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Research Article

# Relation between Abdominal Fat and Serum Cholesterol, Triglycerides, and Lipoprotein Concentrations in Chicken Breeds

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**Abstract:** This study was undertaken to investigate the relation between abdominal fat and serum biochemical indices in chicken. In the study, 120 chickens at 12 weeks of age from Anka and Rugao breeds were used. They were reared under the same environment and management. Blood samples were taken, the serum was harvested by centrifugation, and then the total cholesterol (TCH), triglycerides (TG), and high-density lipoprotein (HDL) were assayed using an enzymatic kit. Very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) were determined using the Friedwald equation. Chickens were slaughtered and the carcasses were dissected manually to estimate the abdominal fat weight. The breeds significantly ($P < 0.01$) differed in TCH and HDL levels. Compared to females, males had significantly ($P < 0.01$) higher levels of TCH and LDL in both breeds. TCH was positively correlated with HDL and LDL. Similarly TG was positively correlated with HDL and VLDL. Abdominal fat weight was positively correlated with all serum biochemical indices in Rugao, and in Anka it was positively correlated with TCH and LDL. In conclusion, breed and sex affected serum biochemical indices. In addition, abdominal fat was affected by the levels of serum biochemical indices.

**Key Words:** Correlation, fat, cholesterol, triglycerides, lipoprotein, chicken

## Introduction

The biological mechanisms that regulate the synthesis and degradation of lipids and lipid transport in plasma are of great significance to animal agriculture. Regulation of lipid synthesis and degradation in meat animals has been studied to some extent. However, the role of plasma lipoproteins in transporting lipid to extra hepatic tissues in meat animals is not well defined (1). Cholesterol is used to build cell membranes and hormones, and the excess cholesterol circulation in the bloodstream can clog blood vessels and increase the risk for heart disease and stroke. A cholesterol-protein package is called a lipoprotein; lipoproteins are either high density or low density, depending on how much protein they have compared to fat. Triglycerides are also present in blood plasma, and in association with cholesterol they form the plasma lipids. Most often high triglycerides are associated with an increase in LDL cholesterol and a decrease in HDL cholesterol. Comparative studies in lean and fat lines of chickens show that, in avian species, triglyceride accumulation in adipocytes depends mainly on the availability of plasma substrate VLDL rather than the activity of LPL, which is not a limiting factor (2).

Adipose tissue in meat is desirable, to some extent, to give a finished appearance to a carcass. Many scientists have explored ways to decrease the abdominal and/or carcass fat in poultry. It has become clear that fat accretion is closely related to the rate of gain (3,4), and nutritional and management practices. There is a strong genetic basis for abdominal or carcass fat accretion and this relationship has been used to develop experimental lines of fat and lean broilers (5-7). The objective of the present study was to investigate the relation between abdominal fat and serum cholesterol, triglycerides, and lipoprotein concentrations in genetically lean and fat chicken breeds.

## Materials and Methods

### Experimental stocks

Anka and Rugao chicken breeds were reared under the same environment and management in Jaingsu

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Poultry Institute, Yangzhou, China. In the present study, 120 birds were used; 60 for each breed and within each breed the numbers of males and females were equal. The calculated nutrient analyses of the diets are reported in Table 1. Diets and water were provided ad libitum at all times during the study period. Birds were reared in floor pens in a light-tight facility. At 12 weeks of age, birds were subjected to feed withdrawal overnight to permit gut clearance, and then 5 ml blood samples were taken from the wing vein of fasting chickens. Serum was harvested by centrifugation at 3000 rpm for 10 min, and then the serum was frozen for future analysis of serum lipid and lipoprotein concentrations and stored at -20 °C. The chickens were slaughtered, the carcasses were eviscerated and dissected manually, and then abdominal fat weight was estimated. The percentage of abdominal fat weight was expressed as a ratio of body weight.

