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Developmental Stability in Chickens Local to Warm Climatic Region 2. Variation in Blood Metabolites Due to Genetic Selection and Crossing

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Abstract: An experiment was conducted to assess the variation in blood metabolic constituents in a local chicken line (CE1) selected five generations for increased 6-wk body weight. Also, line CE1 was reciprocally crossed with a Slow-Growing Commercial Broiler Strain (SGB). The local genetic control line (CRB) was used for genetic comparison. No significant differences were observed in the blood levels of total proteins, albumin, globulin and Albumin/Globulin (A/G) ratio among lines CE1 and CRB in both parental (P) and progeny (F_1) generations. In P generation, total protein levels of 2.22 and 2.16 g/dl were obtained for lines CE1 and CRB and were significantly higher than 1.78 g/dl for strain SGB. Line CE1 had triglyceride level of 178.76 mg/dl which was significantly higher than 122.13 mg/dl for line CRB. Similar trend for the blood lipid metabolites were obtained in F_1 generation. Sex variation in body weight although was obvious, the selection pressure on sex variation in metabolic activity was not existed. Significant heterosis estimates of -22.56 and 5.0% were obtained for the levels of total lipids and cholesterol. The heterosis estimates in the levels of total proteins, albumin, globulin, A/G ratio and triglycerides were -23.71, 9.94, -33.66, 14.97 and -3.63%, but lacked significance. Although heterosis estimates were mostly insignificant, they indicated that the metabolic activity could be drastically changed by crossing. The drastic change in the metabolic activity was too early to be noticeable in a short-term selection program. Selection pressure was more obvious in lipid metabolites, particularly triglycerides, than in protein metabolites. Highly moderate negative and significant correlation coefficient was obtained between globulin level and cholesterol level. The variable correlation relationships among blood metabolites and the insignificant correlations between blood metabolites and body weights did not reflect the continuous metabolic and tissue remodeling associated with growth. This could be due to the small size that characterizes local chickens of warm regions or the shortness of selection scheme that did not result in an obvious change in the metabolic activity.

Key words: Blood metabolites, crossing, growth, heterosis, selection

INTRODUCTION

The continuous remodeling of tissues during the development and growth is intimately associated with high cellular metabolic activity which results from the interaction of genetic composition with cytoplasm, internal cellular environment and external environment. The metabolic activity is altered according to the environmental conditions as well as the change in genetic composition. Because the genetic stress could agitate the organism development (Yost, 1995), chicken lines undergoing breeding programs possibly endure disruption in the developmental homeostasis (Lerner, 1954; Fairfull, 1990). It has been reported that selection for growth has altered the expression of growth-related hormones (McGuinness *et al*., 1995; Zhao *et al*., 1995a; 1995b) and is associated with great stimulation of DNA synthesis in fast growing chicks (Duclos *et al*., 1995). Selection for rapid growth has been contributed to metabolic and skeletal disorders, susceptibility to disease infection, leg problems and ascites in meat stocks (El-Gendy, 1992; Moller and Swaddle, 1997; Yang *et al*., 1997; Sewalem and Wilhelmson, 1999). Liver and spleen sizes have been altered in local chickens short-term selected for growth (El-Gendy, 2009b), revealing possible metabolic disorders or susceptibility to disease infection with the continuity of selection. The development of adipose stores has been also observed in rapidly growing broilers (Sizemore and Barbato, 2002).

The genetic employment of local breeds in poultry production in some regions of the world is of growing concern. But the information about the developmental stability in local breeds undergoing breeding regimes is still limited. The objective of this study was to assess the variation magnitude in blood metabolic constituents in local chickens subjected to breeding scheme for growth.

