeks were fed with a corn or sorghum and barley-based diet in which contained high (+) or low (−) xanthophyll levels, respectively. After the beginning of the trial, from day 41 to 42, eggs from two treatments were collected to artificial incubation. In this trial, 2×2 factorial designs were used and male chicks hatched from breeders fed with a corn or sorghum-based diet. According to the results, it demonstrated that hens fed with a corn-base diet were observed an elevated coloration both in the eggs and newly-hatched chicks ($p<0.05$). The dietary pigments improved pigment deposition in the egg yolk and the tissue of newly-hatched chicks. Besides, there was no difference in growth performance attributed to dietary grain sources both from hens or chicks. There showed no difference of coloration in abdominal fat, shank or breast skin (or kept at 4℃ for 24 hours and 7 days) between two breeder grain sources ($p>0.05$). However, abdominal fat, shank and breast skin from the broiler chicks fed with the corn-based diet had a significantly higher RFC scores, a* and b* value than that fed with the sorghum and barley-based diet. The current results indicated that the broiler dietary grain sources (different xanthophyll contents), other than the breeder dietary grain sources influenced the pigmentation in abdominal fat, shank and breast skin, and the skins stored at 4℃ in broiler. Therefore, it can be suggested that a low xanthophyll-containing diet (sorghum and barley-based diet) might be applied in yellow-skinned broiler breeders without causing negative effects of coloration or growth performance on their offspring at market age.

Key words: broiler breeder, chicken, coloration, grain sources, growth performance

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Introduction

Pigmentation in poultry products is an important factor that influencing the acceptability at the time of consumer purchase (Mugler and Cunningham, 1972; Ouart *et al*., 1988; Wang *et al*., 2009). Throughout plants and animal, carotenoids are a large (>500 identified carotenoids) group of lipid-soluble organic compounds spread (Perez-Vendrell *et al*., 2001). Some carotenoids serve as the precursors of synthesis of vitamin A, and some play significant roles in anti-oxidative capability and immune function (Surai and Sparks, 2001; Wang *et al*., 2009; Sun *et al*., 2015). Xanthophylls and carotenoids refer to the primary sources of pigmentation in poultry diet that are deposited in egg, skin and abdominal fat (Goodwin, 1954; Perez-Vendrell *et al*., 2001). The intensity of pigmentation in broilers is associated with the xanthophylls consumed from diet (Bartov and Bornstein, 1969).

As the most ordinary origin of xanthophylls, corn-based commercial poultry diet produces the yellow skin of broiler that is preferred by customers (Castaneda *et al*., 2005). Considering that sometimes the high price of corn, it is a vital way for manufacturer to cut the formula cost through seeking for corn substitutes, such as sorghum, barley and wheat. However, the usage of sorghum or barley-based diet in poultry production, which lacking in xanthophylls might lead to skin pigmentation problems especially in yellow-skinned chickens. Till now, it had been widely recognized that the broiler breeders fed with sorghum or barley-based diet will produce eggs and chicks with poor coloration (Surai and

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Sparks, 2001; Koutsos *et al*., 2003). Various experiments had been proved that the supplementation of pigment in the diet of breeders could improve the egg yolk pigmentation (Karadas *et al*., 2005; Li *et al*., 2012), antioxidant capacity (Surai *et al*., 2003; Sun *et al*., 2015) and immune function (Koutsos *et al*., 2003; Sun *et al*., 2015) in growing chicks. Nevertheless, the breeder effect on offspring pigmentation was seldom taken into consideration. Based on the Koutsos research, the improvement of egg yolk-derived carotenoids through breeder diet could greatly enhance the skin pigmentation in white leghorn chicks on day 28 (Koutsos *et al*., 2003). Carotenoids in tissues of chicken obtained from their parent can be detected even fed a carotenoid-free diet for 4 weeks. There might exist differences of coloration in broiler between on day 28 and market age. In China, yellow skinned chickens are considered as the most important poultry species. Skin color of chick was regarded as healthy status of birds, thus producing a positive preference for consumer purchase of yellow-skinned chickens. Consequently, pigment deposition has taken a more concerned in yellow-skinned broiler chick than any other strains of chicks. Therefore, the objective of this study was to estimate the effects of different grain sources (corn or sorghum and barley-based diets) in both breeder and broiler diets on chicken coloration or growth performance on the market age.

