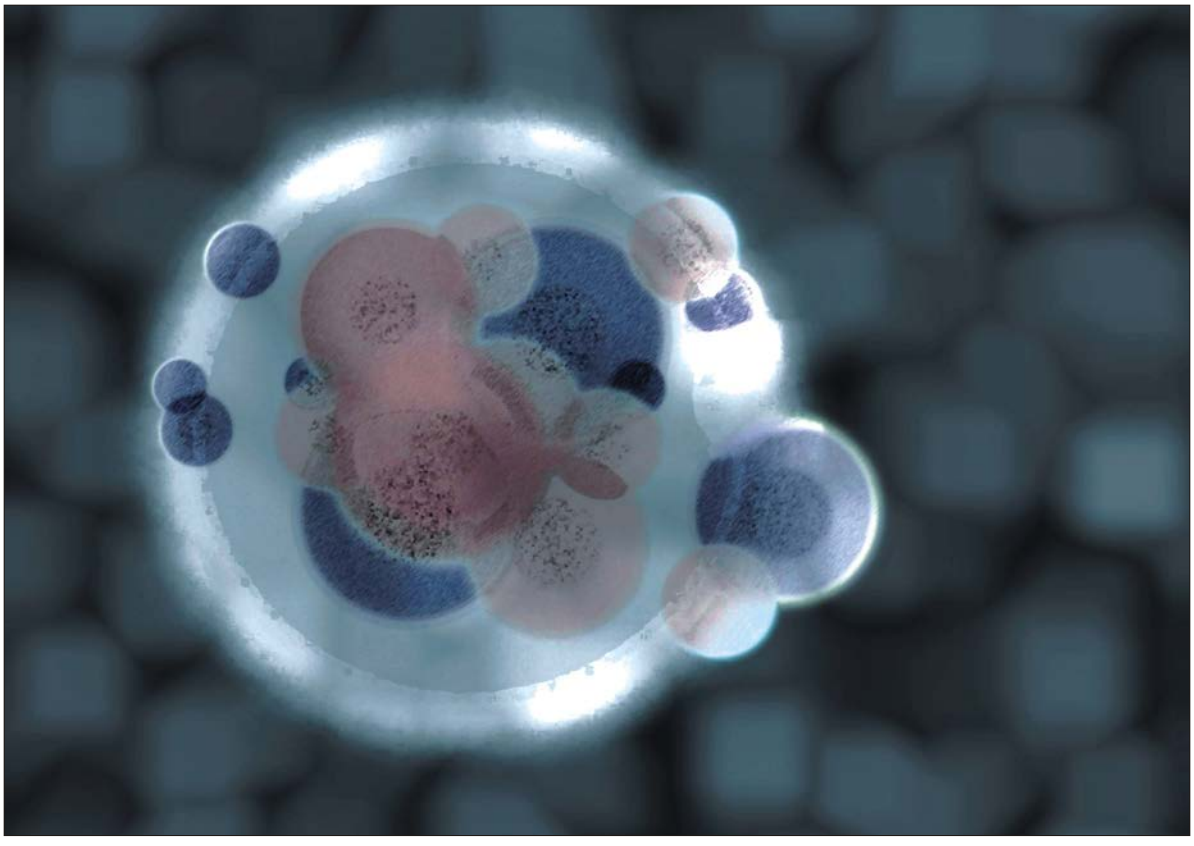

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Relation Between Serum Cholesterol Level, Lipoprotein Concentration and Carcass Characteristics in Genetically Lean and Fat Chicken Breeds

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Abstract: Serum cholesterol, lipoprotein concentration and carcass characteristics data were taken in 30 fat and 40 lean chickens. Breeds were differed significantly ($p<0.001$) in carcass traits and non significantly ($p>0.05$) in carcass portions. Color density and pH were also differed significantly ($p<0.05$), whereas water holding capacity (WHC) and shear force value were non significant ($p>0.05$). Both breeds showed positive correlation for carcass traits, while abdominal fat was negatively related with breast muscle in lean breed. Significant difference ($p<0.05$) were observed in cholesterol and LDL and non significant ($p>0.05$) in triglyceride, VLDL and HDL level. Cholesterol and triglyceride were respectively related with LDL and VLDL. HDL was observed negatively related with triglyceride and cholesterol. Sex was effect significantly ($p<0.05$) in triglycerides and VLDL level and non significantly ($p>0.05$) in cholesterol, HDL and LDL level in fat breed. However, lean breed observed non significant difference ($p>0.05$) for lipoprotein concentrations. Correlation of lipoprotein concentrations and carcass trait were determined. In both breeds lipoprotein concentrations were negatively related with carcass traits. LDL was positively related with breast muscle and abdominal fat weight and triglyceride with live weight in fat breed. In lean breed cholesterol and LDL were presented positive correlation with all carcass traits.

