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Effects of Different Fat Sources in Finisher Diet of Broiler Chickens on Performance, Fat Deposition and Blood Metabolites

Research Article

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ABSTRACT

The aim of this experiment was to assess the effects of using saturated fatty acid (SFA) and some unsaturated fatty acid (UFA) sources in finishing period on performance, fat deposition and blood metabolites of broiler chickens. One hundred and forty four 28-d old male broiler chickens were randomly assigned to 4 treatments and 6 replicates in a completely randomized design. Four isocaloric/isonitrogenous diets containing 5% tallow fat (TF) as SFA source or olive oil (OO), soybean oil (SO) and canola oil (CO) as UFA sources were provided during finisher period (from 29-42 d of age). Average daily feed intake (ADFI) and average daily weight gain (ADWG) of birds fed TF were significantly ($P<0.05$) lower as compared to birds fed vegetable oils in finisher diet. Abdominal fat percentage of birds fed TF and OO increased significantly ($P>0.05$) as compared to those fed SO and CO from 29-42 d of age. Relative weight of bile sac in birds fed TF diet, were significantly ($P<0.05$) higher than birds fed vegetable oils in finisher diets. Blood serum triglyceride of birds fed SO and CO was significantly ($P<0.05$) lower than birds fed TF at 42 d of age. The high density lipoprotein (HDL) of birds was significantly ($P<0.05$) reduced with feeding SO and CO compared to birds fed TF. These data suggest that performance, abdominal fat pad, relative weight of bile sac and some blood serum metabolites may be changed by modification of dietary fat sources, 14 days prior to slaughter.

KEY WORDS blood metabolites, broiler chickens, fat deposition, fatty acid sources, growth performance.

INTRODUCTION

Fats are frequently included in poultry diets to increase the energy density (Pinchasov and Nir, 1992; Sanz *et al.* 1999). The body fat of chicken mainly deposits in regions such as the abdomen, subcutaneous and muscular tissues. A certain amount of intramuscular fat can enhance the traits such as the flavor and tender degrees of meat (Moon *et al.* 2000), but accumulation of abdominal fat in chickens result in increased poultry feed cost and decreased final product quality (Elkin, 1998; Assaf *et al.* 2004). The success of broiler meat production has been strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat (Zerehdaran *et al.* 2004). The control of lipid deposition in broilers aimed at efficient lean-meat poultry production is of current interest and any reduction in the amount of abdominal fat is considered to be positive by both producers and consumers (Fisher, 1984; Hermier, 1997). Many studies have shown that the growth pattern of fat depots can be modified by dietary means. Previous studies have shown that diets rich in unsaturated fatty acids (UFA) led to lower total body fat (Sanz, 2000a), abdominal, mesenteric, neck fat (Crespo and Esteve-García, 2002b) and skin fat (Ferrini

et al. 2008), compared with a diet rich in saturated fatty acids (SFA) or monounsaturated fatty acids (MUFA). Sanz *et al.* (1999), Crespo and Esteve-Garcia (2001) and Villaverde *et al.* (2006) showed that the reduction of fat deposition in broilers was strongly related to fat sources containing different fatty acid (FA) profile. Changes in body fat deposition among broilers fed different dietary fatty acid profiles may be related to different rates of lipid synthesis or lipid oxidation (Crespo and Esteve-Garcia, 2001). Results of *in vitro* experiments in broilers and mammals suggest that polyunsaturated fatty acids (PUFA) may inhibit hepatic lipogenesis. Because abdominal fat pad is well correlated with body fatness in broilers (Whitehead *et al.* 1982), effect of dietary fat could be also reflected by total body fat. The use of an unsaturated dietary fat source instead of saturated fats to produce lower abdominal fat deposition is obviously of interest, but in practice, a drawback related to the fluidity of the carcass fat arises. Studies demonstrated that dietary PUFA decrease blood serum very low density lipoprotein (VLDL), low density lipoprotein (LDL) and cholesterol and increase serum high density lipoprotein (HDL) compared with SFA (Kinsella *et al.* 1990). Crespo and Esteve-Garcia (2003) reported that VLDL is highly correlated with abdominal fat in fed chickens and this correlation decreased when fat was added to diets. The aim of this study was to investigate the effects of using different fat sources in 14 days before slaughter on performance, fat deposition and blood metabolites in broiler chickens.