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MATERIALS AND METHODS

Genetic groups and management: Three genetic groups were used: a local normally feathered crossbred line (CE1) selected five generations for increased 6-wk BW, a non-selected genetic control line (CRB) representing the base population from which line CE1 has been derived and a Slow-Growing Commercial Broiler Strain (SGB). Lines CE1 and CRB have been formed in an on-going research program aiming at increased juvenile body weight of native Egyptian chickens (El-Gendy, 2009a). The chicks of strain SGB were brought at hatch from a commercial hatchery. The chicks of the genetic groups formed the parental generation and were allowed to produce their progeny generation and the reciprocal crosses were also obtained between line CE1 and strain SGB.

In each generation, the genetic group chicks were wing-banded at hatch and chicks of all genetic groups were intermingled and housed in floor pens in a conventional-type house. The chicks were placed in brooded pens (10 birds/m^2) from hatch to 8 wks of age and in rearing pens (8 birds/m^2) to 12 wks of age. The chicks of the parental generation were left in the rearing pens to 18 wks of age and then placed in individual cages during the pre-laying and laying periods. Artificial insemination was applied to obtain the chicks of progeny generation of all mating combinations in the same day. In each generation, the chicks have been routinely raised to 12 wks of age under environmental conditions recommended for raising broiler chicks. The chicks were fed *ad libitum* a broiler starter ration (22-23% CP and 2800 kcal ME/kg) from hatch to 4 wks of age, a broiler finisher ration (19-20% CP and 3100 kcal ME/kg) from 4, to 8 wks of age and a growing ration (15% CP and 2700 kcal ME/kg) from 8 to 12 wks of age. The parental chickens were thereafter fed commercial pre-laying and laying rations. Water was provided *ad libitum* and continuous illumination was also provided to 12 wks of age. All chicks were vaccinated against common viral diseases in the region.

Blood metabolic constituent analysis: At 12 wks of age, 16 individuals were randomly assigned from both sexes of each genetic group or mating combination in the parental and progeny generations. Five-ml blood sample was drawn from the wing vein of each individual and was immediately centrifuged (4500 rpm for 10 min). Individual plasma samples were cooled and stored at -20°C. Upon use, samples were thawed and were used to estimate the levels of plasma total proteins, albumin, total lipids, triglycerides and cholesterol according to the methods of Gornal *et al.* (1949), Doumas *et al.* (1971), Zollner and Kirsch (1962), Fassati and Prencipe (1982) and Richmond (1973), respectively. Plasma globulin was calculated by subtraction of albumin level from the level of total proteins and the Albumin/Globulin (A/G) ratio was then calculated. Also, all individuals in each generation were weighed at hatch and at 6 and 12 wks of age.

Statistical analysis: Analysis of variance was applied to the data set of the levels of blood metabolic constituents and body weights, using the general linear model procedure of the statistical analysis system (SAS, 1999). The statistical model included the effects of genetic group, sex and genetic group by sex interaction. Differences between the genetic groups were tested for significance (Duncan, 1955). Heterosis estimates were obtained and were tested for significance using a contrast analysis.

RESULTS

Blood metabolic constituents: The levels of blood protein and lipid constituents in the parental generation are shown in Table 1. Total protein levels of 2.22 and 2.16 g/dl were obtained for lines CE1 and CRB. These levels were insignificantly differed from each other and were significantly higher than 1.78 g/dl obtained for strain SGB. Similar line differences were found in globulin level. No significant differences were found between different genetic groups in albumin level as well as in A/G ratio. Strain SGB had significantly the highest levels of cholesterol and triglyceride of 694.05 and 194.36 mg/dl, respectively. Lines CE1 and CRB had similar levels of cholesterol. Line CE1 had 178.76 mg/dl for triglyceride level which was significantly higher than 122.13 mg/dl for line CRB.

