Effects of different dietary fat and oil supplements on performance, carcass, and blood characteristics in broiler chickens

Einfluss verschiedener Fett- und Ölzusätze im Futter auf Leistung, Schlachtkör perqualität und Blutkennwerte von Broilern

S. Zafari Naeini, M. R. Rezvani, A. Akhlaghi, H. Atashi and H. Daryabari

Manuscript received 4 April 2012, accepted 2 August 2012

Introduction

An excess body fat deposition in broilers has been a major concern for producers and consumers. Decreasing broiler abdominal fat is of particular interest, as the abdominal fat content at slaughter may represent more than 3 percent of live weight (Sanz et al., 1999). In addition, human studies have shown an association between higher dietary fat intake and cardiovascular diseases. Dietary levels of cholesterol (Hayes, 1995) and fatty acid profiles in lipid fractions (Blanch and Grashorn, 1996) are associated with the development of atherosclerosis and coronary artery diseases in humans. Studies either in birds or in mammals showed the inhibitory effect of polyunsaturated fatty acids (PUFA) on fat tissue synthesis (Sanz et al., 2000), describing the decreased abdominal fat content following dietary PUFAs inclusion. The fats containing the enriched unsaturated fatty acids (UFA) have been reported to be more digestible and absorbable compared to those rich in short-chain saturated fatty acids (SFA; Danicke, 2001). Beef tallow, as a source of fat, has a lower digestibility and metabolizable energy (ME) content in comparison to vegetable oils, attributing to higher long-chain SFA content (Blanch et al., 1995). Other reports indicated that broiler chickens fed diets enriched in PUFAs had lower abdominal (Sanz et al., 1999) or total body (Sanz et al., 2000) fat deposition than those fed diets containing SFA. It has been reported that sunflower oil produced less abdominal fat deposition in broilers than did tallow at different levels of fat inclusions, although the ME content of tallow was lower than that of sunflower oil (Vila and Esteve-Garcia, 1996). Sanz et al. (1999) found a lower abdominal fat content in broilers fed sunflower oil compared to those fed tallow or lard. Furthermore, using conjugated linoleic acid has been reported to be more digestible and absorbable compared to those rich in short-chain saturated fatty acids (SFA; Javadi et al., 2007). Nonetheless, Petenca et al. (2008) found no effect of including animal or vegetable dietary lipid sources on performance, abdominal fat deposition, or tibia density and strength in broilers.

The local oil and fat by-products must be properly analyzed chemically and biologically to determine their using merit and appropriate mixture for animal feeding purposes. Furthermore, despite a good body of literature on the effects of using different dietary fat and oil supplements on performance in broiler chickens, there is a paucity of data on simultaneous usage of saturated and unsaturated fatty acid sources on performance and blood profile in broilers. The previous studies mostly investigated the effects of diets different in ME content; however, the effect of feeding fat and oil supplements in isonitrogenous and isocaloric diets may reveal the differences among treatments based on net energy and show the performance and carcass or blood characteristics responses more precisely. Therefore, the present study was conducted to evaluate the effect of using different fat and oil supplements in isonitrogenous and isocaloric diets on performance and several carcass and blood characteristics in broiler chickens.

Materials and methods

A total of 400 day-old chicks (Ross 308) were obtained commercially (Fars Poultry Co., Shiraz, Iran) and fed a starter diet until d 21 of life. At this time 288 chicks of similar weights (670 ± 1.95 g) were randomly assigned to 36 pens (9 treatments with 4 replicates of 8 birds) and reared on floors covered with wood shavings in a completely randomized design. The diets were isocaloric and isonitrogenous (calculated) in all three rearing stages including starter (0 to 21 d, 13.4 MJ/kg ME, 23% CP), grower (22 to 42 d, 13.4 MJ/kg ME, 20% CP), and finisher (43 to 56 d, 13.4 MJ/kg ME, 18% CP) diets based on NRC (1994) recommendations.

Three types of commercial fat powders, including Palmi Fat* (PAF), Energizer® (ENF), and Berg & Schmidt® (BSF), three types of oils, including Vegetable Oils for Broilers (VOB), Vegetable Oils for Human (VOH), and Free Fatty Acids (FFA) as byproducts of plant oil refinery companies as well as three combinations of three types of fat powders with VOH (1:1 wt:wt) including VOH*BSF, VOH*ENF and VOH*PAF were supplemented in experimental treatments during the grower and finisher stages. Diets were formulated using the UFFDA software (UFFDA, 1992). Fatty acid profile of fat and oil supplements and dietary ingredients of each treatment are shown in Tables 1, 2 and 3, respectively.