MATERIALS AND METHODS

Birds and Diets

One hundred and forty four 28-d-old Ross 308 male broiler chickens with similar body weight (1050±50 g) were divided into 4 dietary treatments in a completely randomized design with 6 replicates of 6 birds each. Four isocaloric/isonitrogenous finisher diets containing 5% tallow fat (as saturated fat source), 5% olive oil (as n-9 fatty acid source), 5% soybean oil (as n-6 fatty acid source) and 5% canola oil (as n-3 fatty acid source) were provided. Birds were placed in wire raised floor battery units (100 cm×120 cm). Each battery unit was equipped with a feeding trough and a water cup. Birds had free access to feed and water all the time and were exposed to 23 h lighting:1 h darkness photoperiod throughout the experiment. Room temperature was kept according to the usual commercial practices. The birds were fed mash diets formulated according to Aviagen recommendations for Ross 308 broiler chickens (Table 1), (Aviagen, 2007).

Carcass characteristics

Two birds per each replicate with average pen weight were selected, sacrificed by decapitation, plucked and eviscerated at 42 d of age. Breast, thigh, liver, pancreas and bile sac removed, weighed and expressed as a percentage of live weight.

Performance criteria

During 28-42 days of age, the average daily feed intake (ADFI), average daily weight gain (ADWG) and feed conversion ratio (FCR) for each group of birds were calculated and mortality was daily weighed, recorded and used to correct the FCR.

Fat deposition

Fat deposition was measured in 4 regions including abdomen, liver and intramuscular tissue (thigh and breast) according to previous report (Moon *et al.* 2000). Abdominal fat pad was removed and weighed. Two g of breast, thigh and liver was selected and dried in two stages (12 h in 65 ˚C, then 12 h in 105 ˚C), then cooled in a desiccator for at least 30 min. The liver, breast and thigh intramuscular fat contents were measured by the Soxhlet system (AOAC, 1990) and were expressed as percentages of dry tissue weight.

Blood metabolites

At 42 d of age, two birds from each replicate with average pen weight was selected, blood samples were taken from wing vein, were kept at room temperature for 30 min. and then centrifuged for 15 min at 3000 rpm to obtain serum. Serum samples were kept in eppendorf tubes at −20 ˚C until analyzed by an auto-analyzer system (Bio Systems S. A. – Costa Brava 30, 08030 Barcelona, Spain) using commercial kits (Bio Systems Co. Spain) and determined triglyceride, total cholesterol, HDL, LDL, VLDL and glucose in blood serum samples.

Statistical analysis

Data of performance, carcass traits and blood metabolites were analyzed by ANOVA using the procedure described by the SAS (2008). All percentage data were converted to arcsine percent before analysis. Duncan means separation test (Duncan, 1955) was used to determine significant differences between treatment mean values ($P<0.05$).

RESULTS AND DISCUSSION

Growth performance

The ADFI, ADWG and FCR of chickens fed finisher diets containing 5% TF, OO, SO and CO are shown in Table 2. The ADFI and ADWG of birds fed diets containing 5% TF in finisher diet, were significantly ($P<0.05$) less than the other birds fed finisher diets containing vegetable oils such as OO, SO and CO. There were not significant differences between ADFI and ADWG of birds fed vegetable oils during 29-42 d of age ($P>0.05$).

Table 1 Ingredients, nutrient compositions and fatty acid profiles of experimental diets