The results of blood constituents in the progeny generation were in general in the same trend as in the parental generation (Table 2). Line CE1 had levels of metabolic proteins components significantly comparable to the levels in strain SGB and line CRB. The levels of total lipids in line CE1 and strain SGB were not significantly differed (1777.41 and 1776.04 mg/dl, respectively) and were significantly higher than 1345.98 mg/dl obtained for line CRB. The variation in triglyceride level among the genetic groups was insignificant and minimal compared to significant variation in the parental generation. The variation in cholesterol level between the genetic groups was typical to that in the parental generation. Lines CE1 and CRB showed cholesterol levels of 151.62 and 161.11 mg/dl and were significantly lower than 239.36 mg/dl for strain SGB.

The sex variations in blood metabolic constituents within genetic group and generation were inconsistent. The level of total proteins was significantly higher in males than in females in both lines CE1 and CRB, but it was lower in males of strain SGB than in females. In general, no significant differences were found between both sexes in most of the genetic groups in the levels of albumin and globulin and in A/G ratio. But males of strain SGB had significantly lower levels of globulin and total lipids and higher level of cholesterol than females.

Table 1: Blood metabolic constituents (LSM±SE) in different genetic groups (parental generation)

Genetic group	Protein components (g/dl)				Lipid components (mg/dl)		
	Total proteins	Albumin	Globulin	A/G ratio	Total lipids	Cholesterol	Triglyceride
Line CE1	2.22^{a}±0.20	1.05^{a}±0.19	1.17^{ab}±0.23	1.39^{a}±0.64	----	147.14^{b}±25.57	178.76^{b}±2.61
Strain SGB	1.78^{b}±0.22	0.95^{a}±0.20	0.82^{b}±0.25	2.60^{a}±0.67	----	694.05^{a}±24.14	194.36^{a}±2.47
Line CRB	2.16^{a}±0.21	0.79^{a}±0.19	1.38^{a}±0.24	0.60^{a}±0.68	----	185.89^{b}±26.26	122.13^{c}±2.68

A/G ratio = Albumin/Globulin ratio. ---, data were not obtained.

^{a,b,c}Blood metabolic constituents of different genetic groups with different superscripts are significantly different ($p \leq 0.05$).

Table 2: Blood metabolic constituents (LSM±SE) in different genetic groups (progeny generation)

Genetic group	Protein components (g/dl)				Lipid components (mg/dl)		
	Total proteins	Albumin	Globulin	A/G ratio	Total lipids	Cholesterol	Triglyceride
Line CE1	2.93^{ab}±0.38	1.07^{a}±0.25	2.20^{ab}±0.37	0.64^{a}±0.24	1777.41^{a}±175.18	151.62^{c}±19.95	203.76^{ab}±3.14
Strain SGB	2.09^{b}±0.41	0.64^{a}±0.40	0.83^{b}±0.25	0.83^{a}±0.37	1776.04^{a}±212.15	239.36^{a}±19.77	207.61^{ab}±3.47
Line CRB	3.41^{a}±0.36	0.97^{a}±0.22	2.38^{a}±0.31	0.56^{a}±0.22	1345.98^{b}±186.05	161.11^{c}±22.37	214.29^{a}±3.37
Cross CE1*SGB	1.68^{b}±0.33	0.76^{a}±0.22	1.16^{ab}±0.31	0.74^{a}±0.23	1132.03^{b}±171.04	180.95^{bc}±20.74	199.24^{b}±3.07
Cross SGB*CE1	2.15^{b}±0.32	1.12^{a}±0.28	0.85^{ab}±0.39	0.95^{a}±0.36	1619.83^{ab}±166.92	229.57^{ab}±17.04	197.20^{b}±2.99
Heterosis	-0.60	+0.09	-0.51	+0.11	-400.80	+9.77	-7.47
Heterosis %	-23.71	+9.94	-33.66	+14.79	-22.56*	+5.00*	-3.63

A/G ratio = Albumin/Globulin ratio.

^{a,b,c}Blood metabolic constituents of different genetic groups with different superscripts are significantly different ($p \leq 0.05$).

*Significant heterosis percentage ($p \leq 0.05$).