All birds received feed and water ad libitum throughout the experiment at a photoperiod of 23h:L:1h-D and were housed in an air-conditioned room with about 33°C at the start of experiment and with a 3°C decrease per wk through 22d. Weekly feed intake and live body weight were recorded after an 8-h feed deprivation. The mortality rates were recorded daily and feed conversion ratios (FCR) were adjusted for mortality. At the end of experiment, blood samples were drawn from brachial vein and centrifuged (1800 x g for 12 min) and plasmas were decanted and stored at −20°C before analyzed for calcium, cholesterol, triglyceride, and
high (HDL), low (LDL), and very low (VLDL) density lipoprotein, using commercially available kits validated for avian species (Pars Azmoon, Iran). At 56 d, 2 birds per replicate were decapitated and eviscerated to weigh the carcass, breast muscle, heart, liver, crop, proventriculus, gizzard, intestine, spleen, thymus, bursa of Fabricius, pancreas, abdominal fat pad, head, feet, wings and gall bladder.

**Statistical analysis**

Data were analyzed using PROC GLM in SAS (2002) and the means were compared by Duncan's multiple range test. A statement of significance was declared at $P < 0.05$ and body weight at the age of 21 d was included in the models as a covariate. The used statistical model was as follows:

$$ y_{ij} = \mu + t_i + b_1 (bw)_{ij} + e_{ij} $$

where: $y_{ij}$ = jth observation in ith treatment, $\mu$ = overall mean, $t_i$ = effect of ith treatment, $b_1$ = regression coefficient of the examined traits on body weight at age of 21-d, $bw_{ij}$ = the body weight at age of 21-d of jth replicate in ith treatment, $e_{ij}$ = residual effect.

**Results**

**Body weight and body weight gain**

Weekly body weight (BW) and daily weight gain are shown in Table 4. The lowest and the highest BW were recorded for ENF and for VOH group, respectively. The lowest values of cumulative gain through 4 to 8 wk of age (2384 g) and average daily gain (ADG; 68.1 g) were also noted for ENF group. No significant differences were observed among other treatments.
Feed intake and feed conversion ratio

Mean daily feed intake and feed conversion ratio (FCR) of experimental treatments are shown in Table 5. The birds in the VOH*PAF group showed the highest (6228 g, 178 g/d) and those in the VOH*BSF showed the lowest (5767 g, 165 g/d) total and average feed intake, respectively. The highest (2.46 g/g) and the lowest (2.14 g/g) total FCR were recorded in ENF and VOH-treated birds, respectively.

Carcass and blood characteristics

Table 6 shows the carcass and blood characteristics at 56 d of age. The highest value for relative abdominal fat pad weight

Table 3. Ingredients and nutrient composition (%) of experimental diets for finisher (43 to 56 d) stage

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>BSF</th>
<th>PAF</th>
<th>ENF</th>
<th>VOH</th>
<th>FFA</th>
<th>VOB</th>
<th>VOH*ENF</th>
<th>VOH*BSF</th>
<th>VOH*PAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>61.6</td>
<td>63.0</td>
<td>62.2</td>
<td>63.2</td>
<td>62.5</td>
<td>63.2</td>
<td>62.8</td>
<td>62.5</td>
<td>63.2</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>29.2</td>
<td>28.9</td>
<td>29.0</td>
<td>28.9</td>
<td>29.0</td>
<td>28.9</td>
<td>29.0</td>
<td>29.0</td>
<td>28.9</td>
</tr>
<tr>
<td>BSF</td>
<td>6.22</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.72</td>
<td>–</td>
<td>2.47</td>
</tr>
<tr>
<td>PAF</td>
<td>–</td>
<td>5.03</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.47</td>
</tr>
<tr>
<td>ENF</td>
<td>–</td>
<td>–</td>
<td>5.69</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.62</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>VOH</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.85</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>FFA</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5.45</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>VOB</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.85</td>
<td>2.62</td>
<td>2.72</td>
<td>2.47</td>
<td>–</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
<td>1.32</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
<td>0.920</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
<td>0.270</td>
</tr>
<tr>
<td>Premix2</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>D,L-methionine</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
</tr>
</tbody>
</table>

1 Berg & Schmidt® (BSF), Palmi Fat® (PAF), Energizer® (ENF), Vegetable Oils for Human (VOH), Free Fatty Acids (FFA), Vegetable Oils for Broilers (VOB), Proportion of 1:1 including VOH*ENF; VOH*BSF; VOH*PAF.