Key words: Cholesterol, lipoprotein, carcass characteristics, chicken breeds

INTRODUCTION

Poultry breeders have achieved rapid increases in the body weight and proportion of breast muscle in the carcass and abdominal fat of broiler chickens. This excess fat accumulation is a waste of energy for poultry breeders and consumer. In laying hen, body fatness is related to egg production. The difference in the growth of lean and fat chicken breeds was due to differences in the number of adipocytes in the abdominal fat. Simon and LeClercq (1982) reported 90% of the difference was within each sex but not between sexes, because female display larger adipocytes and higher ratios of abdominal fat to live weight. In bird, dietary polyunsaturated fatty acids (pUFAs) are released directly from the intestine into the portal blood as triglycerides associated to porto microns (Bensadoun and Rothfield, 1972). These triglycerides are hydrolyzed in plasma by lipoprotein lipase prior to fatty acid uptake by the muscle for oxidation or adipose tissue for re-esterification and storage. Whereas, long-chain PUFAs are incorporated into phospholipids of cell membranes rather than oxidized or stored and they are available in the tissues informs of phospholipids rather than triglycerides (Subbaiah *et al*., 1993). Because high density lipoprotein (HDL) is the main lipoprotein class in avian species (Mossab *et al*., 2001). In the chicken lipogenesis occurs essentially in the liver, adipose tissue only for storage (Carre *et al*., 2002). Fatty acid composition can be an important criterion of carcass quality and is significantly influenced by the fatty acid pattern of the diet (Roth *et al*., 1993). The used of certain fats may have an impact upon organoleptic traits of meat quality (Zollitsch *et al*., 1997). The objectives of the present study was to investigate the relation of serum cholesterol level, triglycerides and lipoprotein concentration with meat quantity and quality in genetically lean and fat chicken breeds.

MATERIALS AND METHODS

Animals and blood collection: Two genetically lean Rugao chicken and fat Wenchang chicken breeds at 12 week old were selected from the Institute of Poultry Science of Jiangsu province, China and they were fed on the same diet and circumstances. The number of birds for each trait was 30 for fat line and 40 for lean line and within each line males and females are equals. Exactly 5 mL of blood was taken from the wing vein of fasting chicken. Blood

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samples were transported to college of Animal Science and Technology, Yangzhou University laboratory. Blood serum was recovered by centrifugation at 3000 rpm for 10 min and then serum was frozen and stored at -20°C.

Meat quantity and quality determination: For meat traits determination, the 70 chickens were taken as a representative sample and were slaughtered at Poultry Institute and then the carcasses were dissected manually. Carcass traits are depicted in (Table 1). In addition the carcass weight and dressing out (%) was expressed as a ratio of carcass and live body weight (Zollitsch *et al*., 1997). For meat quality determination, breast muscle was transported to the College laboratory. Water holding capacity was estimated by placing 1 g of breast muscle into the middle of 16 filter paper covered by hard plastic plate, pressed slowly until 35 kg for 5 min and then the percentage of water losses expressed by the difference in fresh weight before and after pressing on the initial weight. Shear force was evaluated on cores (1.25×2 cm) obtained from the maid-portions of the breast samples by cutting them perpendicularly to fiber direction, using an Instron equipped with a Warner-Bratzler Shear (Castellini *et al*., 2002). The color was measured after homogenizing 3 g breast muscle with 4 mL distilled water for 10 min and then centrifuged for 5 min at 3500 rpm. The supernatant was transferred into color tube and the OD was measured at 540 nm using Spectrophotometer. The same supernant was similar used for pH determination using pH meter.

Biochemical analysis: Total serum cholesterol (free cholesterol+ cholesterol esters) and triglycerides was assayed using a commercial enzymatic kit supplied by (Zhe jiang Dongou Biological Engineering Co., Ltd.) according to the manufacturer recommendations. Samples were incubated for 5 min at 37°C and their absorbances were read at 540 nm with spectrophotometer. High-density lipoprotein cholesterol was detected enzymatically after precipitation of (LDL and VLDL) by heparin and manganese; their absorbances were read at 540 nm with spectrophotometer. Very low-density lipoprotein cholesterol was estimated as [Triglycerides/5] (Friedwald *et al*., 1972) and therefore, low-density lipoprotein cholesterol is estimated using the Friedewald equation [Low-density lipoprotein cholesterol = Total cholesterol-High-density lipoprotein cholesterol-Trigylerides/5] (Friedwald *et al*., 1972).