Line CE1 showed no significant difference between sexes in any of the lipid components. In line CRB, males had significantly less levels of cholesterol and triglyceride than females.

The heterotic effect: Both reciprocal crosses had levels of total proteins that were significantly correspondent to each other and correspondent to those of the parental groups (Table 2). The cross SGB*CE1 had a cholesterol level of 229.57 mg/dl, which was significantly correspondent to 239.36 mg/dl for the parental strain SGB and higher than 151.62 mg/dl for the parental line CE1. The reciprocal crosses had heterosis estimates with different magnitudes in different blood metabolites. The heterosis estimates in the levels of total proteins, albumin, globulin, A/G ratio and triglycerides were -23.71, 9.94, -33.66, 14.79 and -3.63%, but lacked significance. However, significant heterosis estimates of -22.56 and 5.0% were obtained for the levels of total lipids and cholesterol. Sex variation was significantly shown in only the level of total proteins in the cross SGB*CE1, where males had 1.13 g/dl and females had 3.17 g/dl.

The correlations among blood metabolic constituents: Significant to highly significant correlation coefficients were estimated among the levels of different protein components (Table 3). In line CE1, a correlation coefficient of 0.55 was between the level of total proteins and albumin level. The correlation coefficient between the level of total proteins and the level of globulin was 0.70 in strain SGB and 0.85 in line CRB. Also, high significant correlation coefficients of 0.65 to 0.86 were estimated between albumin level and A/G ratio in all genetic groups. Significant correlations of 0.60 and -0.58 were estimated between the level of total proteins and the levels of total lipids and cholesterol in strain SGB. No significant correlations were found between albumin level and any of the lipid components in all genetic groups. But globulin level was significantly correlated with cholesterol level by -0.61 and -0.53 in line CE1 and strain SGB, respectively.

Table 3: The correlation coefficient estimates among blood constituents in the different genetic groups (parental generation)

Blood constituents	Genetic group		
	Line CE1	Strain SGB	Line CRB
Total proteins-albumin	0.55*	0.39	0.36
Total proteins-globulin	0.25	0.70**	0.85***
Total proteins-A/G ratio	0.01	0.09	0.06
Albumin-globulin	-0.67**	-0.38	-0.17
Albumin-A/G ratio	0.81***	0.65*	0.86***
Globulin-A/G ratio	-0.70**	-0.42	-0.38
Total lipids-cholesterol	-0.30	-0.50*	-0.17
Total lipids-triglyceride	0.09	-0.19	-0.07
Cholesterol-triglyceride	0.62*	0.07	0.29
Total proteins-total lipids	-0.22	0.60*	-0.28
Total proteins-cholesterol	-0.24	-0.58*	-0.32
Total proteins-triglyceride	-0.16	-0.16	-0.44
Albumin-total lipids	-0.39	0.30	0.22
Albumin-cholesterol	0.35	-0.06	-0.17
Albumin-triglyceride	0.22	0.09	-0.27
Globulin-total lipids	0.26	0.33	-0.45
Globulin-cholesterol	-0.61*	-0.53*	-0.24
Globulin-triglyceride	-0.40	-0.24	-0.31
A/G ratio-total lipids	-0.19	0.49	0.07
A/G ratio-cholesterol	0.36	-0.11	-0.14
A/G ratio-triglyceride	0.41	-0.16	0.02

A/G ratio = Albumin/Globulin ratio.

*The correlation coefficient estimate is significant ($p \leq 0.05$).

