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Effects of Skip a Day Feeding and Dietary Fat Type on Abdominal Fat Pad and Blood Lipids in Broiler Chickens

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Abstract: This experiment carried out to study the effects of skip a day feeding and different dietary unsaturated to saturated fatty acids ratio on serum cholesterol and triglyceride levels and carcass traits. A total of 720 10-days-old male Ross chicks were fed diets with Unsaturated/saturated fatty acid ratio (U/S) of 2, 3.5, 5 or 6.5 as ad lib or skip a day feeding program during 18-28 days of age. Generally at 28 day of age, chicks body, liver and abdominal fat pad weights and serum triglyceride concentration were significantly ($p<0.05$) lower and serum cholesterol level were significantly higher in the restricted compared with ad libitum birds. Re-feeding moved out these differences at 42 days of age except for body weight. The serum cholesterol and triglyceride concentrations were decreased ($p<0.05$) by increased dietary U/S.

Key words: Skip a day feeding, dietary fat, abdominal fat pad, serum lipids, broilers

INTRODUCTION

The selection for increased growth has, produced a chicken with excessive fatness and this has become a problem in modern broilers strains. Commercial broiler strains contain between 13-18% of their body weight as ether-extractable fat (Griffin, 1993).

Because of limited capacity of digestive tract, plant or animal fats or their mixtures are important components of broilers high energy diets. Fats with high unsaturated fatty acid content have a more absorbability and there is a known synergism between saturated and unsaturated fats (Freeman, 1984; Hulan *et al*., 1984).

Usually, fats with a high level of unsaturated fatty acids are better absorbed than highly saturated lipids. In addition, the age of young broiler chickens is another important factor for the ability to digest fats. Changes in body fat deposition between broilers fed different dietary fatty acid profiles may be related to different rates of lipid synthesis or lipid oxidation. Its showed that hepatic fatty acid synthetase activity is decreased by diets with added sunflower oil (rich in PUFA of n-6 series) compared with those fed lard and can result in abdominal fat pad reduction (Sanz *et al*., 2000). It has been well known that dietary intake of n-6 and n-3 PUFAs is effective in lowering blood lipids level.

Broilers are generally full-fed from start to market and are encouraged to eat as much as possible, since more feed consumption means faster growth and better feed conversion. McGovern *et al*. (1999) found that 40-day body weight was significantly greater in the ad libitum birds than in the feed-restriction birds. Saleh *et al*. (1996) reported that final body weight did not differ among those restricted to 20 or 40% and those fully fed and the abdominal fat percentage decreased with increasing feed restriction.

Summers *et al*. (1990) could not show an advantage in terms of abdominal fat for broilers with restricted feeding from 7 to 14 days of age when compared with broilers that ate ad libitum. Additional work by Plavnik *et al*. (1986) noted that feed restriction from 1 week of age for male broilers would produce significantly less abdominal fat. Khontabrab *et al*. (1997) reported that feed withdrawal markedly inhibited deposition of abdominal fat. Fontana *et al*. (1993) found that no significant differences were observed for abdominal fat pad and liver weights between early restricted birds and ad libitum controls at 49 days of age. In Tanaka and Shigeno (1975) study, Broiler chickens were deprived of feed for up to 4 days and then re-fed on a stock diet. Deprivation caused a fall in the concentration of serum triglycerides while cholesterol tended to increase.

The objective of this study was to survey the effects of feed restriction and different dietary unsaturated to saturated fatty acids ratio on abdominal fat pad and serum lipids in broiler chickens.

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MATERIALS AND METHODS

Seven hundred and twenty, 10 days old male chicks (Ross 308) were used in the study. The birds were randomly assigned according to their initial body weights to a completely randomized design with a 2*4 factorial arrangement with 3 replicate and 30 chicks for each replicate. Experiment factors were: 1-skip a day or free feeding at days 18-28 of age and 2-diets with different unsaturated to saturated fatty acid ratios (2, 3.5, 5 and 6.5) formulated using different levels of sunflower oil and tallow. Fatty acids content of beef tallow and sunflower oil determined by gas chromatography and other information for diet formulation extracted from NRC (1994). The birds were fed a grower diet until 28 days of age followed by a finishing diet at 29 to 42 days of age. The basal diets were formulated using Ross Co. (Anonymous, 2002) guideline. Fatty acid composition of ingredients and the composition of experimental diets are shown in Table 1 and 2, respectively.