### Serum biochemical analysis

Total serum cholesterol (free cholesterol + cholesterol esters) and triglycerides were assayed according to the manufacturer's recommendations using a commercial enzymatic kit supplied by Zhe jiang Dongou Biological Engineering Co., Ltd. Samples were incubated for 5 min at 37 °C, and then their absorbances were read at 540 nm with a 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. Likewise, very low-density lipoprotein cholesterol is estimated as [Triglycerides/5] (8). Low-density lipoprotein cholesterol is estimated using the Friedewald equation [Low-density lipoprotein cholesterol = Total cholesterol – High-density lipoprotein cholesterol – Trigylerides/5] (8).

### Data analysis

All values are presented as the means ± standard deviation of mean (S.E.M.) and the significant difference between breeds and sexes were determined by Student's t-test using SAS 9.0 software. Pearson correlation coefficients were computed between cholesterol, triglycerides, lipoprotein concentrations, abdominal fat weight, and percentage of abdominal fat weight. All statements of significance were assessed at $P < 0.05$.

## Results

### The effect of breed and sex on serum biochemical indices

Chicken breeds significantly differed ($P < 0.01$) in cholesterol and high-density lipoprotein levels. No significant difference was observed between breeds on triglycerides, very low-density lipoprotein, and low-density lipoprotein levels (Table 2). Males, compared to females, show significantly ($P < 0.01$) higher levels of cholesterol and lower lipoprotein density within Anka and Rugao chicken breeds. Indeed, triglycerides, high-density lipoprotein, and very low-density lipoprotein levels were not significantly ($P > 0.05$) different between males and females (Table 3).

### Correlation between abdominal fat and serum biochemical indices

The increase of the total cholesterol level in Anka breed was associated with increased levels of high-density lipoprotein and low-density lipoprotein and decreased levels of triglycerides and very low-density lipoprotein. In addition, a high level of triglyceride was positively

Table 2. The effect of breed on cholesterol, triglycerides, and lipoprotein indices in chicken.

| Breed | Anka | Rugao |
|---|---|---|
| TCH[1] | 141.39 ± 3.53* | 157.80 ± 4.94* |
| TG[2] | 19.09 ± 0.97 | 20.35 ± 0.69 |
| HDL[3] | 93.97 ± 2.78* | 118.15 ± 3.99* |
| VLDL[4] | 3.82 ± 0.19 | 4.07 ± 0.14 |
| LDL[5] | 43.44 ± 3.99 | 35.56 ± 4.68 |

[1]Total cholesterol; [2]Triglycerides; [3]High-density lipoprotein;
[4]Very low-density lipoprotein; [5]Low-density lipoprotein
The sample size for each breed was 60 individuals.
* Significant difference between breeds is at 0.05

Table 1. Diet formulation.

| Number of ration | CP | CF | Ash | Ca | P | NaCl | Meth | Water |
|---|---|---|---|---|---|---|---|---|
| 510[1] | ≥21.0 | ≤5.0 | ≤7.0 | 0.8-1.3 | ≥0.60 | 0.3-0.8 | ≥0.37 | ≤13.0 |
| 511[2] | ≥19.0 | ≥5.0 | ≤7.0 | 0.7-1.2 | ≥0.55 | 0.3-0.8 | ≥0.32 | ≤13.0 |

[1]0-3 week, [2]4-12 week

Table 3. The effect of sex on cholesterol, triglycerides, and lipoprotein indices in chicken.

| Breed | Anka | | Rugao | |
|---|---|---|---|---|
| Sex | Male | Female | Male | Female |
| TCH[1] | 148.48° ± 4.43* | 134.30° ± 5.26* | 176.25° ± 6.46* | 139.35° ± 5.84* |
| TG[2] | 17.58° ± 0.84 | 20.59° ± 1.72 | 20.73° ± 1.05 | 19.96° ± 0.94 |
| HDL[3] | 91.97° ± 4.16 | 95.97° ± 3.71 | 125.47° ± 5.76 | 110.82° ± 5.28 |
| VLDL[4] | 3.52° ± 0.17 | 4.12° ± 0.34 | 4.15° ± 0.21 | 3.99° ± 0.19 |
| LDL[5] | 52.66° ± 5.63* | 34.22° ± 5.21* | 46.58° ± 7.05* | 24.54° ± 5.57* |

[1]Total cholesterol; [2]Triglycerides; [3]High-density lipoprotein; [4]Very low-density lipoprotein; [5]Low-density lipoprotein

The sample size for each sex within breeds was 30 individuals.