**The correlation coefficient estimate is significant ($p \leq 0.01$).

***The correlation coefficient estimate is significant ($p \leq 0.001$).

Table 4: The correlation coefficient estimates among blood constituents in the different genetic groups (progeny generation)

	Genetic group				
Blood constituents	Line CE1	Strain SGB	Line CRB	Cross CE1*SGB	Cross SGB*CE1
Total proteins-albumin	0.30	-0.57	0.09	0.69*	0.74*
Total proteins-globulin	0.72	0.55	0.76*	0.90***	0.77*
Total proteins-a/g ratio	-0.23	-0.71	-0.19	-0.42	-0.01
Albumin-globulin	-0.17	-0.41	-0.58	0.29	0.14
Albumin-A/G ratio	0.82*	0.74	0.89**	0.15	0.61
Globulin-A/G ratio	-0.67	-0.99	-0.85**	-0.63	-0.59
Total lipids-cholesterol	0.53	0.59	0.26	-0.29	0.44
Total lipids-triglyceride	0.20	-0.42	-0.45	-0.38	0.42
Cholesterol-triglyceride	-0.26	-0.52	-0.63	0.59	-0.13
Total proteins-total lipids	0.47	-0.25	0.61*	-0.49	-0.61*
Total proteins-cholesterol	0.54	-0.41	0.16	-0.10	-0.31
Total proteins-triglyceride	-0.39	0.18	-0.48	0.49	-0.38
Albumin-total lipids	0.36	0.56	-0.12	-0.63	-0.57
Albumin-cholesterol	0.67	-0.08	0.004	0.33	-0.56
Albumin-triglyceride	-0.54	-0.41	0.27	0.21	-0.22
Globulin-A/G ratio	-0.67	-0.99	-0.85**	-0.63	-0.59
Globulin-total lipids	-0.35	0.96	0.65*	-0.48	-0.44
Globulin-cholesterol	0.10	-0.09	0.07	-0.26	0.32
Globulin-triglyceride	-0.61	-0.91	-0.55	0.57	-0.49
A/G ratio-total lipids	0.54	0.19	-0.18	0.20	0.18
A/G ratio-cholesterol	0.47	0.35	0.09	0.41	-0.18
A/G ratio-triglyceride	-0.01	0.16	0.23	0.11	0.32

A/G ratio = Albumin/Globulin ratio. *The correlation coefficient estimate is significant ($p \leq 0.05$). **The correlation coefficient estimate is significant ($p \leq 0.01$). ***The correlation coefficient estimate is significant ($p \leq 0.001$).

Table 5: The correlation coefficient estimates between body weights and blood constituents (parental generation)

		Blood constituents						
Genetic group	Body weight	Total proteins	Albumin	Globulin	A/G ratio	Total lipids	Cholesterol	Triglyceride
Line CE1	Hatch	0.49	0.01	0.42	-0.47	0.27	-0.54*	-0.41
	6 wks	0.10	0.15	-0.08	-0.21	-0.05	-0.29	-0.26
	12 wks	0.30	0.47	-0.28	0.19	-0.09	-0.26	-0.19
Strain SGB	Hatch	-0.65**	-0.38	-0.36	-0.28	-0.40	0.39	0.13
	6 wks	-0.46	-0.09	-0.39	-0.02	-0.42	0.47*	-0.02
	12 wks	-0.61**	-0.17	-0.48	-0.29	-0.33	0.42	0.30
Line CRB	Hatch	0.47	0.25	0.36	-0.10	0.30	-0.11	0.04
	6 wks	0.27	0.49	0.01	0.49	0.36	-0.59	-0.19
	12 wks	0.50	-0.23	0.66*	-0.54	-0.40	-0.30	-0.14

A/G ratio = Albumin/Globulin ratio. *The correlation coefficient estimate is significant ($p \leq 0.05$). **The correlation coefficient estimate is significant ($p \leq 0.01$).

The correlations among blood constituents in the progeny generation did not differ from those obtained in the parental generation (Table 4). In line CRB, significant to highly significant correlations were estimated between the level of total proteins and the level of globulin or between the level of albumin or globulin and A/G ratio. Also, the correlations among lipid components, although insignificant, were moderate to highly moderate. Crosses CE1*SGB and SGB*CE1 showed significant to highly significant correlations between the level of total proteins and albumin level (0.69 and 0.74, respectively) and between the level of total proteins and globulin level (0.90 and 0.77, respectively).

