

Effects of Supplemental Fat to Low Metabolizable Energy Diets on Cholesterol and Triglyceride Contents of Broiler Meat

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Abstract: Problem statement: Modern diets high in Saturated Fatty Acids (SFA) and low in Monounsaturated (MUFA) and Polyunsaturated (PUFA) fatty acids are mostly blamed for the increased incidence of cardiovascular diseases. Since dietary fatty acids are absorbed by monogastric animals and deposited in their tissues without significant modification, considerable potential exists for the manipulation of the fatty acid profile of poultry meat and eggs. In the present study, effects of different sources and levels of supplemental fat to low energy diets on energy and protein intake and efficiency during grower and finisher periods and cholesterol and Triglyceride (TG) contents of breast and thigh meat of broiler chicks were investigated. **Approach:** One hundred and eighty 1 day old Ross 308 broiler chicks of both sexes were used for 42 days. The chicks were randomly allocated to 15 pens containing 12 chicks each with 3 replicates and assigned to receive one of the 5 dietary treatments of 2 sources (soybean oil and beef tallow) and 2 levels of fat (20 and 40 g kg⁻¹) in a completely randomized design with factorial arrangement. There was also a control treatment (without supplemental fat) in this experiment. All chicks were fed with a commercial starter diet from 1-10 day, where-after fed with isocaloric and isonitrogenous diets. **Results:** There were significant differences in energy and protein intake and energy and protein efficiency among treatments in all phases of the experiment (p<0.05). Energy and protein intake was significantly higher in the chicks fed with 40 g kg⁻¹ soybean oil that compared to other groups. The effect of different sources and levels of supplemental fat on cholesterol and TG contents of thigh and breast meat of broiler chicks in 42 day of age was significant (p<0.05). Adding 20 g kg⁻¹ soybean oil significantly decrease levels of cholesterol in thigh and breast meat (p<0.05). The highest TG value of breast meat was observed in control chicks compared with other groups (p<0.05). **Conclusion:** Supplementation of broiler diets with 20 g kg⁻¹ soybean oil improved energy efficiency, decreased cholesterol content of breast and thigh meat of broiler chicks in comparison with other groups.

Key words: Fat source, meat cholesterol, broiler chicks, low energy diet

INTRODUCTION

Use of fats for animal feed has many advantages. Fats are frequently included in broiler diets to increase the energy density. Besides supplying energy, the addition of fat to animal and poultry diets improves the absorption of fat-soluble vitamins, provides varying quantities of the essential fatty acids, increases the palatability of rations and improves the energy efficiency (Baiao and Lara 2005; Nitsan *et al.*, 1997). A number of different fat sources are available for poultry from the vegetable sources and rendering industry. The primary sources are poultry fat, tallow, yellow grease, lard, blends and vegetable fats such as sunflower oil, soybean oil, or palm oil. When different fat sources fed

to birds as a portion of a diet, most experiments indicated no differences in performance parameters (Quart *et al.*, 1992; Pesti *et al.*, 2002). The response of commercial broilers to supplemental dietary fat varies with respect to the type of supplemental fat and its inclusion rate (Wiseman and Salvador 1989; Keren-Zvi *et al.*, 1990; Nitsan *et al.*, 1997). Tallow has traditionally been used in poultry diets and there has been a great use of tallow in blended oil for poultry (Tabeidian *et al.*, 2005). Tallow has include about 42.5% SFA and only 1% Unsaturated Fatty Acids (UFA) that all of them are n-6 fatty acids (Sadeghi and Tabeidian, 2005). Soybean oil stimulated growth rate of chicks when supplemented in poultry diets. Several studies have shown better utilization of unsaturated fats, leading to higher ME for

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unsaturated fats. Studies with rats and broilers have reported that unsaturated vegetable oils produce lower fecal energy losses and, consequently, higher ME than animal fats (Alao and Balnave, 1985; Zollitsch *et al.*, 1997). Overall, in view of prevalence of human coronary heart disease, consumption of PUFA in broiler diets could be considered as a useful complementary option for the amelioration of coronary vascular disease. Dietary fatty acids are absorbed by monogastric animals and deposited in tissues without significant modification. Therefore, there is considerable potential for the manipulation of the fatty acids profiles of poultry tissue by dietary means so as to increase the supply of PUFA suitable for human consumption. There are few published researches about effects of supplemental fat to low energy diets on some productive traits and cholesterol and TG concentration in breast and thigh meat of broiler chicks. Therefore, the objective of the present experiment was to evaluate the effect of different sources and levels of supplemental fat to low metabolisable energy diets on some productive traits, cholesterol and TG concentration in breast and thigh meat of broiler chicks.