At the end of grower (28 days) and finisher (42 days) periods, pancreas, liver and abdominal fat pad weights were determined in 6 birds from each treatment. At same times, blood samples were collected from jugular vein from 12 birds randomly chosen from each treatment and serum was prepared and stored at -20°C for determination of cholesterol and triglyceride via spectrophotometer. The data were analyzed using the GLM procedure of SAS software (SAS Institute, 2001). Significant differences among treatment means were determined using Duncan's new multiple range test.

RESULTS

The effects of different dietary ratios of unsaturated to saturated fatty acids on carcass traits at 28 and 42 days of age are presented in the Table 3. The percent of Carcass and pancreas was not influenced by the nature of the diet and feeding program at any stage of experiment. At 28 days of age, the chicks fed on different dietary fat types had a similar liver weight. However, compared to chicks fed ad libitum, the chicks on skip a day feeding during 18-28 days of age had significantly ($p<0.05$) lower liver weight. At 42 days of age, effect of feed restriction on liver weight disappeared, but chickens fed diet with U/S = 2 had a higher liver weight especially relative to chickens fed diet with U/S = 3.5 ($p<0.05$).

Feed restriction caused a significant reduction in abdominal fat pad at 28 days of age ($p<0.05$), while after returning to free access to feed, this difference moved

Table 1: Fatty acid composition of ingredients

		Fatty acid type (%)					
Ingredients	Crude fat (%)	16:0	16:1	18:0	18:1	18:2	18:3
Corn	3.8	0.62	-	0.10	1.17	1.82	0.09
Soybean meal	1	0.24	0.01	0.05	0.16	0.47	0.07
Sunflower oil	100	6.70	0.10	4.30	27.40	57.10	3.70
Beef tallow	100	25.00	4.20	22.70	37.00	2.50	0.30

Table 2: Composition and calculated nutrient content of broiler grower (fed 10 to 28 days) and finisher (fed 29 to 42 days) diets with different unsaturated to saturated fatty acids ratios

	Unsaturated to saturated fatty acids ratio							
	2		3.5		5		6.5	
Ingredients (%)	Grower	Finisher	Grower	Finisher	Grower	Finisher	Grower	Finisher
Corn	42.83	49.29	46.02	52.42	47.29	53.66	47.97	54.33
Soybean meal	42.38	36.35	41.75	35.72	41.50	35.48	41.36	35.34
Sunflower meal	1.49	1.32	4.36	4.14	5.50	5.26	6.12	5.86
Beef tallow	9.07	8.85	3.64	3.52	1.48	1.40	0.33	0.27
$CaCO_3$	0.99	1.00	1.00	1.01	1.00	1.01	1.00	1.01
DCP	1.84	1.88	1.83	1.87	1.83	1.87	1.83	1.87
Common salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL- Methionine	0.34	0.31	0.34	0.30	0.34	0.30	0.33	0.30
HCl-Lysin	0.18	0.13	0.18	0.14	0.19	0.15	0.19	0.15
ME (kcal kg^{-1})	3150.00	3200.00	3150.00	3200.00	3150.00	3200.00	3150.00	3200.00
Crud protein	21.00	19.00	21.00	19.00	21.00	19.00	21.00	19.00
Calcium	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Av. Phosphorus	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Sodium	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Lysin	1.20	1.05	1.20	1.05	1.20	1.05	1.20	1.05
Methionine	0.54	0.49	0.54	0.49	0.54	0.49	0.54	0.49
Met + Cys	0.85	0.78	0.85	0.78	0.85	0.78	0.85	0.78