Ingredients	29-42 d			
	Tallow fat	Olive oil	Soy oil	Canola oil
Corn	56.97	59.64	59.64	59.64
Soybean meal	34.81	26.27	26.27	26.27
Corn gluten meal	-	5	5	5
Fat source	5	5	5	5
Sodium chloride	0.39	0.39	0.39	0.39
Dicalcium phosphate	1.61	1.61	1.61	1.61
Limestone	1.14	1.14	1.14	1.14
DL-methionine	0.21	0.17	0.17	0.17
L-lysine HCL	-	0.18	0.18	0.18
Vit + Min premix[a]	5	5	5	5
Calculated nutrients				
ME, kcal/kg	3100	3100	3100	3100
Crude protein %	20	20	20	20
Ether extract %	6.9	6.9	6.9	6.9
Calcium %	0.9	0.9	0.9	0.9
Available P %	0.45	0.45	0.45	0.45
Sodium %	0.18	0.18	0.18	0.18
Lysine%	1.12	1.12	1.12	1.12
Met + Cys %	0.86	0.86	0.86	0.86
Threonine %	0.83	0.83	0.83	0.83
Fatty acid profile (%)				
SFA	51.41	18.24	16.44	7.55
UFA	48.23	83	80.43	87.26
MUFA	41.52	73.46	22.54	63.42
PUFA	8.70	9.23	60.55	27.60
Total n9	36.33	68.74	22.26	62.44
Total n6	5.25	9.52	54.34	20.13
Total n3	1.22	0.45	7.35	9.37

[a] To provide vitamins and minerals per kilogram of diet : vitamin A: 11000 IU; vitamin D_3:1800 IU; vitamin E: 36 mg; vitamin K_3: 5 mg; vitamin B_{12}: 1.6 mg; Thiamine: 1.53 mg; Riboflavin: 7.5 mg; Niacin: 30 mg; Pyridoxine: 1.53 mg; Biotin: 0.03 mg; Folic acid: 1 mg; Pantothenic acid: 12.24 mg; Etoxycoin: 0.125 mg; Fe: 250 mg; Zn-sulfate: 84 mg; Mn-sulfate: 160 mg; Iodine: 1.6 mg; Cu-sulfate: 20 mg; Selenium: 0.2 mg and Cobalt: 0.4 mg.
SFA: saturated fatty acids; UFA: unsaturated fatty acids; MUFA: monounsaturated fatty acids and PUFA: polyunsaturated fatty acids.

Table 2 Effects of different dietary fat sources on growth performance of broiler chickens during 29-42 d of age[*]

Performance criteria	Dietary fat sources (5% supplemented)				P-value	SEM
	Tallow fat	Olive oil	Soy oil	Canola oil		
Final body weight (g) at 42 d	1648[b]	1888[a]	1866[a]	1857[a]	0.014	50.48
ADFI (g)	103.48[b]	129.89[a]	140.68[a]	134.78[ab]	0.003	4.72
ADWG (g)	53.22[b]	64.86[a]	66.40[a]	64.39[a]	0.033	3.14
FCR (g:g)	1.95	2.01	2.13	2.10	0.083	0.07
Livability (%)	92.77	93.29	93.11	94.76	0.898	2.10

[*] Initial body weight of chicks at 29 d was 1050 (±50 g) and data are means of 6 birds.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of mean.
ADFI: average daily feed intake; ADWG: average daily weight gain and FCR: feed conversion ratio.

Fat deposition of internal organs

Fat contents of abdomen, liver, thigh and breast of chickens fed finisher diets containing 5% TF, OO, SO and CO are shown in Table 3. Results showed that liver and intramuscular fat contents were not affected significantly (P>0.05) with replacing SFA fat source (TF) with UFA fat sources (vegetable oils) but replacing TF with vegetable oils (SO and CO) during finisher period (29-42 d) improved percentage of abdominal fat pad in broiler chickens (P<0.05).

Carcass characteristics

Carcass yield, breast, thigh, liver, bile sac and pancreas weight as live weight from chickens fed finisher diets containing 5% TF, OO, SO and CO are shown in Table 4. Supplementation of different dietary fat sources had no influence on carcass yield, breast (with bone), thigh (with bone), liver and pancreas relative weight (P>0.05), but bile sac of birds fed TF, were significantly higher than birds fed diets contained vegetable oils in finisher diets (P<0.05).

Table 3 Effects of different dietary fat sources on abdominal fat pad, liver and intramuscular (breast and thigh) fat of broiler chickens at 42 d of age*

Fat deposition	Dietary fat sources (5% supplemented)				P-value	SEM
	Tallow fat	Olive oil	Soy oil	Canola oil		
Abdominal fat pad[2] (% of live weight)	1.20[a]	1.18[a]	0.93[b]	0.98[b]	0.014	0.04
Liver fat (% of tissue dry matter)	14.06	14.31	13.22	13.89	0.095	0.27
Breast fat (% of tissue dry matter)	2.39	2.36	2.45	2.45	0.947	0.13
Thigh fat (% of tissue dry matter)	5.62	5.31	4.81	4.66	0.096	0.23

* Data are means of 6 birds.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of mean.

