Effect of a High Fat Diet Fed Prior to or at Sexual Maturity on Egg Weight[1,2]

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ABSTRACT This study compared the effects of a low fat, high carbohydrate diet with a high fat diet fed prior to or at the onset of egg production on initial egg weight. Commercial egg-type pullets were assigned to one of three dietary regimens: 1) the control (CON), a low fat, high carbohydrate diet, 2) a high fat (HF) diet containing eight parts of fat, and 3) the high carbohydrate diet provided prelay and the high fat diet during the production period (CHO-HF). The carbohydrate prelay and laying diets contained .990 and .943% fat and had a calculated metabolizable energy (ME) value of 2,831 and 2,697 kcal/kg, respectively. The high fat prelay and laying diets contained 8.959 and 8.484% fat with a calculated ME value of 3,202 and 3,032 kcal/kg, respectively. The first 60 eggs produced by each pullet were collected and weighed.

At Egg 60, no significant differences were seen in body weight and abdominal adipose tissue. The CON treatment had a significantly greater liver weight, liver lipid content, and ovary weight than the HF or CHO-HF treatments. The CON and HF treatments had a similar hen-day egg production (HDP). The CHO-HF treatment was slow to adjust to the high fat diet and that may have caused the lower HDP that was seen for this treatment. No indication of a failure to adjust to the high fat diet was noted for the HF treatment. Additionally, a high fat diet resulted in higher egg weights.

This study indicates that when fat was supplemented to the diet prior to the onset of egg production, pullets adjusted to the high fat diet and HDP was not adversely affected.

(*Key words:* fat supplementation, sexual maturity, egg weight, pullets)

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INTRODUCTION

An increase in egg weight occurs when commercial egg-type pullets are fed a high fat diet during the initial stages of egg production (Shutze *et al.*, 1962; Marion and Edwards, 1964; Balnave and Weatherup, 1974). Shutze *et al.* (1962) reported 20-wk-old pullets that received diets containing supplemental corn oil produced significantly larger eggs during the first 6 to 8 wk of egg production than pullets receiving diets with no added corn oil. Weiss and Fisher (1957) fed White Leghorn pullets either a diet containing no supplemental fat or one containing 10% supplemental fat starting at eight wk of age. At 12 and 24 wk of age, body weight of the pullets fed the high fat treatment was significantly greater than that of pullets fed the treatment without fat supplementation. Pullets receiving the high fat treatment started egg production 2 wk earlier than those receiving no added fat. The difference in age at sexual maturity was attributed to the larger body weight. Cunningham and Morrison (1976) fed chicks either a low energy diet (1% added dietary fat) or a high energy diet (4.75% added dietary fat) from 1 day of age until the first egg was produced. Body weights were greater for the pullets fed the high energy treatment than for the pullets fed the low energy treatment from 3 to 12 wk of age. However, no differences in body weight or caloric intake occurred at 18 wk of age.

The stage of sexual development when the feeding of a fat-supplemented diet is initiated is important. No previous studies have evaluated the effects of dietary fat supplementation initiated at different stages of reproductive development. Perhaps a fat-supplemented diet increases initial egg weight by affecting body weight or ovarian development. The purpose of the present study was two-fold. The first objective was to determine the effect of a high fat diet fed prior to production of the first egg on the age and body weight at sexual maturity. The second objective was to evaluate the initial pro-

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ductive performance of pullets that received a high fat diet prior to or at the time that the first egg was produced.

MATERIALS AND METHODS

Forty-eight commercial egg-type pullets (Shaver 288) were obtained at 127 days of age. Birds were housed in individual cages in a temperature (21 C)-controlled room. The lighting regimen (15.5 h light:8.5 h dark) remained constant throughout the study. Pullets were randomly assigned to one of three dietary regimens. The first regimen was a control treatment (CON) in which pullets were fed high carbohydrate diets that contained one part of fat (.990% fat in the prelay diet and .943% fat in the layer diet). In the second regimen, a high fat treatment (HF), pullets received prelay and laying diets that contained eight parts of fat (8.959% fat in the prelay diet and 8.484% fat in the layer diet). In the final treatment, pullets received the high carbohydrate diet (.990% fat) until the first egg was produced and then the high fat diet (8.484% fat) during the production period (CHO-HF).

Diet compositions are shown in Table 1. Soybean meal was the protein source in all diets and upon analysis was found to contain 47.4% protein and 87.5% dry matter. Dextrose was used as the carbohydrate source. Control diets contained 1 part of added vegetable oil to improve their texture. Fat content and the calculated metabolizable energy (ME) content of the diets were .990% and 2,831 kcal/kg for the prelay diet and .943% and 2,697 kcal/kg for the laying diet, respectively. High fat diets were formulated by isocalorically replacing 18.7 parts by weight of dextrose in the carbohydrate diet with 7 parts of added fat. On a parts basis, all diets had the same calorie:nutrient ratio. Consequently, the high fat prelay and laying diets contained 8.959 and 8.484% fat resulting in calculated ME values of 3,202 and 3,032 kcal/kg, respectively. After the first egg was produced by a pullet, the pullet received a layer ration that contained five parts of oyster shell (4.717% of CHO layer diet and 5.302% of HF layer diet).

