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Effects of Fat Sources and Energy to Protein Ratio on Growth Performance and Carcass Composition of Chicks

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Abstract

Three hundred and twenty-four 1 day old chicks were used to determine the effects of fat source and energy to protein ratio on growth performance, carcass composition and the efficiency of nutrient utilization. Chicks were assigned, in a completely randomized design, to a 3 * 3 factorial arrangement of treatments. Chicks received one of three fat sources(no fat, tallow, corn oil) and one of three energy to protein ratios(16, 14 and 12kcal ME/g CP). All diets were formulated to be isocaloric(3.2Mcal ME/kg diets) using published ME values for the diet ingredients. Addition of fat to the diet increased ADG, average daily feed intake, and gain to feed. Chicks fed diets containing fat had increased percentage body DM and ether extract(EE), but percentage CP was not different. Chicks fed diets containing fat had increased efficiency of protein and energy deposition. Addition of fat as either tallow or corn oil yielded similar results. Reducing the energy to protein ratio of the diet did not affect ADG or gain to feed, but tended to decrease average daily feed intake($p=0.08$), as well as resulting in linear($p<0.05$) reductions in body percentage DM, EE and also total EE. Increasing the energy to protein ratio did not affect percentage or total body CP. Adding fat to poultry diets improved growth performance and the efficiency of growth of chicks. Decreasing the energy to protein ratio did not affect growth performance, but reduced EE in the body of chicks.

Key words: chicks, dietary fat, energy, protein

INTRODUCTION

Dietary fats have been shown to improve efficiency of feed utilization of poultry diets. This improvement in performance has been attributed to the high energy concentration of fats. The addition of fat to poultry diets has been reported to increase the ME of the diets more than can be predicted from the published ME values of the individual ingredients(1-3). Sibbald(4) suggested that the "extra-caloric" effect of supplemental fats could be due to a positive interaction between unsaturated fatty acids present in the ingredients of the diet and the saturated fatty acids supplied by added fat. This positive interaction may enhance micelle formation and overall fat absorption or affect retention time of feedstuffs(5). Synergism among dietary fatty acids, howerever, cannot satisfactorily explain the "extra-caloric effect" of vegetable oils(3).

Diet containing a narrow energy/protein ratio causes decreased carcass fat(6). Body composition data on a DM basis demonstrate a positive relationship between dietary protein and percentage lean tissue(7). The level of dietary protein can also affect lipid metabolism in chicks(7). The calculation of the optimum energy to protein ratio becomes complicated when different sources of fat are used. The purpose of the persent research was to describe the effects of fat source at three different energy to protein ratios, and to determine how fat source affects the optimum energy to protein ratio for growth, feed efficiency and carcass composition.

MATERIALS AND METHODS

Animals

Three hundred twenty-four leghorn chicks were divided into nine experimental treatments and housed for 21 days in battery brooders. Six chicks, three males and three females, were used per pen with six replications per treatment.

Treatments

Chicks were assigned, in a completely randomized design, to a 3 * 3 factorial treatment arrangement. Main effects were dietary fat source and energy to protein ratio. The three dietary fat sources were no fat, 5% tallow and corn oil, the energy to protein ratios were 16kcal/g protein(19% CP), 14kcal/g protein(22%

Table 1. Diet composition

Energy : Protein, kcal ME/g CP	No fat			5% tallow			5% corn oil		
	16	14	12	16	14	12	16	14	12
Ingredient, %									
Corn	64.9	47.2	28.5	50.8	42.9	35.2	50.6	42.9	35.2
Soybean meal 44%	31.0	41.0	51.3	33.4	41.8	50.0	33.6	41.8	50.0
Dicalcium phosphate	1.6	1.6	1.5	1.7	1.6	1.6	1.7	1.6	1.6
Limestone	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Base mix[1)]	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Selenium pmx[2)]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tallow				5.0	5.0	5.0			
Cellulose[3)]				6.4	6.0	5.5	6.3	6.0	5.5
Corn oil							5.0	5.0	5.0
Corn starch		7.5	16.0						
Total	100	100	100	100	100	100	100	100	100
Calculated analysis									
CP, %	19.1	19.0	19.1	22.0	22.0	22.0	25.0	85.0	25.0
ME, Mcal/kg	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Methionine, %	0.62	0.60	0.60	0.67	0.67	0.66	0.72	0.73	0.73
Lysine, %	1.1	1.1	1.1	1.31	1.32	1.32	1.56	1.54	1.54
Ca, %	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Available P, %	0.45	0.45	0.45	0.45	0.46	0.46	0.46	0.46	0.46

1)The base mix provided per kilogram of diet : 10mg Cu, 100mg Fe, 100mg Mn, 100mg Zn, 3mg I, 1mg Co, 92mg Ca, 11,000 IU vitamin D_3, 3.3mg menadione Na bisulfide, 11 IU vitamin E, 6.6mg riboflavin, 11.9mg Ca-pantothenate, 77mg niacin, 0.11mg d-biotin, 0.66mg folacin, 0.011mg vitamin B_{12} 880mg choline Cl

2)The selenium premix provided 0.2mg Se per kilogram of diet

3)Solkafloc, from James River Corporation, Berlin, NH

CP) and 12kcal/g protein(25% CP). All diets were isocaloric(3.2Mcal ME/kg diet), and were formulated to provide daily intakes of vitamins and minerals that met or exceeded NRC(8) requirement(Table 1). Feed and water were available *ad libitum*. Fresh feed was added to feeders once a day approximately at 09:00.