Materials and Methods

Birds Management and Diets

In this experiment, six thousand yellow-skinned broiler breeders at 27 weeks old with similar body weight and genetic background (WENS Yellow-Feathered Chicken, WYFC) were randomly divided into two treatments with six replicates. Hens were raised in cages in a temperature-controlled room at a commercial broiler breeder farm in Guangdong Wens Foodstuff Group Co., Ltd. Birds fed with a corn or sorghum and barley-based diet in which contained high (＋) and low (－) xanthophyll levels, respectively. All diets were formulated in accordance with the Chinese feeding standard (NY/T33-2004). The composition and nutritional level of the experimental diets were shown in Table 1. The breeder feeding trial lasted for 10 weeks and hens were free accessing to water and feed. The light programme was 16 h light: 8 h dark and ambient temperature controlled by a wet-curtain cooling system. From day 41 to day 42 of the trial, six thousand fertilized eggs (2 treatments with 3 replicates each) were collected from each treatment to hatch artificially and the mean hatchability of the fertilized eggs reached 95.80% and 95.92% in high (＋) and low (－) xanthophyll treatments, respectively.

On hatching day, one thousand and eight hundred healthy male chickens from corn and sorghum treatments were randomly selected and were fed a corn or sorghum and barley-based diet in which included the high and low levels of total xanthophyll. There were four treatments of progeny designed as follows, respectively, parents and chicks fed the corn-based diet (＋＋), parents fed a corn-based diet and chicks fed a sorghum and barley-based diet (＋－), parents and chicks fed the sorghum and barley-based diet (－－), parents fed a sorghum and barley-based and chicks fed a corn-based diet (－＋). Each of the four progeny groups contained 6 pens of 75 birds each. Based on the Chinese feeding standard (NY/T33-2004) (Table 1), feeds were provided as crumbles during the first week and subsequently substituted with whole pellets. All birds had access to water and the experimental diets ad libitum. The room temperature was maintained at 35℃ during the first week, 33℃ in the second week, and ranged from 14 to 20℃ from the third week. The light programme was 23 h light: 1 h dark.

Xanthophyll Determination

Samples of corn, barley, sorghum, corn gluten meal and the experimental diets were taken from more than 6 sites and then mixed into each single sample for the measurement of the total xanthophyll contents through using the method in the AOAC 43.018–43.023. To be brief, 2 g of freeze-dried sample was added into a 100 mL of volumetric flask with 1 mL distilled water, 2 m*l* 40% KOH-methanol solution, and 30 mL of solvent mixtures (10 hexane, 7 acetone, 6 ethanol: 7 toluene (v:v)) with a water bath at 56℃ for 20 minutes. After placing in dark for one hour, the mixture was added 30 m*l* N-hexane, and then supplied with 10% $NaSO_4$ solution to 100 m*l* and shaken vigorously. Through standing for one hour, the upper solution was measured at 474 nm.

Growth Performance and Color Evaluation

On day 42 of the breeder trial, three eggs were taken from each replicate to determine yolk color on the basis of the Roche color fan (RCF). On the day of hatching, two chickens from each replicate were sacrificed by jugular vein slit to measure the coloration of skin (shank, thigh and breast), liver and yolk in accordance with the RCF scores.

From each of the four groups, 12 chicks (2 for each replicate) were slaughtered on day 63 of the broiler trial. Eviscerated carcasses were rinsed and chilled in ice water, and dried at room temperature, then placed in plastic bags and refrigerated for 7 days. Skin and abdominal fat color were determined immediately after slaughter by RCF and color coordinates: L*, lightness; a*, redness; and b*, yellowness (Minolta chroma meter CR-10, Konica Minolta, Inc., Osaka, Japan). After refrigerated for 24 hours and 7 days, skin color of carcasses was also measured with the application of the same method. Aimed at avoiding the deviation, all the skin color was determined at the same part of birds. Both body weight (BW) and feed intake (FI) were measured as 6 replicates on days 63. Based on these data, the body weight gain (BWG), feed to gain ratio (F: G) were calculated, and dead chickens were recorded daily to calculate livability.