Table 4 Table 4 Effects of different dietary fat sources on carcass yield, breast and thigh relative weight of broiler chickens at 42 d of age*

Organs weight	Dietary fat sources (5% supplemented)				P-value	SEM
	Tallow fat	Olive oil	Soy oil	Canola oil		
	(% of live weight)					
Carcass yield	67.01	67.84	66.29	67.10	0.776	1.04
Thigh	19.91	20.85	19.72	19.92	0.690	0.63
Breast	22.76	22.96	23.50	22.88	0.991	0.77
Bile sac	0.13[a]	0.09[b]	0.09[b]	0.08[b]	0.039	0.01
Liver	2.28	2.29	2.41	2.37	0.912	0.12
Pancreas	2.44	2.43	2.19	2.28	0.476	0.12

* Data are means of 6 birds.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of mean.

Blood metabolites

The blood serum triglyceride, total cholesterol, HDL, LDL, VLDL and glucose of chickens fed finisher diets containing 5% TF, OO, SO and CO are shown in Table 5. Serum triglyceride and HDL levels were significantly (P<0.05) influenced by different dietary fat sources, but there were no significant differences in other blood serum metabolites among birds fed different dietary fat sources (P>0.05).

Leeson *et al.* (1987) reported that saturation degree of a dietary fat can influence ADFI, ADWG and FCR which results from better availability of energy from unsaturated fatty acids. There are different reports on performance of broiler chickens fed different fat sources. For example Crespo and Esteve-Garcia (2001), Viveros *et al.* (2009) and Burlikowska *et al.* (2010) compared PUFA and SFA fat sources in chicken diets and indicated that BW and FCR were not affected significantly by the supplemented fat sources.

In another experiment, Crespo and Esteve-Garcia (2002b) compared OO, sunflower oil (SFO) and linseed oil (LO) as vegetable oils with TF from 28-53 days and reported that chickens fed TF, had a higher feed-to-gain ratio than those fed vegetable oils. Sanz *et al.* (2000) used different fat sources including TF and vegetable oil at 0, 8, 12, and 28 d prior to slaughter on broiler performance, but showed no effect on ADFI, ADWG or final BW of birds. Pinchasov and Nir (1992) reported a significant linear increase in the FCR of broiler chickens fed diets with increased levels of UFA. Such an effect may be due to differences in dietary fat digestibility which resulted in differences in metabolizable energy (Wiseman *et al.* 1991).

In current study, feeding vegetable oils to chickens resulted in significant higher ADWG and ADFI in the finishing period as compared to chickens fed TF, but FCR of birds fed TF and OO, were numerically better than birds fed SO and CO due to less FI in TF and OO groups. Newman *et al.* (2002) used 8% of SFO, fish oil (FO) or TF in diet and observed lower FCR in the birds fed diet containing 8% TF. In this study, one of the main causes to lower ADWG of birds fed TF was lower feed consumption.

Crespo and Esteve-Garcia (2002) reported that use vegetable oils rich in PUFA, produced less fat deposits than chickens fed diets rich in SFA (TF) or MUFA (OO). Similarly, in present study replacing of TF (SFA) or OO (MUFA) with SO and CO (PUFA), caused to lower abdominal fat.

Crespo and Esteve-Garcia (2002b) showed that the location of fat deposition depends on the kind of fatty acid added to the diet (SFA or PUFA). Birds fed with diets containing SFA tend to have larger abdominal and mesenteric fat compared to the other fat deposits. Sanz *et al.* (1999) reported that inclusion of SFA fat source compared to UFA fat source in broiler diet, produced higher accumulation of intramuscular and abdominal fat. Sanz *et al.* (2000b) reported a reduction in abdominal fat deposit of birds fed diets containing 8% SFO compared to 8% TF. There is little research regarding the effects of the switch time from diets rich in UFA to SFA diet on fat deposition of birds. Crespo and Esteve-Garcia (2002b) used different fat sources in broiler diets from 28-53 d and reported that broilers fed TF, presented higher abdominal fat percentage than those fed vegetable oils.