Data collection

Feed intake and weight change were recorded weekly. At the end of the experimental period, two birds per pen were randomly selected for determination of body composition. The selected birds were fasted for 12h, sacrificed and feathers were removed. The birds were stored at -20°C until homogenization. Both of the birds from a given pen were ground together in a meat grinder and mixed thoroughly. A representative subsample of the ground material was collected for analyses.

Laboratory analyses

Carcass samples were analyzed for CP by the Kjeldahl procedure(N * 6.25), ether extract(EE) using Soxhlet (extraction in ethyl ether for 48h) and DM by lyophilization.

Statistical analyses

Data were subjected to analysis of variance using the GLM procedure of SAS(9). The main effects were dietary fat source and energy to protein ratio. *A priori* orthogonal cantrasts(10) were designed to evaluate the effect of fat addition and the effect of tallow vs corn oil, and also linear and quadratic components of the main effects.

RESULTS AND DISCUSSION

Fat source

The effects of fat source on growth performance and carcass composition are listed in Table 2. The addition of fat to the diet caused improvements in ADG, average daily feed intake(ADFI) and gain to feed

Table 2. Growth performance and carcass composition of chicks fed different sources of fat

	Fat source			P[1]	SE
	No fat	Tallow	Corn oil		
ADFI, g/d[2,3]	216.8	227.8	230.7	0.007	3.0
ADG, g/d[3]	128.3	138.5	142.3	0.004	2.9
Gain/Feed[3]	0.590	0.607	0.619	0.03	0.007
DM, %[3]	38.22	38.94	38.72	0.13	0.25
EE, %[3,4]	16.39	18.28	17.89	0.03	0.5
Protein, %	16.83	16.56	16.73	0.44	0.15
Total DM, g[3]	1136.3	1241.7	1267.5	0.0003	26.7
Tatal protein, g[3]	500.5	527.5	548.0	0.02	11.43
Total EE, g[3]	491.1	583.3	585.0	0.0005	20.29
Protein intake, kg	1.00	1.05	1.06	0.0001	0.015
Protein efficiency[3,5]	0.506	0.506	0.519	0.0001	0.007
Energy efficiency[3,6]	0.467	0.507	0.509	0.0001	0.01

1)Probability level
2)Average daily feed intake
3)No fat vs fat significant, $p<0.05$
4)Ether extract
5)Protein efficiency is equal to total protein divided by protein intake
6)Energy efficiency is equal to total body energy divided by energy intake

Table 3. Growth performance and carcass composition of chicks fed different protein levels

	Energy : Protein ratio, kcal ME/g CP			P[1]	SE
	16	14	12		
ADFI, g/d[2]	230.8	222.4	221.9	0.08	3.0
ADG, g/d	137.3	136.3	135.8	0.94	2.9
Gain/Feed[3]	0.595	0.611	0.611	0.22	0.0007
DM, %[4]	39.7	38.5	37.6	0.0001	0.25
EE. %[4,5]	20.1	17.3	15.1	0.0001	0.5
Protein, %	16.6	16.8	16.7	0.57	0.15
Total DM, g[4]	1257	1210	1179	0.13	26
Tatal protein, g	525	527	524	0.97	11
Total EE, g[4]	636	544	478	0.0001	20
Protein intake, kg[4]	0.92	1.03	1.16	0.0001	0.015
Protein efficiency[4,6]	569	512	448	0.0001	7.4
Energy efficiency[4,7]	531	497	456	0.0001	10.3

1)Probability level
2)Average daily feed intake
3)Energy:protein by fat source interaction, $p<0.05$
4)Linear effect of protein, $p<0.05$
5)Ether extract
6)Protein efficiency is equal to total protein divided by protein intake
7)Energy efficiency is equal to total body energy divided by energy intake

(G/F) in chicks. The addition of fat to the diet also resulted in an increase in the percentage DM and EE, but did not affect the percentage CP found in the body of chicks. The addition of fat also resulted in an increase in total DM, EE and CP in the body of chicks. Present results agree with the results of Seaton et al. (11). Chicks fed added fat were more efficient in deposition of dietary protein and dietary energy than chicks receiving diets with no added fat. Fat deficiency increases membrance viscosity and may modify, in this capacity, the function of their integral proteins (12). The results of present experiment demonstrate clearly the previously observed "extra-caloric effect" of added fat with respect to growth performance and nutrient utilization(13). The fact that there was no difference between tallow and corn oil does not support the contention that synergism between the fatty acids present in the feedstuffs is responsible for the enhanced performance. Synergism would have been greatest when tallow was included in the diet, and should have produced superior performance.

Energy : protein ratio

The effects of energy to protein ratio on growth performance and carcass composition of chicks are listed in Table 3. Decreasing the energy to protein ratio (by increasing the protein concentration of the diet) did not affect ADG.