Statistical Analysis

In this work, all the data were analyzed through using statistical software SPSS 17 (SPSS Inc., Chicago, USA). Data obtained for RCF scores of egg yolk, liver, residual yolk, and skin of shank, thigh and breast on 1 day old chick were used to analyze t-test. Skin and abdominal color of broiler were explored by two-way ANOVA using the general linear model procedure. The model was composed of the

Table 1. **Composition and nutritional level of experimental diets for broiler breeders[1] and chicks[2,3]**

Ingredient (g/kg)	Breeder hens		Broilers					
			Starter		Grower		Finisher	
	+	−	+	−	+	−	+	−
Corn	673	0	624		683	0	703	0
Sorghum	0	500	0	400	0	362	0	401
Barley	0	170	0	211	0	300	0	267
Soybean meal	171	148	287	306	206	248	170	232
Corn gluten meal	0	0	30	0	44.4	0	50	0
Extruded soybean	53	60	0	0	0	0	0	0
Soybean oil	0	19.0	11.1	35.8	17.3	42.3	29	54.8
Limestone	78.0	76.2	13.2	12.6	13.8	13	14.5	13.1
Dicalcium phosphate	9.3	8.7	12.5	12.7	10.3	10.2	8.4	8.4
NaCl	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Lys·HCl	0.28	1.70	4.6	3.89	6.73	5.05	7.48	5.37
D, L-Met	0.45	0.8	1.78	2.41	2.57	3.28	1.61	2.55
Threonine	0	0.60	0.83	1.17	1.29	1.53	1.36	1.61
Choline chloride	1.5	1.5	1.2	1.2	1.2	1.0	1.0	1.0
Premix compound	10	10	10	10	10	10	10	10
Nutritive value								
Crude protein, %	14.8	14.8	20.5	20.5	18.5	18.5	17	17
Calcium, %	3.1	3.1	0.90	0.90	0.85	0.85	0.80	0.80
Available phosphorus, %	0.38	0.38	0.35	0.35	0.31	0.31	0.28	0.28
AME, kcal/kg	2750	2750	2900	2900	3030	3030	3100	3100
Lysine, %	0.8	0.78	1.23	1.24	1.12	1.13	1.01	1.02
Met+Cys, %	0.55	0.55	0.86	0.86	0.89	0.89	0.75	0.75
Threonine, %	0.57	0.56	0.81	0.81	0.74	0.74	0.67	0.67
Arginine, %	0.88	0.90	1.38	1.38	1.21	1.24	1.15	1.18
Tryptophan, %	0.18	0.17	0.22	0.23	0.19	0.2	0.15	0.17

[1] Premix compound provided per kg of diet: retinol, 3.6 mg; cholecalciferol, 0.06 mg; tocopherol, 30 mg; menadione, 4.0 mg; riboflavin, 9.0 mg; niacin, 40 mg; D-pantothenic acid, 12 mg; cobalamin, 0.020 mg; biotin, 0.20 mg; folacin, 1.5 mg; thiamine, 3.0 mg; pyridoxine, 4.5 mg; 9.0 mg of Cu from $CuSO_4 \cdot 5H_2O$; 100 mg of Zn from $ZnSO_4 \cdot H_2O$;110 mg of Mn from $MnSO_4 \cdot H_2O$; 70 mg of Fe from $FeSO_4 \cdot H_2O$; 1.0 mg of I from KI; 0.3 mg of Se from Na_2SeO_3.