MATERIALS AND METHODS

Birds and experimental diets: A total of 180 1-day-old mixes Ross 308 broiler chicks were randomly allocated to 15 groups of 12 birds each and reared under

industry standard condition for 42 days. The birds received a lighting schedule of 23 L:1 day. The experimental treatment included control diet (without supplemental fat), 20 g kg⁻¹ soybean oil, 40 g kg⁻¹ soybean oil, 20 g kg⁻¹ tallow and 40 g kg⁻¹ tallow. The diets (mash form) were formulated to meet nutrient requirements according to National Research Council (1994). Feed and water were provided *ad libitum* during the experiment. All chicks were fed a commercial starter diet from 1-10 day of age. Experimental diets were fed in 2 periods of grower (11-28 days) and finisher (29-42 days) of age. Diets consisted primarily of corn and soybean meal. All diets were similar in ME, CP and other nutrients. Composition of experimental diets is presented in Table 1.

Data and sample collection: Birds were weighed and feed intake was measured weekly. Energy and protein intake, energy and protein efficiency were calculated in grower, finisher and whole phases of the experiment. Mortality was recorded throughout of the experiment. At the end of the experiment, two birds from each replicate with body weight similar to mean replicate body weight were selected, slaughtered and cholesterol and TG contents of breast and thigh were determined by the Folch *et al.* (1957) method.

Table 1: Composition of experimental diets in different periods of the experiment (g kg⁻¹)

Ingredient	Grower					Finisher					
	Starter	1	2	3	4	5	1	2	3	4	5
Corn	565.70	658.10	599.70	552.10	606.60	555.80	706.70	649.00	601.40	655.80	605.10
Soybean meal	382.10	303.70	319.20	340.70	317.90	338.00	259.10	270.50	292.00	269.20	289.20
DCP	17.40	14.80	14.80	14.90	14.80	14.80	14.00	14.10	14.20	14.10	14.20
Sand	-	-	24.90	31.10	19.40	30.20	0.90	27.30	33.50	21.70	32.50
Soybean oil	10.00	-	20.00	40.00	-	-	-	20.00	40.00	-	-
Beef tallow	-	-	-	-	20.00	40.00	-	-	-	20.00	40.00
Oyster shell	11.60	10.40	10.30	10.20	10.30	10.20	10.00	9.90	9.80	9.90	9.80
Vitamin permix ¹	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Mineral permix ²	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Salt	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
DL-Methionine	3.00	1.90	2.00	2.10	2.00	2.10	0.90	1.00	1.10	1.00	1.10
L-Lysine	2.20	3.10	1.10	0.90	1.10	0.90	0.40	0.20	-	0.30	0.10
Composition											
ME (MJ kg ⁻¹)	11.91	12.12	12.12	12.12	12.12	12.12	12.33	12.33	12.33	12.33	12.33
Crude protein	220.00	193.60	193.60	193.60	193.60	193.60	175.00	175.00	175.00	175.00	175.00
Calcium	9.46	8.22	8.22	8.22	8.22	8.22	7.77	7.77	7.77	7.77	7.77
Avail.P	4.73	4.11	4.11	4.11	4.11	4.11	3.88	3.88	3.88	3.88	3.88
Arginine	14.15	12.04	12.30	12.44	12.29	12.41	10.82	10.96	11.10	10.94	11.06
Lysine	13.27	10.97	10.95	10.95	10.95	10.95	9.14	9.14	9.14	9.14	9.14
Met + Cys	10.31	8.68	8.68	8.68	8.68	8.68	7.31	7.31	7.31	7.31	7.31
Sodium	1.33	1.34	1.33	1.32	1.33	1.32	1.35	1.34	1.33	1.34	1.33