Body weights were measured on the day that the first egg was produced. All eggs were collected and weighed during the production period. One hen assigned to the CHO-HF treatment never started egg production and was removed from the experiment. Each pullet was weighed and killed in the afternoon of the day that Egg 60 was produced. The weights of the liver, ovary plus ova, and abdominal adipose tissue were determined. Liver lipid was analyzed using the technique described by Hamilton and Garlich (1971). One pullet assigned to the CON treatment and four assigned to the CHO-HF treatment produced eggs sporadically and did not produce 60 eggs. These pullets were killed at 263 days of age. Statistical analyses and correlations were derived by the general linear models (GLM) procedure (Barr *et al.*, 1979). Treatment means were separated using the method of least significant difference. Differences were declared significant at $P \leq .05$.

RESULTS AND DISCUSSION

During the prelay period, feed, protein, and caloric consumption were not significantly different among the treatments (Table 2). Additionally, there were no significant differences in the age when the first egg (Egg 1) was produced or body weight at Egg 1. Cunningham and Morrison (1976) fed diets containing 2,843 to 3,284 kcal ME/kg of feed from 1 day of age until the first egg was produced. Pullets that received the high energy diet consumed less feed than those receiving low energy diet. No differences were seen in caloric intake, age, or body weight when the first egg was produced.

After the onset of lay, feed and caloric consumption, average egg weight and egg production were determined for three production periods consisting of Eggs 1 to 20, 21 to 40 and 41 to 60 (Table 3). During the first production period, daily feed consumption was lower for the CHO-HF treatment than the other treatments; the CHO-HF fed pullets appeared to be slow to adjust to the high fat diet that was fed to them at Egg 1. The caloric and protein consumption of the CHO-HF group was depressed when compared to CON and HF groups' caloric consumption. Previously Waring *et al.* (1968) and Jackson *et al.* (1969) reported that a high fat diet was poorly accepted by pullets and resulted in decreased feed consumption. During the last two production periods in the present study (Table 3), there were no differences in feed consumption between the CHO-HF and HF treatments, which indicates that hens fed the CHO-HF diet eventually adjusted to the high fat diet. During the production of Eggs 41 to 60, hens receiving HF and CHO-HF diets consumed significantly less feed than the CON treatment. Calorie and protein intake amounts were similar among all the treatments for the last two produc-

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TABLE 1. *Composition of the carbohydrate (CHO) and high fat (HF) diets fed before the first egg (prelay) and during the production period*

Ingredients	CHO Diet				HF Diet			
	Prelay		Production		Prelay		Production	
	(parts)	(%)	(parts)	(%)	(parts)	(%)	(parts)	(%)
Soybean meal	33.000	32.673	33.000	31.132	33.000	36.954	33.000	34.999
Dextrose	60.226	59.630	60.226	56.817	41.526	46.502	41.526	44.036
Vitamin premix[1]	.050	.050	.050	.047	.050	.056	.050	.053
Mineral premix[2]	.640	.634	.640	.604	.640	.717	.640	.679
Defluorinated phosphate	2.670	2.644	2.670	2.519	2.670	2.990	2.670	2.831
Calcium carbonate	3.382	3.349	3.382	3.191	3.382	3.787	3.382	3.586
Methionine hydroxy analog[3]	.032	.032	.032	.030	.032	.036	.032	.034
Soybean oil[4]	1.000	.990	1.000	.943	8.000	8.959	8.000	8.484
Oyster shell			5.000	4.717			5.000	5.302
Total parts	101.000	100.001	106.000	100.000	89.300	100.001	94.300	100.000
Metabolizable energy, kcal/kg of feed	2,831		2,697		3,202		3,032	
Protein, %	15.50		14.76		17.53		16.60	

[1] Vitamin mixture supplied in milligrams per kilogram diet: vitamin B_{12}, .06; Riboflavin, 8.8; niacin, 33.1; d-pantothenic acid, 11.0; menadione, 2.0; folic acid, .28; pyridoxine, 1.1; thiamine, 1.1; selenium, .1; D-biotin, .011; and vitamin A, 6,615 IU/kg; vitamin D_3, 3,308 IU/kg; vitamin E, 6.6 IU/kg.