[2] Premix compound provided per kg of diet: retinol, 3.0 mg; cholecalciferol, 0.045 mg; tocopherol, 20 mg; menadione, 3.5 mg; riboflavin, 8.0 mg; niacin, 35 mg; D-pantothenic acid, 10 mg; cobalamin, 0.015 mg; biotin, 0.18 mg; folacin, 1.2 mg; thiamine, 2.0 mg; pyridoxine, 3.5 mg; 8.0 mg of Cu from $CuSO_4 \cdot 5H_2O$; 80 mg of Zn from $ZnSO_4 \cdot H_2O$; 100 mg of Mn from $MnSO_4 \cdot H_2O$; 60 mg of Fe from $FeSO_4 \cdot H_2O$; 0.7 mg of I from KI; 0.3 mg of Se from Na_2SeO_3.

[3] "+" and "−" mean breeders fed with a corn or sorghum-based diet in which contained high and low xanthophyll levels, respectively.

main effects of breeder, broiler and their interaction. When the main effect(s) or interaction was significant, differences among means were determined and statistical differences were set at $p<0.05$.

Results

Xanthophyll Levels in Feedstuffs and Diets

According to Table 2, sorghum and barley contained relatively low xanthophyll levels than corn. However, corn gluten meal possessed the highest xanthophyll content among the feedstuffs. Conformed to the expectation, the sorghum and barley-based experimental diets had significantly low xanthophyll contents.

Growth Performance

Through observation, there was no statistically significant difference in body weight on day 0 or day 63, body weight gain, feed to gain ratio, feed intake or livability attributed to dietary grain sources both from breeders or broilers ($p>0.05$) (Table 3).

Coloration Measurement

Grain sources in breeder diet imposed significant influence on RCF scores of the egg yolk, skin of shank and breast, liver and residual yolk in 1 day old chick ($p<0.05$) (as shown in Table 4). Hens fed with the corn-base diet were observed an elevated coloration of the egg yolk, skin of shank and breast, liver and the residual yolk of the newly-hatched chicks in comparison with that fed with sorghum and barley-based diets ($p<0.05$).

As shown in Table 5 and Table 6, there were no significant difference of RFC scores, L, a* or b* values in shank or breast skin coloration between breeder dietary grain sources ($p>0.05$). Nevertheless, broiler dietary grain sources significantly influenced RFC scores, a* and b* value in shank as well as breast skin ($p<0.05$). Shank and breast skin from

Table 2. **Total contents of xanthophyll in corn, barley, sorghum, corn protein and the experimental diets[1]**

Item			Total contents of xanthophylls (mg/kg)
Corn			15.9
Barley			5.66
Sorghum			6.72
Corn gluten meal			198
Breeder hens diets		+	15.32
		−	3.94
Broiler diets	Starter	+	18.9
		−	3.44
	Grower	+	22.6
		−	3.60
	Finisher	+	23.6
		−	3.30

[1] "+" and "−" mean breeders fed with a corn or sorghum-based diet in which contained high and low xanthophyll levels, respectively.

Table 3. **Effect of breeder and broiler dietary grain sources on growth performance**

Breeder[1]	Broiler[2]	BW on day 0, g	BW on day 63, g	BWG, g/d	F:G	FI, g/d	Livability, %
−	−	34.03	1962	30.27	2.56	77.5	97.7
+	−	34.05	1935	29.95	2.56	76.5	97.3
−	+	34.09	1937	30.05	2.56	77.0	97.7
+	+	34.07	1943	30.05	2.58	77.3	98.6
SEM		0.07	8	0.14	0.01	0.3	0.3
Breeder	−	34.41	1950	30.16	2.56	77.2	97.7
	+	34.45	1939	30.00	2.57	76.9	98.0
Broiler	−		1949	30.11	2.56	77.0	97.5
	+		1940	30.05	2.57	77.2	98.2
p-value	Breeder	0.786	0.533	0.569	0.685	0.597	0.711
	Broiler	—	0.619	0.833	0.232	0.771	0.306
	Breeder×Broiler	—	0.339	0.569	0.468	0.307	0.295

Values shown are means and pooled standard error (SEM) ($n=6$);
[1] "−" and "+" Means broiler breeder fed a sorghum and barley-based diet and corn-based diet, respectively;
[2] "−" and "+" Means broiler fed a sorghum and barley-based diet and corn-based diet, respectively.