Large energy to protein ratios in the diet tended to cause increases in feed intake. Increased feed intake by chicks fed diets with a wide energy to protein ratio has been observed previously(14). Decreasing the energy to protein ratio resulted in a linear decrease in percentage body DM and EE, as well as total body DM and EE. In contrast, there was no effect of energy to protein ratio on the percentage or total protein in the body of chicks. The main effect of narrowing the energy to protein ratio in this experiment was to improve the body composition of chicks by decreasing the amount of fat present in the body. Griffiths et al. (14) suggested that birds consuming a diet with a wide energy to protein ratio over-consume energy in an effort to meet their protein requirement. This over-consumption of energy was associated with increased fat deposition in the body. When the energy to protein ratio is narrow, birds eat less feed to meet their protein requirement and therefore, consume less energy. Carcasses from chicks fed diets with narrow energy to protein ratios contain less fat than carcasses of chicks fed diets with wide energy to protein ratios(6,15,16). Resebrough and Steele(7) found that *in vitro* lipogenesis was decreased when chicks were fed diets with narrow energy to protein ratios. It is possible that a portion of the reduction of body EE is due to the effect of a reduced energy to protein ratio on lipogenesis. Protein intake of chicks increased as the energy to protein ratio in the diet decreased. Decreasing the energy to protein ratio linearly decreased the efficiency of protein and energy deposition in the body of chicks. The results on energy and protein deposition efficiency are similar to results observed by Jackson et al.(17).

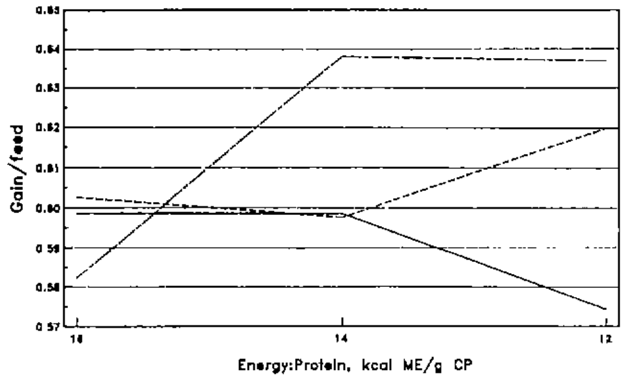

Fig. 1. Interaction($p<0.05$) between fat source and energy to protein ratio on gain to feed.
Lines represent no fat ——, tallow -----, and corn oil — · —.

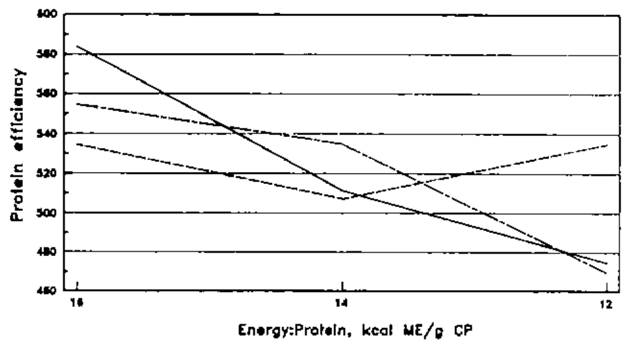

Fig. 2. Interaction($p<0.05$) between fat source and energy to protein ratio on protein efficiency.
Lines represent no fat ——, tallow -----, and corn oil — · —.

Significant interactions between fat source and energy to protein ratio effects were observed for G/F and protein efficiency. Data on these two criteria are illustrated in Figs. 1 and 2, respectively. Gain/feed increased as energy to protein ratio decreased to 14 kcal ME/g CP, when corn oil was the fat source then plateaued at energy to protein ratios narrower than 14kcal ME/g CP. Gain/feed was unchanged as energy to protein ratio decreased from 16 to 14kcal ME/g CP then increased when fat was included as tallow and decreased when no fat was included in the diet. A possible explanation for this difference is that at low protein levels the chicks increased their feed intake in an effort to meet their protein requirement. When the concentration of protein in the diet is increased, intake is decreased and growth is retarded causing G/F to be reduced. Protein efficiency decreases as energy to protein ratio decreases when the diet contains either no fat or corn oil. Protein efficiency appears to be less affected when tallow is included in the diet.

The results presented demonstrate the "extra-caloric" effect of fat in the diet. Inclusion of fat in the diet improved growth performance and the efficiency of tissue deposition. Alteration of the energy to protein ratio did not affect growth performance, but as the ratio was decreased there was a decrease in the efficiency of protein and energy deposition. Decreasing the energy to protein ratio linearly decreased the amount of fat found in the carcass of chicks. It does not appear that, if maximizing carcass leanness is the goal, I have reached the required energy to protein ratio. In contrast, the results indicate that, if growth rate and G/F are the most important criteria, relatively wide energy to protein ratios are tolerated by chicks.

The results of this research indicate that the optimal energy to protein ratio depends on the criteria which is of most importance. The optimum ratio is different whether growth rate, efficiency or carcass composition is most important. The "extra-caloric effect" of fat was similar for tallow and corn oil.

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