2 Contained per Kg: retinol acetate, 4.13 mg; DL-α-tocopherol acetate, 42 mg; cholecalciferol, 0.008 mg; menadione, 2 mg; thiamine, 2 mg; riboflavin, 6.6 mg; pyridoxine, 5 mg; cyanocobalamin, 0.02 mg; niacin, 99 mg; folic acid 1 mg; biotin, 0.15 mg; Calcium d-pantothenate, 15 mg; choline chloride, 0.7 g; Ca, 2.3 g; Cu, 5 mg; Zn, 51 mg; Fe, 60 mg; Mn, 71 mg; I, 0.6 mg; Se, 0.2 mg.

Table 4. Weekly mean live body weight and average daily gain depending on dietary fat and oil supplements

<table>
<thead>
<tr>
<th>Treatment1</th>
<th>BSF</th>
<th>PAF</th>
<th>ENF</th>
<th>VOH</th>
<th>FFA</th>
<th>VOB</th>
<th>VOH*ENF</th>
<th>VOH*BSF</th>
<th>VOH*PAF</th>
<th>P value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (wk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>672</td>
<td>672</td>
<td>672</td>
<td>671</td>
<td>670</td>
<td>671</td>
<td>671</td>
<td>671</td>
<td>670</td>
<td>0.856</td>
<td>2.18</td>
</tr>
<tr>
<td>4</td>
<td>1004</td>
<td>1013</td>
<td>969</td>
<td>1048</td>
<td>1008</td>
<td>1034</td>
<td>1040</td>
<td>1015</td>
<td>1020</td>
<td>0.021</td>
<td>18.3</td>
</tr>
<tr>
<td>5</td>
<td>1511</td>
<td>1544</td>
<td>1429</td>
<td>1604</td>
<td>1514</td>
<td>1562</td>
<td>1582</td>
<td>1518</td>
<td>1544</td>
<td>0.003</td>
<td>24.9</td>
</tr>
<tr>
<td>6</td>
<td>2002</td>
<td>2040</td>
<td>1865</td>
<td>2096</td>
<td>1975</td>
<td>2057</td>
<td>2104</td>
<td>2007</td>
<td>2092</td>
<td>0.002</td>
<td>36.1</td>
</tr>
<tr>
<td>7</td>
<td>2602</td>
<td>2649</td>
<td>2502</td>
<td>2798</td>
<td>2606</td>
<td>2768</td>
<td>2744</td>
<td>2701</td>
<td>2711</td>
<td>0.013</td>
<td>53.7</td>
</tr>
<tr>
<td>8</td>
<td>3065</td>
<td>3134</td>
<td>2839</td>
<td>3261</td>
<td>3090</td>
<td>3242</td>
<td>3257</td>
<td>3142</td>
<td>3169</td>
<td>0.009</td>
<td>64.1</td>
</tr>
<tr>
<td>Daily gain (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>48.2</td>
<td>48.5</td>
<td>43.4</td>
<td>54.4</td>
<td>48.8</td>
<td>51.5</td>
<td>51.6</td>
<td>49.0</td>
<td>50.0</td>
<td>0.043</td>
<td>2.44</td>
</tr>
<tr>
<td>5</td>
<td>72.4</td>
<td>75.9</td>
<td>65.8</td>
<td>79.4</td>
<td>72.3</td>
<td>75.5</td>
<td>77.5</td>
<td>71.8</td>
<td>75.0</td>
<td>0.029</td>
<td>3.50</td>
</tr>
<tr>
<td>6</td>
<td>70.1</td>
<td>70.8</td>
<td>62.4</td>
<td>70.2</td>
<td>65.9</td>
<td>70.6</td>
<td>74.6</td>
<td>69.9</td>
<td>78.3</td>
<td>0.044</td>
<td>3.06</td>
</tr>
<tr>
<td>7</td>
<td>85.7</td>
<td>87.1</td>
<td>90.9</td>
<td>100.3</td>
<td>90.1</td>
<td>101.7</td>
<td>91.4</td>
<td>99.0</td>
<td>88.4</td>
<td>0.385</td>
<td>5.70</td>
</tr>
<tr>
<td>8</td>
<td>92.7</td>
<td>97.0</td>
<td>78.1</td>
<td>92.7</td>
<td>96.8</td>
<td>94.7</td>
<td>102.7</td>
<td>88.2</td>
<td>91.6</td>
<td>0.622</td>
<td>7.72</td>
</tr>
<tr>
<td>Average</td>
<td>73.8</td>
<td>75.8</td>
<td>68.1</td>
<td>79.4</td>
<td>74.8</td>
<td>78.3</td>
<td>79.5</td>
<td>76.5</td>
<td>76.7</td>
<td>0.020</td>
<td>2.11</td>
</tr>
<tr>
<td>Total</td>
<td>2584</td>
<td>2655</td>
<td>2384</td>
<td>2780</td>
<td>2618</td>
<td>2758</td>
<td>2784</td>
<td>2646</td>
<td>2683</td>
<td>0.021</td>
<td>73.8</td>
</tr>
</tbody>
</table>