The correlations between blood constituents and body weights: Line CE1 showed a significant correlation of -0.54 between cholesterol level and hatch weight (Table 5). In strain SGB, highly significant correlations of -0.65 and -0.61 were estimated between the level of total proteins and each of hatch weight and 12-wk body weight and a significant correlation of 0.47 was between cholesterol level and 6-wk body weight. Also, line CRB showed a significant correlation of 0.66 between globulin level and 12-wk body weight. In the progeny generation, the correlation coefficients between blood constituents and body weights were also variable and mostly insignificant in all genetic groups (Table 6). In the reciprocal crosses, the correlation coefficients did not differ from the general trend shown in the parental genetic groups, except a significant correlation of 0.62 was between cholesterol level and hatch weight in the cross CE1*SGB and a significant correlation of -0.79 was between globulin level and hatch weight in the cross SGB*CE1.

Table 6: The correlation coefficient estimates between body weights and blood constituents (progeny generation)

		Blood constituents						
Genetic group	Body weight	Total proteins	Albumin	Globulin	A/G ratio	Total lipids	Cholesterol	Triglyceride
Line CE1	Hatch	0.43	0.18	-0.52	0.42	0.51	0.23	-0.03
	6 wks	-0.43	0.01	-0.83*	0.38	-0.04	0.03	0.39
	12 wks	0.31	0.49	-0.43	0.75	0.27	0.75**	-0.07
Strain SGB	Hatch	0.10	0.26	-0.96	0.56	-0.001	0.16	-0.22
	6 wks	-0.18	-0.74	0.48	-0.49	0.13	0.61	-0.37
	12 wks	-0.54	0.83	-0.87	0.93	-0.14	0.13	-0.47
Line CRB	Hatch	-0.35	0.60	-0.70*	0.76*	-0.27	-0.02	0.13
	6 wks	-0.22	0.33	-0.48	0.56	-0.17	0.24	-0.06
	12 wks	-0.19	-0.44	0.22	-0.28	0.34	0.44	-0.24
Cross CE1*SGB	Hatch	-0.15	0.01	-0.02	0.06	0.41	0.62*	0.05
	6 wks	-0.34	-0.10	-0.15	0.20	0.46	0.33	-0.09
	12 wks	-0.13	-0.07	0.14	-0.02	0.12	0.48	0.08
Cross SGB*CE1	Hatch	-0.56	0.22	-0.79*	0.80	0.17	0.02	0.43
	6 wks	0.37	0.42	-0.22	0.15	-0.34	-0.81	0.16
	12 wks	0.09	0.41	-0.43	0.67	-0.14	-0.27	0.43

A/G ratio = Albumin/Globulin ratio. *The correlation coefficient estimate is significant ($p \leq 0.05$). **The correlation coefficient estimate is significant ($p \leq 0.01$).