Statistical analysis: All values are presented as the means±standard error of mean (SEM) of several independent experiments. Significant differences were obtained using a paired Student's t-test (Steel and Torrie, 1980). The relation between carcass traits and lipoprotein concentration was determined using Pearson bivariate coefficient correlation, all analysis was performed by SPSS software.

RESULTS

Fat line chicken breed show higher significantly ($p<0.001$) carcass characteristics compared with his corresponding lean line chicken and there are no significant difference between both line in dressing out percentage (Table 1). Therefore, differences in the weights of the various carcass parts reflected the differences in the final weight and hence in the carcass weight. If calculated as a percentage of carcass weight, no significant differences were found between lean and fat lines for the carcass portions.

For the meat quality traits there are no significant difference ($p>0.05$) between fat and lean chicken in water holding capacity (WHC) and shear force value, while color density and pH were significantly different ($p<0.05$). The phenotypic correlation of several carcass characteristics in lean and fat chicken was presented in (Table 2). Both lines showed high positive correlation of carcass characteristics. Negative correlation was only recorded between abdominal fat and breast muscle in lean line chicken.

Biochemical analysis: Serum cholesterol level and lipoprotein concentration in the present study, indicated that there are significance difference ($p<0.05$) in total cholesterol and LDL between breeds. Triglyceride, VLDL and HDL concentration was not significant ($p>0.05$) in both lines (Table 3). Total cholesterol level was observed positively related with LDL level and triglyceride was related with VLDL. Highly negative correlation was found between HDL and triglyceride and cholesterol as presented in (Table 4). The effect of sex on blood serum analysis shown in (Fig. 1), indicated that in lean chicken there are no significant difference ($p>0.05$) between male

Table 1: Meat quantity and quality in fat and lean chicken breeds

Parameters	Fat chicken	lean chicken	p-value
Live weight (g)	1075±37	878±20.52	0.000
Carcass weight (g)	886±34	718±17.96	0.000
Dressing out (%)	82.2±0.38	81.73±0.31	0.878
Breast muscle weight (g)	142±5	119±3.36	0.000
Breast (%)	16.20±0.39	16.46±0.28	0.166
Leg muscle weight (g)	228±10	183±4.89	0.000
Leg muscle (%)	25.71±0.34	25.67±0.19	0.490
Abdominal fat weight (g)	22±3	9±1.04	0.000
Abdominal fat (%)	2.52±0.26	1.19±0.14	0.433
Heart weight (g)	5±0.3	4±0.12	0.000
Heart (%)	0.55 ±0.02	0.49±0.01	0.896
Liver weight (g)	20±0.6	18±0.43	0.001
Liver (%)	2.33±0.05	2.44±0.31	0.984
Water holding capacity (%)	33.81±0.75	32.07±1.09	0.122
pH	5.59±0.02	6.05±0.06	0.000
Shear value (kg/cm^2)	3.11±0.156	2.89±0.11	0.309
Color density	0.75±0.03	0.579±0.03	0.003

No. of observation was 30 birds for fat and 40 birds for lean

Table 2: Phenotypic correlation of carcass characteristics in fat and lean chicken breeds

Parameter	LWT	CWT	BWT	LWT	ABFWT	HWT	LIWT
LWT	1	0.991**	0.520**	0.936**	0.299*	0.876**	0.850**
CWT	0.995**	1	0.544**	0.948**	0.291*	0.877**	0.830**
BWT	0.781**	0.768**	1	0.552**	-0.007	0.339*	0.358*
LGWT	0.944**	0.953**	0.719**	1	0.252*	0.789**	0.789**
ABFWT	0.403*	0.406*	0.433*	0.334	1	0.238	0.256
HWT	0.820**	0.830**	0.512**	0.790**	0.287	1	0.788**
LIWT	0.728**	0.738**	0.554**	0.677**	0.315	0.606**	1

Note: Above diagonal lean chicken line and below diagonal fat chicken line, LWT: Live Body Weight; CWT: Carcass Weight; BWT: Breast Muscle Weight; LGWT: Leg Buscle Weight; ABFWT: Abdominal Fat Weight; HWT: Heart Weight; LIWT: Liver Weight, ** Significant at ($p<0.01$), * Significant at ($p<0.05$), No. of observation was 30 birds for fat and 40 birds for lean