1 a,b,c: within each row, means with common superscript(s) are not statistically different (p < 0.05).

2 Berg & Schmidt® (BSF), Palmi Fat® (PAF), Energizer® (ENF), Vegetable Oils for Human (VOH), Free Fatty Acids (FFA), Vegetable Oils for Broilers (VOB), Proportion of 1:1 including VOH*ENF; VOH*BSF; VOH*PAF.
was recorded for VOB (4.00%) and VOH (4.01%) fed birds; however, ENF treated birds showed the lowest values (2.52%). The highest relative weights of pancreas were recorded for VOH (0.262%), and the lowest one was found for VOH*PAF (0.183%). Other carcass characteristics were not affected by the experimental treatments.

The highest blood cholesterol level was observed in VOH*PAF (220 mg/dL) group, higher than values for BSF (180), VOH (186) and VOH*BSF (186) group. ENF treated birds showed the highest blood triglyceride levels (15.2 mg/dL); however, the lowest ones were concomitantly recorded for FFA (10.5 mg/dL), VOH (11.0 mg/dL), and VOB.
(11.1 mg/dL) groups. Birds in ENF group showed the highest blood LDL and VLDL levels (106 and 32.8 mg/dL, respectively), and those in VOH*BSF group had the lowest plasma levels of LDL (55.2 mg/dL). No differences were found in blood calcium levels among the experimental groups.

Discussion

Supplementing with VOH resulted in a higher percentage of abdominal fat in the current work. This is consistent with ZOLLITSCH et al. (1997) who found a lower fecal energy loss in broilers fed unsaturated vegetable oils compared to those fed animal fats. The higher ME content of unsaturated fat may be stored as triglyceride in adipose tissue of fat depots. PAN et al. (1979) suggested that replacing soybean oil with tallow increased the amount of abdominal fat in chickens. In the present study, the ME content of dietary treatments was the same and it could be expected that the source of energy might have affected the net energy available for gain. In the absence of other nutrients, the further net energy could be deposited as abdominal fat as found in the current work. PESTI et al. (2002) reported that the percentage of net energy in the ME of the fat sources might be variable. SCOTT et al. (1976) concluded that the net energy is 75% of the ME of carbohydrates, 60% of the ME of proteins, and 90% of the ME of fats. The higher net energy to ME ratio in chicks fed VOH diet may be explained by a higher rate of substrate availability and then a faster β-oxidation of unsaturated compared with saturated fatty acids (LEYTON et al., 1987); however, the previous reports are inconsistent. SANZ et al. (1999) reported a higher lipid accumulation for broilers fed saturated fats than for those fed unsaturated fats. Our finding is in contrast with the findings of WONGSUTHAVAS et al. (2007) and POTENCA et al. (2008) who found no effect on performance and abdominal fat pad deposition in broilers fed animal or vegetable dietary lipids.