Table 5 Effects of different dietary fat sources on blood serum metabolites of broiler chickens at 42 d of age

Blood metabolites	Dietary fat sources (5% supplemented)				P-value	SEM
	Tallow fat	Olive oil	Soy oil	Canola oil		
Triglyceride (mg/dL)	44[a]	41.80[ab]	38.87[b]	39.92[b]	0.009	0.85
Cholesterol (mg/dL)	124.60	123.77	125.31	122.80	0.460	1.27
LDL[2] (mg/dL)	36.60	53.10	34.44	34.12	0.189	0.85
HDL (mg/dL)	78.80[a]	77[b]	73.20[b]	73.80[b]	0.039	1.35
VLDL (mg/dL)	7.20	6.95	6.78	7.02	0.683	0.21
Glucose (mg/dL)	213.40	229.99	225	225.44	0.983	4.37

* Data are means of 6 birds.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of mean.
LDL: low density lipoprotein; HDL: high density lipoprotein and VLDL: very low density lipoprotein.

Also, they showed that liver fat was lower in broilers fed LO as compared to those fed TF. Sanz *et al.* (2000) used four different feeding programs designed to include TF and vegetable oil at different times prior to slaughter on broiler fat deposition. In that study, abdominal fat pad weight increased in a linear manner as the number of days before slaughter in which the animals were fed the TF diets increased. Wiseman (1988) concluded that 80% of changes in fatty acid profile of abdominal fat occurred about 14 d after diet changeover. This study was done 14 days before slaughter and showed no differences between liver and intramuscular fat contents of chickens with replacing TF with vegetable oils but replacing SFA fat source (TF) and MUFA fat source (OO) with PUFA fat sources (SO and CO) increased relative weight of abdominal fat in broiler chickens.

It is postulated that if the ratio of nutrients to energy in diet remained constant, no adverse effect on carcass yield could be anticipated. In current study, all diets were isocaloric and isonitrogenous, therefore no significant differences were observed in percentage of carcass traits, but relative weight of bile sac of birds was influenced by different dietary fat sources. Birds fed TF presented higher weight of bile sac than those fed vegetable oils that may be suggest that inclusion of TF in diet can instigate biliary secretions more than other fat sources. Crespo and Esteve-Garcia (2002b) used vegetable oils and TF from 28-53 days and reported that liver weight was not different between treatments.

Andreotti *et al.* (2001) observed similar performance, carcass yield and cut yields of broiler chickens fed diets containing poultry fat, CO, SO, SFO or lard.

The concentration of triglyceride, cholesterol and glucose in blood serum of broiler chickens can be controlled by feed manipulation. Hermier (1997) reported that serum lipoprotein concentrations could be changed by dietary fat in broilers. The HDL is beneficial and transport cholesterol from the peripheral tissues to the liver, is the main fraction of lipoproteins in the blood of the birds (Peebles *et al.* 1997).

Because serum HDL carries about 75% of total cholesterol in chicks (Peebles *et al.* 1997c), it is more likely that this lipoprotein may be more influenced by the type of dietary fat. In present study, addition of TF to diet 14 days before slaughter resulted in accretion in serum HDL as compared to vegetable oils, but Silva *et al.* (2001), did not observe significant variation in the HDL values of broilers fed either vegetable oil or lard.

In addition, use of vegetable oils rich in PUFA such as SO and CO markedly reduced serum triglyceride rather than TF. Burlikowska *et al.* (2010) reported that different fat sources did not influence significantly the level of fat metabolism in birds.

CONCLUSION

The results of current study indicated that vegetable oils in finishing diets (29-42 d) of broiler chickens improved some performance indices as compared to chickens fed diet rich in animal fat. Moreover, lower abdominal fat pad weight was observed in birds fed finishing diet containing vegetable oils compared to birds fed diet containing animal fat. Serum triglyceride and HDL levels were significantly (P<0.05) influenced by modification of dietary fat sources 14 days prior to slaughter.

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