Table 3: Liver, Pancreas and abdominal fat pad content*

Treatment		28 days of age			42 days of age		
F[1]	U/S[2]	Liver (%)	AF[3] (%)	Pan[4] (%)	Liver (%)	AF (%)	Pan (%)
F1	2.0	3.7c	1.0ab	0.39	2.1abc	2.4b	0.35
F1	3.5	3.5bc	1.7ab	0.43	2.0abc	2.1b	0.38
F1	5.0	3.4bc	1.7ab	0.4	2.1ab	2.5b	0.39
F1	6.5	3.2c	2.1a	0.41	2.0bc	2.4b	0.34
F0	2.0	3.5bc	1.0cd	0.45	2.2a	2.4b	0.39
F0	3.5	3.5abc	1.0cd	0.4	1.9c	2.2b	0.3
F0	5.0	3.8ab	0.9d	0.43	2.1ab	2.5ab	0.39
F0	6.5	4.0a	1.4bc	0.43	2.1ab	3.2a	0.34
SEM		0.16	0.19	0.03	0.07	0.26	0.02
P_I[5]		0.22	0.5	0.8	0.5	0.4	0.4
P_T[6]		0.01	0.001	0.5	0.1	0.2	0.1
	2.0	3.3	1.4ab	0.42	2.1a	1.51b	0.31
	3.5	3.5	1.3ab	0.45	2.0b	1.94b	0.33
	5.0	3.6	1.1b	0.34	2.1a	1.92b	0.32
	6.5	3.6	1.7a	0.42	2.0ab	2.76a	0.34
$P_{U/S}$[7]		0.25	0.04	0.3	0.04	0.1	0.1
F1		3.7a	1.8a	0.41	2.1	2.6	0.33
F0		3.1b	1.1b	0.44	2.1	2.3	0.31
P_F[8]		0.031	0.001	0.1	0.51	0.2	0.1

a-d Values in the same column in each comparison group, with no common superscript differ significantly ($p<0.05$), * Values are means of 6 birds per treatment. [1]F = feeding program, F1: a dlibitum, F0: skip a day. [2]U/S= Dietary fat unsaturated to saturated fatty acids ratio. [3]AF = Abdominal fat pad. [4]Pan = Pancreas. [5]P_I= P value of interaction of U/S ratio and feeding program. [6]P_T = P value of comparison of treatments obtained by combination of U/S ratio and feeding program. [7]$P_{U/S}$= P value of effect of U/S ratio. [8]P_F= P value of effect of feeding program

Table 4: Serum cholesterol and triglyceride concentration (mg dL^{-1}) *

Treatment		28 days of age		42 days of age	
F[1]	U/S[2]	Cholesterol	Triglyceride	Cholesterol	Triglyceride
F1	2.0	151.3a	38.22a	77.90	30.2ab
F1	3.5	131.8b	29.9b	72.80	25.4bc
F1	5.0	120.2c	30.5b	72.50	22.4d
F1	6.5	128.8bc	29.1c	78.10	18.3d
F0	2.0	127.6bc	38.3a	82.60	33.5a
F0	3.5	114.8d	39.0ab	76.30	25.6bc
F0	5.0	112.2d	31.3abc	79.50	22.9cd
F0	6.5	109.6d	28.3ab	78.10	22.38c
SEM		4.20	3.2	5.10	1.50
P_I[3]		0.59	0.75	0.67	0.44
P_T[4]		0.003	0.02	0.66	0.12
	2.0	138.00a	38.2a	80.40	31.8a
	3.5	123.3b	34.5b	74.70	25.7b
	5.0	117.5b	30.9c	76.10	22.90bc
	6.5	117.5b	31.6c	78.30	20.40c
$P_{U/S}$[5]		0.02	0.01	0.85	0.02
F1		114.8b	34.3a	78.10	25.80
F0		131.8a	31.9b	75.60	23.60
P_F[6]		0.0004	0.03	0.63	0.40

a-d Values in the same column in each comparison group, with no common superscript differ significantly ($p<0.05$), * Values are means of 12 birds per treatment. [1]F = feeding program, F1: adlibitum, F0: skip a day. [2]U/S = Dietary fat unsaturated to saturated fatty acids ratio. [3]P_I = P value of interaction of U/S ratio and feeding program. [4]P_T = P value of comparison of treatments obtained by combination of U/S ratio and feeding program. [5]$P_{U/S}$ = P value of effect of U/S ratio. [6]P_F = P value of effect of feeding program

out at day 42. Abdominal fat pad in broiler chickens fed diet with most unsaturated fat (U/S = 6.5) at both 28 and 42 days of age was significantly lower than other treatments ($p<0.05$). With respect to studied parameters, no significant interaction observed between feeding program and dietary fat type.