Table 3: Serum concentration of lipoprotein (mg/dl) in fat and lean chicken breeds

Parameter	Fat chicken	Lean chicken	p-value
No	30	40	
Total cholesterol	121.73±5.00	137.77±3.59	0.025
Triglyceride	56.92±3.70	48.79±2.99	0.533
High density lipoprotein	59.62±2.93	61.40±1.55	0.480
Low density lipoprotein	50.32±4.58	66.61±3.46	0.030
Very low density lipoprotein	11.38±2.74	9.76°0.61	0.537

Table 4: Correlation of lipoprotein concentration in fat and lean chicken breeds

	TCH	TG	HDL	VLDL	LDL
TCH	1	0.270	0.219	0.272	0.890**
TG.	0.496**	1	-0.023	1.000**	0.111
HDL	-0.092	-0.522**	1	-0.025	-0.214
VLDL	0.496**	1.000**	-0.522**	1	0.114
LDL	0.834**	0.257	-0.392*	0.257	1

No. of observation was 30 birds for fat and 40 birds for lean, Note: Above diagonal lean chicken line and below diagonal fat chicken line. TCH: cholesterol; TG: triglycerides; HDL: High Density Lipoprotein; VLDL: Very Low Density Lipoprotein; LDL: Low Density Lipoprotein.** Significant at ($p<0.01$), * Significant at ($p<0.05$)

Table 5: Correlation analysis of lipoprotein concentration and carcass traits in fat chicken breeds

Parameters	TCH	TG	HDL	VLDL	LDL
Live weight (g)	-0.325	0.163	-0.228	-0.163	-0.071
Carcass weight (g)	-0.327	-0.173	-0.229	-0.173	-0.066
Breast muscle weight (g)	-0.163	-0.169	-0.166	-0.169	0.050
Leg muscle weight (g)	-0.298	-0.150	-0.205	-0.150	-0.069
Abdominal fat (g)	-0.167	-0.174	-0.162	-0.174	0.083
Heart weight (g)	-0.315	-0.177	-0.199	-0.177	-0.069
Liver weight (g)	-0.286	-0.116	-0.131	-0.116	-0.083

No. of observation was 30 birds

Table 6: Correlation analysis of lipoprotein concentration and carcass traits in lean chicken breeds

Parameters	TCH	TG	HDL	VLDL	LDL
Live weight (g)	0.084	0.023	0.211	0.025	0.132
Carcass weight (g)	0.082	-0.011	0.205	-0.009	0.142
Breast muscle weight (g)	-0.101	0.054	-0.149	0.057	0.070
Leg muscle weight (g)	-0.073	-0.040	0.050	-0.037	0.067
Abdominal fat (g)	0.198	-0.181	0.279	0.181	0.132
Heart weight (g)	0.229	0.057	0.273	0.058	0.110
Liver weight (g)	-0.069	-0.023	0.134	-0.022	0.002

No. of observation was 40 birds

and female in total cholesterol level, triglycerides, HDL, VLDL and LDL. However, in fat chicken triglycerides and VLDL was significantly difference ($p<0.05$), while tota cholesterol, HDL and LDL was non significantly difference ($p>0.05$).

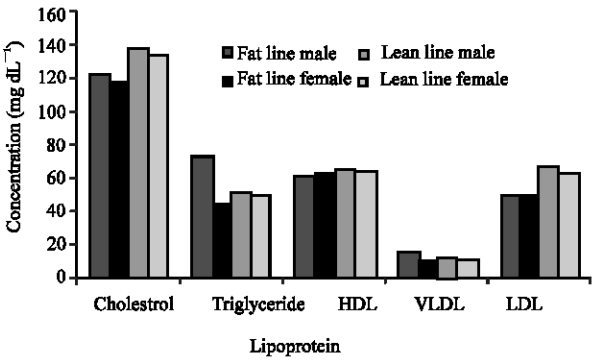

Fig. 1: Sex effect for lipoprotein concentration in fat and lean chicken No. of observation was 30 birds for fat and 40 birds for lean

Relation of lipoprotein concentration with carcass traits: In fat chicken cholesterol, triglyceride, HDL, VLDL and LDL were negatively related with carcass traits. Positive relation was also found between LDL and breast muscle and abdominal fat weight, as well as triglyceride and live weight (Table 5). On the other hand, in lean line cholesterol and LDL were positively related with all carcass traits. Whereas, total cholesterol, triglyceride, VLDL and HDL presented negative and positive relation with carcass traits (Table 6).