Table 4. **Effect of dietary treatment on egg yolk and chick RCF scores on day 1**

Treatment[1]	Egg yolk	Chick				
		Skin			Liver	Residual yolk
		Shank	Thigh	Breast		
−	2.05	1.39	1.17	1.22	1.44	3.72
+	6.94	3.78	1.50	1.95	5.45	5.33
SEM	0.75	0.53	0.20	0.19	0.68	0.33
p-value	<0.001	0.030	0.060	0.020	<0.001	0.007

Values shown are means and pooled standard error (SEM) ($n=6$);
[1] "+" and "−" mean breeders fed with a corn or sorghum-based diet in which contained high and low xanthophylls levels, respectively.

Table 5. **Effect of breeder and broiler dietary grain sources on RCF scores, L*, a*, and b*values of shank skin[1]**

Breeder[2]	Broiler[3]	RFC scores	L	a	b
−	−	1.25	79.6	4.95	25.0
+	−	1.25	78.2	4.98	25.8
−	+	6.00	75.1	12.2	58.6
+	+	5.60	75.1	9.02	54.7
SEM		0.18	0.6	0.47	1.0
Breeder	−	3.63	77.3	8.55	41.8
	+	3.43	76.6	7.00	40.3
Broiler	−	1.25	78.9	4.96	25.4
	+	5.80	75.1	10.59	56.6
p-value	Breeder	0.577	0.610	0.125	0.459
	Broiler	<0.001	0.130	<0.001	<0.001
	Breeder×Broiler	0.577	0.600	0.120	0.260

Values shown are means and pooled standard error (SEM) (n=12);
[1] L=lightness; a=redness; b=yellowness
[2] "−" and "+" Means broiler breeder fed a sorghum and barley-based diet and corn-based diet, respectively;
[3] "−" and "+" Means broiler fed a sorghum and barley-based diet and corn-based diet, respectively.

Table 6. **Effect of breeder and broiler dietary grain sources on RCF scores, L*, a*, and b*values of breast skin**

Breeder[1]	Broiler[2]	RFC scores	L*	a*	b*
−	−	1.25	75.4	3.53	10.0
+	−	1.50	74.6	4.55	12.9
−	+	3.75	71.5	6.30	22.4
+	+	3.20	71.5	6.52	23.0
SEM		0.25	0.8	0.44	0.8
Breeder	−	2.50	73.4	4.91	16.2
	+	2.35	73.0	5.54	18.0
Broiler	−	1.38	75.0	4.04	11.4
	+	3.48	71.5	6.41	22.7
p-value	Breeder	0.766	0.806	0.488	0.271
	Broiler	<0.001	0.047	0.018	<0.001
	Breeder×Broiler	0.432	0.804	0.652	0.482

Values shown are means and pooled standard error (SEM) (n=12);
[1] "−" and "+" Means broiler breeder fed a sorghum and barley-based diet and corn-based diet, respectively;
[2] "−" and "+" Means broiler fed a sorghum and barley-based diet and corn-based diet, respectively.

the birds received the corn-based diet obtained a relatively higher RFC scores, a* and b* value than that from the sorghum and barley-based diet. There existed no significant interaction for shank and breast coloration between breeder and broiler dietary grain sources.

Broiler dietary grain sources exerted significant influence on RFC scores and b* value ($p<0.001$) of abdominal fat (Table 7). RFC scores and b* value of abdominal fat decreased from birds ingested the sorghum and barley-based diet than that from chickens which has been exposed to the corn-based diet. No significantly difference was observed in abdominal fat coloration between breeder dietary grain sources ($p>0.05$) or interaction effect of breeder and broiler dietary grain source ($p>0.05$).