* Significant difference between sexes within breeds is at 0.05

correlated with high-density lipoprotein and very low-density lipoprotein and negatively correlated with low-density lipoprotein. On the other hand, an increase in high-density lipoprotein level in blood serum was related with an increase in total cholesterol, triglyceride, and very low-density lipoprotein and a decrease in the level of low-density lipoprotein (Table 4). In Rugao, total cholesterol, triglyceride, and lipoprotein concentrations were positively correlated with each other and a negative correlation was observed between high-density lipoprotein and low-density lipoprotein.

The relationship between the serum biochemical indices abdominal fat weight and the percentage of abdominal fat weight within breeds was studied and the results are provided in Table 5. The high abdominal fat weight observed in Anka breed was associated with high levels of serum total cholesterol, low-density lipoprotein, low levels of triglyceride, high-density lipoprotein, and very low-density lipoprotein. Hence the fat weight was estimated as a ratio of body weight; it increased with high levels of LDL and decreased with low levels of total cholesterol, triglycerides, high-density lipoprotein, and very low-density lipoprotein. In Rugao, abdominal fat weight was positively correlated with all serum biochemical concentrations. Similarly, the percentage of abdominal weight was positively correlated with triglyceride, very low-density lipoprotein, and low-density lipoprotein, and negatively correlated with the total cholesterol and high-density lipoprotein.

## Discussion

The levels of serum total cholesterol and high-density lipoprotein were significantly higher in Rugao compared to Anka ($P < 0.01$). However, triglyceride, very low-density lipoprotein, and low-density lipoprotein levels were not significantly different. This may be due to the fact that Rugao was leaner than Anka. Therefore, the

Table 4. Correlation coefficient matrix of cholesterol, triglycerides, and lipoprotein indices in 2 chicken breeds.

| Parameters | TCH[1] | TG[2] | HDL[3] | VLDL[4] | LDL[5] |
|---|---|---|---|---|---|
| TCH[1] | 1 | -0.062 | 0.217 | -0.062 | 0.729** |
| TG [2] | 0.114 | 1 | 0.068 | 1.000** | -0.152 |
| HDL[3] | 0.467** | 0.095 | 1 | 0.068 | -0.507** |
| VLDL[4] | 0.114 | 1.000** | 0.095 | 1 | -0.153 |
| LDL[5] | 0.654** | 0.011 | -0.363** | 0.009 | 1 |

[1]Total cholesterol; [2]Triglycerides; [3]High-density lipoprotein;
[4]Very low-density lipoprotein; [5]Low-density lipoprotein
Above the diagonal is Anka breed and below the diagonal is Rugao breed
** Correlation is significant at the 0.01 level (2-tailed)

Table 5. Correlation coefficient analysis between abdominal fat and cholesterol, triglycerides and lipoprotein indices in 2 chicken breeds.

| Parameters | Anka | | Rugao | |
|---|---|---|---|---|
| | Abdominal fat | Abdominal fat% | Abdominal fat | Abdominal fat% |
| TCH[1] | 0.089 | -0.167 | 0.440* | -0.027 |
| TG[2] | -0.145 | -0.021 | 0.209 | 0.109 |
| HDL[3] | -0.248 | -0.395* | 0.236 | -0.138 |
| VLDL[4] | -0.144 | -0.020 | 0.209 | 0.107 |
| LDL[5] | 0.259 | 0.133 | 0.257 | 0.086 |

[1]Total cholesterol; [2]Triglycerides; [3]High-density lipoprotein;
[4]Very low-density lipoprotein; [5]Low-density lipoprotein
*Correlation is significant at the 0.05 level (2-tailed).