In the current study, mixing the vegetable oils, including VOH, with the fat powder products (BSF), containing both unsaturated and saturated fatty acids, decreased the plasma levels of cholesterol, LDL, and VLDL. Further, the birds in the same group showed a higher weight of breast muscle and a lower abdominal fat pad weight. The latter might suggest an inhibitory effect of the treatments on lipogenesis or repartitioning the lipids in the body. Using mixed oil and fat supplement sources such as VOH*BSF-containing diets could produce better blood profiles of lipoproteins, which might potentially be coincided with meat of a better quality for human consumption. Attempts have been made to reduce excessive fatness in poultry through controlling the VLDL metabolism. Plasma VLDL, as an indicator of fatness in broilers, has been used to study the lipoprotein metabolism and body lipid content of broilers. DANESHIYAR et al. (2011) reported that supplementation of turmeric rhizome powder in broiler chickens diets decreased plasma triglyceride and VLDL concentrations and the concentrations of SFAs and triglycerides in thigh meat. Lean and fat lines of chickens have been selected based on their abdominal fat content or plasma VLDL concentration. Using certain fats may affect the organoleptic traits of meat quality (ZOLLITSCH et al., 1997). Previous studies showed that dietary ingredients can be manipulated to change blood profile, so that animals fed diets rich in cholesterol or saturated fat had an elevated carcass and blood cholesterol level. Also, it has been reported that HDL values were highest in the groups fed the diet containing corn oil and the lowest in the groups fed tallow, in contradiction to those reported for LDL (ÖZDOGAN and AKSIT, 2003). Increased serum HDL attenuated the adverse effect of high blood cholesterol (GUYTON and HALL, 1996, ÖZDOGAN and AKSIT, 2003). Due to experimental limitations and availability of resources, the fatty acid profile as well as the approximate analysis of the meat were not measured in the current work; however, using mixed oil and fat supplements as in VOH*BSF group irrespective of an acceptable performance and abdominal fat content produced better blood profile of lipoproteins, potentially associating with meat of better quality for human consumption. Being high in linoleic acid content (18:2), VOH might be mixed with SFA containing fats (e.g. BSF) and find an application to decrease the incidence of cardiovascular diseases in human.

Conclusions and Applications

1. The effect of dietary fat sources on performance, abdominal fat content and blood parameters was different.
2. The highest value of performance was recorded in group fed VOH but this group had the highest relative value of abdominal fat pad.
3. The highest values of triglyceride, LDL, and VLDL were recorded in birds fed ENF and the lowest values of these parameters were noted for VOH.
4. Although ENF treatment produced the lowest abdominal-fat broiler, dietary VOH*BSF treatment could produce low abdominal fat, acceptable performance and improved blood characteristics, which might be beneficial to both the broiler producers and human health.

Acknowledgments

The authors would like to thank the entrepreneurship center of Shiraz University for financial support (Shiraz University, Shiraz, Iran). We are also indebted to D. Taghizade and G. Abbasi for diligent aid during the grow-out period. The material facilities by Mr. Rohani and Mr. Frozan (Rad Ard Pars Co.) are acknowledged.

Summary

The present study was conducted to evaluate the effect of different dietary fat and oil supplements on performance and certain blood and carcass characteristics in broiler chickens using 288 broiler chicks. During the first 3 wk of grow-out period, the chicks were fed a commercial diet according to NRC (1994) specifications. Dietary treatments were provided from wk 4 of age, including 3 types of commercial fat powders [Palmi fat® Fat powder (PAF), Energizer® Fat powder (ENF), and Berg & Schmidt® Fat powder (BSF)], 3 types of oils [Vegetable Oils for Broilers (VOB), Vegetable Oils for Human (VOH), and Free Fatty Acids (FFA)], and 3 combinations of fat powders with VOH at proportion of 1:1 (including VOH*BSF; VOH*ENF; VOH*PAF) in a completely randomized design. Each treatment had 4 replicates of 8 chickens each. All treatments were isocaloric and isonitrogenous. Weekly feed consumption and body weight were measured during the last 5 wk and blood samples were taken at the end of experiment for lipoprotein metabolism. After the production period (56 d of age), 2 chicks were randomly selected from each replicate, for carcass analysis. The results showed that chicks fed VOH*BSF had improved feed conversion, body weight, and blood characteristics compared to the other treatments. It was concluded that using mixed oil and fat supplement sources was associated with better blood profiles of lipoproteins, potentially with meat of better quality for human consumption.
Zusammenfassung

Einfluss verschiedener Fett- und Ölzusätze im Futter auf Leistung, Schlachtkörperqualität und Blutkennwerte von Broilern


Stichworte

Broiler, Fett, Öl, Futterverwertung, Abdominalfett, Lipoprotein

References


UFFDA, 1992: User Friendly Feed Formulation, University of Georgia.


Arch.Geflügelk. 2/2013

Key words

Broiler, fat, oil, feed efficiency, abdominal fat, lipoprotein

References


Zafari Naehi et al.: Effects of different dietary fat and oil supplements on broiler chickens 95

Correspondence: M.R. Rezvani, Department of Animal Science, College of Agriculture, Shiraz University, Bagaj, Shiraz, Iran; E-mail: rezvanig@shirazu.ac.ir