Broiler dietary grain sources significantly affected RCF scores and b* values in shank and breast skin of carcass refrigerated for 24 hours and 7 days (as shown in Table 8). After refrigerated for either 24 hours or 7 days, RCF scores and b*values measured in shank and breast skin were lower in bird fed with the sorghum and barley-based diet than those of chickens fed with the corn-based diet ($p<0.001$). There was no significant differences in RCF scores and b*values of

Table 7. **Effect of breeder and broiler dietary grain sources on RCF scores, L*, a*, and b*values of abdominal fat**

Breeder[1]	Broiler[2]	RFC scores	L*	a*	b*
−	−	1.05	68.5	1.78	13.8
+	−	1.03	68.9	2.53	12.4
−	+	5.95	66.9	2.1	22.6
+	+	6.20	67.5	1.25	23.7
SEM		0.12	1.0	0.29	0.5
Breeder	−	3.48	67.7	1.91	18.2
	+	3.63	68.2	1.89	18.1
Broiler	−	1.03	68.7	2.15	13.1
	+	6.08	67.2	1.65	23.1
p-value	Breeder	0.539	0.793	0.966	0.929
	Broiler	<0.001	0.465	0.398	<0.001
	Breeder×Broiler	0.682	0.956	0.199	0.285

Values shown are means and pooled standard error (SEM) ($n=12$);
[1] "−" and "+" Means broiler breeder fed a sorghum and barley-based diet and corn-based diet, respectively;
[2] "−" and "+" Means broiler fed a sorghum and barley-based diet and corn-based diet, respectively.

Table 8. **Effect of breeder and broiler dietary grain sources on RCF scores and b*values of shank and breast skin of carcass refrigerated for 24 hours and 7 days**

Breeder[1]	Broiler[2]	Shank				Breast			
		24 hours		7days		24 hours		7days	
		RFC scores	b*	RFC scores	b*	RFC scores	b*	RFC scores	b*
−	−	1.50	28.1	1.2	25.8	1.50	11.3	1.25	11.3
+	−	1.00	26.3	1	25.8	1.20	11.6	1.20	11.5
−	+	5.56	51.6	5.25	49.1	2.6	27.8	2.6	25.6
+	+	5.4	48	5.2	43.8	2.4	24.1	2.4	23.4
SEM		0.13	1	0.11	1.1	0.1	0.5	0.1	0.8
Breeder	−	3.53	39.8	3.23	37.4	1.95	19.5	1.93	18.4
	+	3.20	37.1	3.1	34.8	1.80	18.9	1.80	17.4
Broiler	−	1.25	27.2	1.1	25.8	1.35	11.5	1.23	11.4
	+	5.48	49.8	5.23	46.4	2.40	26.9	2.50	24.5
p-value	Breeder	0.208	0.201	0.58	0.227	0.548	0.481	0.605	0.535
	Broiler	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Breeder ×Broiler	0.513	0.664	0.739	0.236	0.548	0.329	0.756	0.491

Values shown are means and pooled standard error (SEM) ($n=12$);
[1] "−" and "+" Means broiler breeder fed a sorghum and barley-based diet and corn-based diet, respectively, and the same as following tables;
[2] "−" and "+" Means broiler fed a sorghum and barley-based diet and corn-based diet, respectively.

shank and breast skin of carcass refrigerated for 24 hours or 7 days for breeder effect ($p>0.05$). In addition, the interaction effect of breeder and broiler dietary grain sources also displayed no significantly differences in all the measurements ($p>0.05$).

Discussion

Dietary xanthophylls are ingested from diet and absorbed in intestine, which may be accumulated without modification or may be metabolized through the organism. Subsequently, it can be deposited into variety tissues such as skin, egg yolk, abdominal fat, muscle, liver, and immune organs (Koutsos *et al*., 2003; Breithaupt, 2007). Numerous researchers pointed out that dietary pigments supplementation will improve their pigment deposition in egg yolk (Koutsos *et al*., 2003; Surai *et al*., 2003; Li *et al*., 2012; Sandeski *et al*., 2014). Our results also demonstrated RCF score of egg yolk from breeders fed with corn-based diet was higher than that from breeders which provided with sorghum-based diet. In addition, an enhanced coloration of liver, residual yolk and skin of shank, thigh and breast in day-old chickens can also been observed from breeder corn-based diet treatment. These results conformed to previous studies that egg yolk color depended on the absorption and deposition of the carotenoids from the hen diet (Sandeski *et al*., 2014) and higher carotenoid content in egg yolk contribute to an increased pigment deposition in all tissues (liver, yolk sac membrane, muscles, adipose tissue, kidney, lung and plasma) in 1-d-old chicken (Surai and Sparks, 2001; Surai *et al*., 2003; Karadas *et al*., 2005).