VLDL turnover is greater in laying hens than in nonlaying hens (9). Developing oocytes have been identified as a characteristic for fat deposition for laying hens (10). High plasma levels of lipid in laying hens reflect the significant demand for yolk lipids by the growing oocytes (11). In addition, the LDL and VLDL particles in meat-type cockerel chickens occur in much smaller proportions, with LDL exceeding VLDL, compared to HDL (12). Chapman (13) and Hermier et al. (2) noted that the plasma concentrations of HDL in laying hens are depressed 2- to 3-fold compared to mature hens or roosters. Bird age may influence the relationship between lipoprotein metabolism and egg production (14). The total number of eggs decreased in hens with increased blood LDL concentrations, and highly productive hens produced little LDL (15).

Males, compared to females, show significantly ($P < 0.01$) higher levels of cholesterol and low-density lipoprotein within Anka and Rugao. Indeed, triglyceride, high-density lipoprotein, and very low-density lipoprotein levels were not significantly ($P > 0.05$) different between males and females. In agreement with our results, Whitehead and Griffin (16) found that plasma VLDL and triglyceride concentrations were similar in males and females and only slightly higher in birds fed on the high-fat diet. In contrast, we previously observed that sex significantly affected triglycerides and very low-density lipoprotein concentrations in the Wenchang chicken breed (17). In addition, Robertson and Cumming (18) also reported that the relation between C-peptide ratios and serum lipoprotein concentration differed by gender and phenotype. In humans, normal male and female serum apoB levels tend to increase continuously with age. However, the increase in serum apoB levels in males in each age group was more compared to females, leading to significant sex related differences in apoB levels (19). Likewise, age- and sex-related variations were observed in serum LDL cholesterol levels in males and females (20). In chicken, aging hens appear to lose the ability to assemble VLDL correctly; therefore, the LDL level increased in serum (15). Similar results were also noted by Rönnemaa et al. (21) that LDL cholesterol was almost 20% higher in obese compared to lean chickens in both genders, because the metabolism of adipose tissue in the post-obese state is known to differ compared to the subjects who have constantly been lean (22).

Correlation of serum biochemical concentrations within 2 breeds showed that cholesterol was positively correlated with HDL and LDL levels, whereas triglycerides were positively correlated with HDL and VLDL levels. In addition, HDL was negatively correlated with LDL in both chicken breeds. Wahl et al. (19) indicated that, in many instances, the positive relationships between LDL cholesterol (LDL-C) and other lipoprotein lipids became inverse in the presence of triglyceride elevation. Among human hyperlipidemic subjects, an elevation in cholesterol level alone rarely altered relationships, but an elevation in triglyceride level, either alone or in conjunction with an elevation in cholesterol concentration, was associated with substantial changes in relationships involving the low-density lipoprotein (LDL) fraction (19).

In the present study, abdominal fat weight was positively correlated with all serum biochemical concentrations in Rugao. However, in Anka, it was positively correlated with total cholesterol and low-density lipoprotein, and negatively correlated with triglyceride, high-density lipoprotein, and very low-density lipoprotein. Hermier et al. (2) indicated that the growth of adipose tissue in birds depends directly on the VLDL-TG level. The fatty acid pattern of the abdominal fat was significantly influenced by the dietary fatty acid (23). Fatness or obesity is related to several disturbances in lipid and lipoprotein metabolism. For instance, high concentrations of serum triglyceride-rich lipoproteins and a low concentration of high-density lipoprotein (HDL) cholesterol are the most characteristic findings, whereas serum low-density lipoprotein (LDL) cholesterol level is usually much less elevated in obesity (24,25).

Hence the abdominal fat weight was expressed as a ratio of body weight, it was negatively correlated with all serum biochemical concentrations except LDL in Anka. On the other hand, in Rugao, it was positively correlated with triglycerides, VLDL, and LDL, and negatively correlated with cholesterol and HDL. Previously no effect of obesity on serum lipoprotein levels was found (26). Altered levels of serum triglycerides and HDL cholesterol in obesity might be mediated by changes in the activities of the key lipoprotein metabolizing enzymes, such as increased activity of hepatic lipase (27), decreased or unchanged activity of post-heparin plasma lipoprotein lipase (LPL) (28), and high or normal activity of adipose tissue LPL (29). Finally, obesity is caused by the interaction of genetic and environmental factors related to lifestyle (30).

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