DISCUSSION

Differences in the proportions of different carcass parts, especially the breast muscle are economically important and the abdominal fat is a representative of fattening in birds. The present study confirms that the difference of lean and fat line in rate of fat deposition in extra-hepatic tissue is due to inherited difference, since birds were grown under the same environmental and nutritional conditions. However, the biochemical mechanisms for these differences are still limited. Further experiments are therefore needed, such as determination of lipoprotein concentration and single nucleotide polymorphism of concern genes.

Carcass quality was significantly influenced by the fatty acid pattern of the diet (Yau *et al.*, 1991; Roth *et al.*, 1993). And the response of intramuscular fat to dietary triglycerols is different to that of adipose tissue (Hrdinka *et al.*, 1996). Abdominal fat was significantly influenced by the dietary fatty acid pattern (Zollitsch *et al.*, 1997). Previously lean and fat chicken lines have been selected for adipose tissue weight (LeClerq *et al.*, 1980; Cahaner and Nitsan, 1985) and for VLDL (Whitehead and Griffin, 1984). In accordance to that the difference between fat line and lean in adiposity is not a result of difference in food consumption or metabolic utilization of energy (LeClerq *et al.*, 1980). The pH is known to influence the structure of myofibrils and consequently the WHC and color of meat. Therefore, highly significant difference ($p<0.01$) of pH and color density was found in fat and lean chicken. Similarly, Warris (2000) and Castellini *et al.* (2002) indicated that shrinkage of contractile fiber caused by a lower pH reduced WHC and therefore increases light scattering. Because low pH reduces the important of myoglobin to absorb green light, then the meat appears less red and more yellow. There are no significant difference between fat and lean chicken for the tenderness and water holding capacity of breast muscle meat. Previous study indicated that the tenderness was decreased with age (Touraille *et al.*, 1991). However, Sonaiya *et al.* (1990) found no difference due to age. Stress during animal production and in the immediate pre-slaughter periods has been recognized by Lawrie (1991) that was a major determinant of ultimate meat quality. This changes the rate of postmortem glycolsis and acidification (Chrystall *et al.*, 1982; Lawrie, 1991).

Fasting chicken have almost no chylomicrons and very low-density lipoproteins (Wendlandt and Davis, 1973; Bartley, 1989). Fat chicken line elevated triglyceride, very low density lipoprotein and decreased cholesterol and low density lipoprotein compared with lean chicken line. In agreement with Peebles *et al.* (2004) decreased serum triglyceride was accompanied by a significant decrease in body weight of fasted layers. In other work, laying ducks fasted for 3 days were also reported to experience concomitant decreases in body weight, abdominal and liver fat percentage and plasma triglycerides (Lien *et al.*, 1999). As observed in this study elevated triglyceride concentrations have generally been associated with low HDL cholesterol and the presence of small dense LDL (Barrett, 1998). Comparative studies in lean and fat lines of chickens show that in avian species, triglycerides accumulation in adipocytes depend manly on the availability of plasma substrate VLDL rather than the activity of LPL (Hermier *et al.*, 1989). This was concord with the assumption that the growth of adipose tissue in birds depends directly on the VLDL-triglyceride level (Hermier *et al.*, 1991). In accordance with Hermier (1997) hepatic secretion and plasma concentration of VLDL were always higher in fat line than lean chicken; he indicated that VLDL concentration reflected the availability of plasma triglycerides and therefore the susceptibility to fattening. And usually higher in chicken than turkeys, whatever the physiological state (Kouba *et al.*, 1995). In case of turkey VLDL concentration was a good indicator of the degree of fatness (Griffin and Whitehead, 1985; Kouba *et al.*, 1995). HDL is the main lipoprotein class in avian species (Chapman *et al.*, 1981). In the present study HDL concentration was found similar in both lines.

The abdominal fat weight in the present study was found to be positively correlated with LDL in fat chicken line and with cholesterol, HDL and LDL in lean chicken. Contrary to this study Griffin *et al.* (1991) indicated that body fat content was highly correlated with rate of secretion of plasma triglyceride rich lipoprotein. Selection of broilers for rapid growth rate leads to excessive fat accumulation. The increase in fat in adipose tissue is mainly due to hepatic lipogenesis (LeClercq, 1984). Fat chicken line reduced cholesterol concentration therefore the difference was significant ($p<0.05$) between breeds. Peebles *et al.* (2004) reported that there were no significant main effect due to hen age for serum cholesterol and serum triglycerides and diameter of VLDL particles belonging to the 90th population percentile. However, there were significant main effects due to bird age for body mass ($p<0.0001$).

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