¹: **Supplied kg⁻¹ of diet:** 6050 µg vitamin A (retinyl acetate + retinyl palmitate), 55 µg vitamin D₃, 22.05 µg vitamin E (α-topheryl acetate), 2.0 mg K₃, 5 mg B₁, 6.0 mg vitamin B₂, 60 mg vitamin B₃, 4 mg vitamin B₆, 0.02 mg vitamin B₁₂, 10.0 mg pantothenic acid, 6.0 mg folic acid, 0.15 mg biotin, 0.625 mg ethoxyquin; ²: **Supplied kg⁻¹ of diet:** 500 mg CaCO₃, 80 mg Fe, 80 mg Zn, 80 mg Mn, 10 mg Cu, 0.8 mg I, 0.3 mg Se

Statistical analyses: The data from this experiment were subjected to one-way analysis of variance as factorial arrangement 2x2 with 2 sources and 2 levels of fat and, thus there were 4 treatments and 3 replicates for each treatment and also a control diet (without fat supplemented). The obtained data were submitted to analysis of variance, using the General Linear Model Procedure (GLM) of SAS software (SAS Institute, 2000). Means were compared by Duncan's multiple range tests at 5% probability (Duncan, 1955). Statistical model of this experiment was as follow:

$$X_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijk}$$

In this equation the words:

X_{ijk} = The value of each observation
 $\mu, \alpha_i, \beta_j, (\alpha\beta)_{ij}, e_{ijk}$ = Overall mean, effects of fat sources, fat levels, interaction of fat sources and levels and experimental error respectively

RESULTS

Effects of different sources and levels of supplemental fat on energy intake and energy efficiency are presented in Table 2. Effect of source of supplemental fat on energy intake was significant in grower and finisher periods of the experiment ($p < 0.05$). There was significant differences among treatments for energy intake in grower, finisher and whole phases of the experiment for fat levels ($p < 0.05$). Interaction between 2 factors was significant in grower, finisher and whole periods of the experiment ($p < 0.05$). Treatment 4 had the lowest (respectively 4950.27,

12289.59 in 11-28 and 11-42 day) and treatment 3 had the highest value (respectively 5224.35, 7759.62 and 12983.98 in 11-28, 29-42 and 11-42 day) for energy intake trait. There was significant differences among treatments for energy efficiency in grower, finisher and whole phases of the experiment for fat sources ($p < 0.05$). Effect of fat levels on energy efficiency was significant in whole phases of the experiment ($p < 0.05$). Interaction between 2 factors was significant in all phases of the experiment ($p < 0.05$). In this study, energy efficiency was lowest in group fed with diet containing 20 g kg⁻¹ soybean oil (respectively 4.63, 5.65 and 5.18 in grower, finisher and whole phases of the experiment) and highest in the control group (respectively 4.86, 6.47 and 5.70 in grower, finisher and whole phases of the experiment).

Effects of different sources and levels of supplemental fat on protein intake and protein efficiency are presented in Table 3. Effect of source and also level of supplemental fat on protein intake was significant in all phases of the experiment ($p < 0.05$). Interaction between 2 factors was significant in all phases of the experiment ($p < 0.05$). Effect of source of supplemental fat on protein efficiency was significant in all phases of the experiment ($p < 0.05$). There was significant differences among treatments for protein efficiency in whole phases of the experiment for fat levels ($p < 0.05$). Interaction between sources and levels of supplemental fat on protein efficiency was significant in all phases of the experiment ($p < 0.05$). In chicks fed with diets containing 20 g kg⁻¹ soybean oil, protein efficiency was higher than other groups in all phases of the experiment.

Table 2: Effect of different sources and levels of supplemental fat on Energy Intake (EI) and Energy Efficiency (EE) of broiler chicks