Table 4 shows the effects of feed restriction and dietary fat U/S ratio on serum cholesterol and triglyceride concentrations. Skip a day feeding at 18-28 days of age, caused a significant increase in serum cholesterol and a major decrease in triglyceride concentration determined at day 28 days of age ($p<0.05$). Re-feeding at 29-42 days of age moved out these differences at 42 day of age.

Dietary fat type had a considerable effect on serum lipids too. At both 28 and 42 days of age with increasing the U/S ratio there was a corresponding significant reduction in serum triglyceride concentration ($p<0.05$).

At 28 days of age diet with the highest U/S ratio caused a significant reduction in serum cholesterol level too ($p<0.05$), but no differences observed at 42 days of age.

DISCUSSION

Liver role is primarily to provide intermediary metabolites for biosynthesis (Stevens, 1996). This role is particularly important for triglyceride production as adipose tissue in birds has very little capacity for de novo triglyceride biosynthesis, So triglyceride storage in other tissues depends on blood lipids availability originated from diet or hepatic lipigenesis (Saadoun and Leclercq, 1983).

Herzberg and Rogerson (1990) reported that in broiler chickens fed a standard diet, about 28% of total body lipogenesis occur in liver. On the other hand, Zhong *et al.* (1995) showed that there is a relation between lipogenesis reduction and liver weight decrease due to feed restriction.

Significant reduction in liver weight because of feed restriction is in agreement with previous reports (Palo *et al*., 1995; Plavnik and Yahav, 1998; Bartov, 1987; Ramlah *et al*., 1996), while in some cases contrary results reported (Petek, 2000). Effect of feed restriction on abdominal fat pad reduction has reported by other researchers too (Plavnik and Hurwitz, 1985; Petek, 2000). There are also same reports about this difference compensation after re-feeding (Fontana *et al*., 1993; Ramlah *et al*., 1996).

Phetteplace and Watkins (1990) showed that different mixtures of a saturated (poultry fat) and unsaturated (fish oil) fats in diet didn't affect liver weight that irrespective of dietary fat type is in agreement with present study.

Effect of feed restriction on serum's cholesterol increase and triglyceride decrease at 21 days of age, regardless of type and severity of restriction is in agreement with previous studies (Tanaka and Shigeno, 1975; Kubikova *et al*., 2001; Santoso, 2002b).

In researches with differing results, Santoso (2001) used a restricted feeding program and observed a reduction in serum triglyceride level but serum cholesterol concentration was not affect. Even Santoso (2002a) reports an increase in plasma triglyceride level due to a middle feed restriction at earlier ages in broiler chickens.

Effect of unsaturated fats on reducing blood lipids is in agreement with previous reports. Sanz *et al.* (2000) showed that consumption diet with 8% sunflower oil in compare to 8% tallow until 32 days of age cause a reduction in plasma triglyceride that indicate high clearance rate of lipids toward tissues.

Crespo and Esteve-Garcia (2003) showed that broiler chickens fed diet containing sunflower oil had a lower blood cholesterol level relative to birds fed diet with tallow. De novo synthesis of fatty acids in birds depends on dietary carbohydrate to supply acetyl CoA, so this biosynthesis in fed birds is higher than fasted ones.

Different studies suggest that poly unsaturated fatty acids (PUFA) capable to inhibit lipogenesis (Wilson *et al*., 1986; Sanz *et al*., 2000) and carry out this function via down regulation of hepatic lipogenec enzymes (Allmann and Gibson, 1965) or enhancing oxidation rate of fatty acids (Shimomura *et al*., 1990; Sanz *et al*., 2000).

This effects can explain that why PUFA in compare to saturated or mono unsaturated fatty acids results in abdominal fat pad reduction (Crespo and Estere Garcia, 2001).

Based on lower abdominal fat pad deposition in the birds fed diets rich in sunflower oil, it may be speculated that blood circulating lipids was preferentially utilized by macular tissues as an immediate energy source rather than stored in adipose tissue.

Sanz *et al.* (2000) concluded that the lower abdominal fat deposition occurring in broiler chickens fed a sunflower enriched diet compared with those fed a tallow enriched diet may be explained by an increased rate of b-oxidation of unsaturated dietary fats and reduced endogenous fatty acid synthesis despite higher dietary fat absorption (Sanz *et al*., 2000).

These results show that it's possible to change abdominal fat pad percent by altering dietary unsaturated to saturated fatty acids ratio and feeding program.

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