As expected and with the consideration that all birds were fed with same nutrition level diets, there was no effect of breeder and broiler dietary grain sources on growth performance. The similar results were also reported in other documents (Perez-Vendrell *et al*., 2001; Meriwether *et al*., 2010; Gao *et al*., 2013; Sun *et al*., 2015). However, some researchers still reveal that supplementation of xanthophylls may contribute to the increasing of chicken birth weight (Koutsos *et al*., 2006; Sun *et al*., 2015). In the present study, our data exhibited that there was no difference on body weight on day 0 between the two treatments. The partial reason might be the relative low level of dietary xanthophyll (15.32 mg/kg vs. 40 mg/kg) in current trail in comparison with previous experiments.

Actually, color shows strong association with customers' choices on various products such as egg, chick, and salmon flesh (Mugler and Cunningham, 1972; Hudon, 1994; Maga, 1994; Froning, 1995). Various factors have been reported to affect poultry color such as genetic background, dietary pigment source and concentration, body condition, hormonal status and process (Hudon, 1994; Sirri *et al*., 2010). Genes associated with canthaxanthin, natural lutein, and orange II are considered as the key regulatory genes involved in the mechanism of pigmentation in broilers (Tarique *et al*., 2014). A stable nitrogen and carbon isotopes analysis had been conducted by Wang (2014) in order to trace the origin of pigment in broilers. The δ13C values in muscles were significantly influenced by dietary maize contents, indicating that muscle pigment was transferred from diet (Wang *et al*., 2014). Besides, other literatures claimed that dietary pigments were more possible to deposit in the skin and subcutaneous fat. Our data demonstrated that corn-based diet resulted in an increased RFC scores, L*(lightness), a (redness) * and b*(yellowness) values both in shank and breast skin. Nevertheless, abdominal fat observed only higher values of RFC scores and b* and this discrepancy between skin and abdominal fat coloration may be related to tissue specificity. Tissue-specific difference in carotenoids concentration have previously been reported in growing birds (Surai *et al*., 2001; Koutsos *et al*., 2003) and post hatch chicken (Surai and Speake, 1998).

Since it is challenging for birds synthesize the pigments, it has been widely considered that coloration involving carotenoids were primarily determined by the pigment supplementation in the diet (Hudon, 1994; Breithaupt, 2007). Although breeder effect exists for several weeks in growing chickens, the tissue pigmentation will gradually decline since the deprivation of dietary xanthophylls (Surai *et al*., 1998; Koutsos *et al*., 2003; Sun *et al*., 2015). Besides, it has been reported chicks hatched from C+ eggs (breeder diet containing carotenoids) incorporated dietary carotenoids into tissues in a dose-dependent manner, whereas chicks hatched from C- eggs (breeder diet without carotenoids) can never achieve the same level of carotenoids incorporation (Koutsos *et al*., 2003). Breeder exposure of carotenoids might enable the offsprings to deposit pigment later in the life, demonstrating that early period ingested pigment may improve the coloration efficiency in white Leghorn chickens (Koutsos *et al*., 2003). The current results suggested that the broiler dietary grain sources (different xanthophyll contents), other than the breeder dietary grain sources influenced the coloration in abdominal fat, skin, and skin stored at 4℃ in yellow-skinned chickens. This discrepancy might depend on the different genetic backgrounds for experimental birds between previous and current studies and further research might be required. On the basis of the present results, it can be inferred that a low xanthophyll-containing diet (sorghum and barley-based diet) might be applied in yellow-skinned broiler breeders without causing negative effect on their offspring coloration.

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