	EI (Kcal)			EE (g Kcal ⁻¹)		
	11-28	29-42	11-42	11-28	29-42	11-42
Fat source						
Soybean oil	5159.09 ^a	7585.22 ^a	12744.31	4.63 ^b	5.71 ^b	5.22 ^b
Tallow	5045.55 ^b	7471.93 ^b	12517.48	4.79 ^a	6.08 ^a	5.49 ^a
SEM	23.89	25.83	34.64	0.01	0.03	0.01
Fat level						
20 g kg ⁻¹ fat	5022.05 ^b	7375.06 ^b	12397.11 ^b	4.69	5.85	5.32
40 g kg ⁻¹ fat	5182.59 ^a	7682.08 ^a	12864.67 ^a	4.73	5.94	5.38
SEM	23.89	25.83	34.64	0.01	0.03	0.01
Treatment						
Control	5077.52 ^b	7320.39 ^c	12397.91 ^{cd}	4.86 ^a	6.47 ^a	5.70 ^a
20 g kg ⁻¹ soybean oil	5093.82 ^b	7410.80 ^c	12504.62 ^c	4.63 ^c	5.65 ^c	5.18 ^c
40 g kg ⁻¹ soybean oil	5224.35 ^a	7759.62 ^a	12983.98 ^a	4.64 ^c	5.76 ^c	5.25 ^c
20 g kg ⁻¹ tallow	4950.27 ^c	7339.32 ^c	12289.59 ^d	4.75 ^b	6.06 ^b	5.46 ^b
40 g kg ⁻¹ tallow	5140.82 ^{ab}	7604.52 ^b	12745.35 ^b	4.83 ^b	6.11 ^b	5.52 ^b
SEM	33.84	34.93	50.17	0.03	0.05	0.02

Means with different superscripts in each column differ significantly ($p < 0.05$)

Table 3: Effect of different sources and levels of supplemental fat on Protein Intake (PI) and Protein Efficiency (PE) of broiler chicks

	PI (g/L)			PE (g g ⁻¹)		
	11-28	29-42	11-42	11-28	29-42	11-42
Fat source						
Soybean oil	344.41 ^a	449.97 ^a	794.37 ^a	3.22 ^a	2.95 ^a	3.09 ^a
Tallow	336.83 ^b	443.24 ^b	780.07 ^b	3.12 ^b	2.76 ^b	2.94 ^b
SEM	1.59	1.53	2.17	0.01	0.02	0.01
Fat level						
20 g kg ⁻¹ fat	335.26 ^b	437.50 ^b	772.76 ^b	3.18	2.88	3.03 ^a
40 g kg ⁻¹ fat	345.98 ^a	455.71 ^a	801.69 ^a	3.16	2.84	3.00 ^b
SEM	1.59	1.53	2.17	0.01	0.02	0.01
Treatment						
Control	338.96 ^b	434.26 ^c	773.22 ^{cd}	3.07 ^c	2.60 ^c	2.83 ^d
20 g kg ⁻¹ soybean oil	340.05 ^b	439.62 ^c	779.67 ^c	3.23 ^a	2.98 ^a	3.10 ^a
40 g kg ⁻¹ soybean oil	348.76 ^a	460.31 ^a	809.07 ^a	3.22 ^a	2.92 ^a	3.07 ^a
20 g kg ⁻¹ tallow	330.47 ^c	435.38 ^c	765.85 ^d	3.14 ^b	2.78 ^b	2.96 ^b
40 g kg ⁻¹ tallow	343.19 ^{ab}	451.11 ^b	794.30 ^b	3.09 ^{bc}	2.75 ^b	2.92 ^c
SEM	2.26	2.07	3.16	0.02	0.03	0.01

Means with different superscripts in each column differ significantly (p<0.05)

Table 4: Effect of different sources and levels of supplemental fat on cholesterol and TG contents of breast and thigh of broiler chicks (mg 100/g)

	Thigh		Breast	
	Cholesterol	TG	Cholesterol	TG
Fat source				
Soybean oil	106.52 ^b	39.96 ^a	75.11 ^b	16.59
Tallow	139.19 ^a	24.07 ^b	104.69 ^a	20.02
SEM	2.11	0.68	1.37	0.59
Fat level				
20 g kg ⁻¹ fat	114.05 ^b	21.00 ^b	84.25 ^b	21.63 ^a
40 g kg ⁻¹ fat	131.66 ^a	43.04 ^a	95.55 ^a	14.98 ^b
SEM	2.11	0.68	1.37	0.59
Treatment				
Control	125.75 ^b	38.50 ^b	90.40 ^{bc}	28.12 ^a
20 g kg ⁻¹ soybean oil	97.60 ^c	24.50 ^d	69.80 ^d	20.65 ^b
40 g kg ⁻¹ soybean oil	115.45 ^b	55.43 ^a	80.42 ^{cd}	12.53 ^c
20 g kg ⁻¹ tallow	130.50 ^b	17.50 ^e	98.70 ^b	22.62 ^b
40 g kg ⁻¹ tallow	147.88 ^a	30.65 ^c	110.68 ^a	17.43 ^{bc}
SEM	5.61	2.04	4.06	1.81