DISCUSSION

The results obtained in both parental and progeny generations were in general in similar trends of inconsistency. The results revealed insignificant differences in the levels of blood protein constituents among different genetic groups. However, the differences in the levels of blood lipid constituents were significant and mainly attributed to the differences between the genetic groups. The effects of sex and genetic group by sex interaction on the protein and lipid components were mostly inconsistent. The native Egyptian Gimmizah chickens had levels of total lipids and cholesterol of 3177.3 and 314.1 mg/dl respectively, at 16 wks of age (Mahmoud *et al*., 2008) and had triglyceride and cholesterol levels of 138.55 and 245.20 mg/dl respectively, at 46 wks of age (El-Sheikh and Hanafy, 2008). The significant difference between line CE1 and its genetic control line (CRB) in triglyceride level accompanied by the insignificant difference between them in cholesterol level may be attributed to the short-term selection practiced on line CE1. It seems that the effect of short-term selection pressure was more obvious in lipid metabolites, particularly triglycerides, than in protein metabolites. El-Gendy (2009b) reported an early pressure of short-term selection for body weight on the development of liver and spleen and increasing bilateral shank measurements, although the bilateral developmental stability was not influenced. The concentrations of total proteins, albumin and globulin were differed between the native Egyptian breeds at 36 wks old (Hassan *et al*., 2008). The concentrations were 5.16, 3.28 and 1.88 g/dl, respectively in Dandarawi chickens versus 5.59, 3.55 and 2.04 g/dl in Dokki4 chickens. Triglyceride concentration was 139.15 and 143.16 mg/dl in both breeds, respectively. Aksit *et al*. (2006) estimated 1.30 mg/dl for the plasma albumin content of Ross broiler chicks at 7 wks of age. In 5-wk old commercial broiler chickens, Al-Bandr *et al*. (2010) reported levels of 2.34, 1.39 and 1.04 g/dl for total proteins, albumin and globulin and 477 and 174 mg/dl for total lipids and triglyceride, respectively. Also, 6-wk old broiler chicks had levels of total proteins, albumin and globulin of 2.94, 1.68 and 1.25 g/dl (Abdel-Fattah *et al*., 2005) and A/G ratio of 1.39. The levels of total lipids and cholesterol were 657.52 and 133.71 mg/dl, respectively.

The normal sex variation was absent in many traits in the local selected line CE1 and its genetic control line (CRB) in both parental and progeny generations versus significant sex variation in strain SGB. So, sex variation in body weight although was obvious, the expected influence of selection pressure on sex variation in metabolic activity was not existed. Perhaps the drastic change in the metabolic activity was too early to be noticeable in such a short-term selection program. Ibrahim and Saleh (2005) reported levels of 3.87 and 2.23 g/dl for total proteins and albumin in male broiler chicks at 7 wks old. Also, Khan *et al*. (2006) found that the total proteins, albumin and globulin concentrations in blood of 18-wk White Leghorn cockerels were 4.67, 5.60 and 1.63 g/dl, respectively. The levels of total lipids and triglyceride were 6.05 and 162.34 mg/dl, respectively. In the native Egyptian Dandarawi hens at 36 wks old, the concentrations of total proteins, albumin and globulin were 4.32, 2.31 and 2.01 g/dl respectively (Tollba and El-Nagar, 2008). The heavy male broilers, 7 wks old, had a plasma cholesterol level of 111 mg/dl (Thaxton *et al*., 2006). Chowdhury *et al*. (2005) determined an average of cholesterol level of 210 mg/100 ml in laying hens of 1 to 6 wks old. Also, in commercial White Leghorn laying hens, Peebles *et al*. (2006) determined serum cholesterol and triglycerides concentrations of 199 and 3728 mg/dl at 47 wks of age and declined to 162 and 3198 mg/dl at 58 wks of age.

Although the heterosis estimates were mostly insignificant, they indicate the tendency of blood metabolites to drastically change by crossing. Also, blood metabolites varied in their response to crossing, where significant heterosis estimates were obtained in only the levels of total lipids and cholesterol.

The results of the correlations among different blood metabolites in the parental and progeny generations lacked consistency among different genetic groups. In general, significant relationships were found between the level of total proteins and the levels of albumin, globulin, total lipids and cholesterol. Also, negative and significant relationship was observed between globulin and cholesterol levels. Otherwise, low to moderate and mostly insignificant correlation coefficients were found among blood protein constituents or among blood lipid constituents in all genetic groups. These variable relationships as well as the insignificant relationships between blood metabolites and body weights did not reflect the continuous metabolic and tissue remodeling associated with growth. This could be due to the small size that characterizes the local chickens of warm regions or the shortness of selection scheme that did not result in an obvious change in the metabolic activity. El-Gendy (2009b) reported a lack of significance for the correlation coefficients between different bilateral asymmetries of different traits in local lines undergone short-term selection for growth.

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