Means with different superscripts in each column differ significantly (p<0.05)

Effects of different sources and levels of supplemental fat on cholesterol and TG contents of breast and thigh are presented in Table 4. Effect of source of supplemental fat on cholesterol content of breast and thigh and TG content of thigh was significant (p<0.05). There was significant differences among treatments for cholesterol and TG contents of breast and thigh for fat levels (p<0.05). Interaction between 2 factors was significant (p<0.05). Chicks fed with 40 g kg⁻¹ beef tallow and 40 g kg⁻¹ soybean oil had a higher cholesterol (147.88) and TG contents (55.43) in thigh respectively, so the lower cholesterol (97.60) and TG contents (17.50) of thigh was observed in birds fed with 20 g kg⁻¹ soybean oil and 20 g kg⁻¹ beef tallow respectively (Table 4). Breast cholesterol

content in birds fed with 20 g kg⁻¹ soybean oil was significantly lower than other groups (p<0.05). Breast TG content was significantly higher in birds fed with control diet in comparison to birds fed with soybean oil or beef tallow (p<0.05).

DISCUSSION

Higher energy intake in chicks fed with 40 g kg⁻¹ soybean oil in all phases of the experiment may be contributed to higher feed intake in this group. Also, dietary fat is so highly correlated with total energy intake (Sempos *et al.*, 1999). However, other factors may also influence energy intake including the palatability and the physical form of feed, the amount (portion size) and volume of feed consumed as well as behavioral and genetic factors (Beaton *et al.*, 1997). Carew *et al.* (1963) reported that chicks fed with diets containing soybean oil or corn oil consumed more ME than chicks fed with low fat diets. Energy intake in excess of energy expenditure results in energy storage and weight gain. Hence dietary fat could affect energy balance by influencing energy storage, energy expenditure or energy intake. Wongsuthavas *et al.* (2006) reported that different fat sources in broiler diet did not effect on energy intake, energy excretion and energy oxidation.

Rand *et al.* (1958) studied the effect of supplemental fat in chicks with different protein levels. They demonstrated that addition of corn oil to chick diets resulted in an improvement in energy and protein efficiency. They suggested three possible mechanisms: increasing use of dietary energy or protein or by an unidentified growth factor. In recent study, Carew *et al.* (1964) found that supplementation of different fats

(corn oil, beef tallow, soybean oil) in the diet to low fat diet improved energy efficiency in broiler.

Protein intake of chicks fed with 40 g kg⁻¹ soybean oil was significantly higher than other groups in 11-28, 29-42 and 11-42 day). Higher protein intake in this treatment in all phases of the experiment may be contributed to higher feed intake in this group. In 11-28 and 29-42 day of age, protein intake of chicks fed with 20 g kg⁻¹ beef tallow was lower than other groups.

Skrivan *et al.* (2000) observed that substitution of animal fat with vegetable oil decreased the muscles cholesterol content of broiler chicks. Cholesterol is absent in vegetable oils. Furthermore, these oils contain phytosterols, which are able to block reabsorption of bile acids and cholesterol in the ileum (Sklan *et al.*, 1974). Results of this study are in agreement with results of other studies (Katan, 1995; Talebali and Farzinpour, 2005). They reported that thigh muscles in compared with breast, rapidly transfer of fatty acids and glucose to tissue therefore, extra amount of fatty acids can deposited in thigh and also extra amount of glucose can converted to fatty acids and deposited. Due to their function and muscular work, the breast muscles have lower fat than thigh muscles. Crespo and Esteve-Garcia (2001) found that broiler breast muscles have lower cholesterol values than thigh muscle. Muscle cholesterol content of broiler was significantly influenced by the dietary fatty acid profile, so that supplementation of beef tallow and olive oil to broiler diets caused higher cholesterol values than diets containing sunflower and linseed oil. These findings are also consistent with reports of Maraschiello *et al.* (1998), who found higher levels of breast cholesterol for birds fed with diets containing lard than those fed with diets containing olive or sunflower oil.

CONCLUSION

Results of the present study indicated that supplementation of broiler diet with 20 g kg⁻¹ soybean oil significantly improved energy intake and efficiency and reduced cholesterol concentration in breast and thigh meat which would be important for human health.

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