[2] Mineral premix supplied in grams per kilogram diet: NaCl, 4.0; $MgCO_3$, 1.74; $MnSO_4 \cdot H_2O$, .169; $ZnSO_4 \cdot 7H_2O$, .220; $FeSO_4 \cdot H_2O$, .244; $CuSO_4$, .010; $NaIO_3$, 1.75 mg; H_2SeO_3, .164 mg.

[3] DL-Methionine hydroxy analog.

[4] Gallinides Inc., Raleigh, NC; contains .4% ethoxyquin as an antioxidant.

TABLE 2. *Prelay feed, energy, and protein consumption and age and body weight at Egg 1 of pullets fed three dietary regiments (mean ± standard error of the mean)*

Variable	CON[1]	HF[1]	CHO-HF[1]
Feed consumption,[2] g/day	80 ± 3	75 ± 2	79 ± 3
Caloric consumption,[2] kcal/day	226 ± 8	239 ± 8	222 ± 7
Protein consumption,[2] g/day	12.4 ± .4	13.1 ± .4	12.2 ± .4
Body weight, kg	1.66 ± .01	1.72 ± .01	1.73 ± .01
Age at Egg 1, days	159 ± 3	162 ± 2	163 ± 2

[1] CON = Control (low fat, high carbohydrate diet); HF = high fat diet; CHO-HF = high carbohydrate diet until first egg, then high fat diet.

[2] Measured from 127 days of age to Egg 1.

tion periods. This indicates that pullets consuming the high fat diets adjusted feed intake to maintain caloric intake similar to that of the CON treatment.

Fat supplementation prior to the onset of sexual maturity resulted in the highest initial egg weights (Table 3). The average egg weight for Eggs 1 to 20 was significantly greater for the HF treatment that received the high fat diet prior to the onset of production than for the treatments receiving diets with no added fat during the prelay period. These initial high weights resulting from dietary fat supplementation occurred without concomitant lower egg production rates.

Fat supplementation at the first egg production was also influential in producing higher egg weights when compared with effects of the CON diet. The average weight of eggs produced by hens receiving the CHO-HF diet was greater than that of the CON treatment for all three production periods (Table 3). During the second production period, pullets receiving a fat-sup-

TABLE 3. *Daily feed, energy, and protein consumption and egg parameters during three production periods of pullets fed three dietary regimens (mean ± standard error of the mean)*

Production period	Production parameter	CON[1]	HF[1]	CHO-HF[1]
Eggs 1 to 20	N	16	16	15
	Feed consumption, g/day	98 ± 4^{a}	95 ± 3^{a}	83 ± 4^{b}
	Caloric consumption, kcal/day	265 ± 11	287 ± 10	253 ± 13
	Protein consumption, g/day	14.5 ± .6	15.7 ± .6	13.8 ± .7
	Average egg weight, g	50.9 ± .3^{c}	53.9 ± .3^{a}	53.2 ± .3^{b}
	HDP,[2] %	74.7 ± 5.0	79.1 ± 2.8	73.0 ± 4.7
Eggs 21 to 40	N	16	16	15
	Feed consumption, g/day	117 ± 6^{a}	108 ± 5^{ab}	96 ± 4^{b}
	Caloric consumption, kcal/day	315 ± 16	328 ± 15	290 ± 12
	Protein consumption, g/day	17.3 ± .9	18.0 ± .8	15.9 ± .7
	Average egg weight, g	55.1 ± .4^{b}	56.4 ± .3^{a}	56.9 ± .2^{a}
	HDP, %	78.7 ± 3.6^{a}	82.5 ± 3.3^{a}	64.4 ± 4.6^{b}
Eggs 41 to 60	N	14	16	11
	Feed consumption, g/day	128 ± 7^{a}	109 ± 5^{b}	104 ± 6^{b}
	Caloric consumption, kcal/day	346 ± 20	329 ± 15	315 ± 18
	Protein consumption, g/day	19.0 ± 1.1	18.0 ± .8	17.2 ± 1.0
	Average egg weight, g	56.3 ± .3^{c}	57.8 ± .3^{b}	59.0 ± .3^{a}
	HDP, %	82.7 ± 4.9^{ab}	89.4 ± 2.8^{a}	72.5 ± 4.2^{b}

$^{a-c}$Means in rows for each parameter with different superscripts are significantly different ($P \leq .05$).

[1] CON = Control (low fat, high carbohydrate diet); HF = high fat diet; CHO-HF = high carbohydrate diet until first egg, then high fat diet.

[2] Hen-day egg production.

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TABLE 4. *Body weight and tissue and organ parameters at Egg 60 of pullets fed three dietary regimens (mean ± standard error of the mean)*

Parameter	CON[1]	HF[1]	CHO-HF[1]
N	16	16	15
Body weight, kg	1.63 ± .04	1.72 ± .05	1.66 ± .05
Abdominal adipose tissue weight, g	40.6 ± 5.4	55.7 ± 8.0	52.0 ± 6.7
Liver weight, g	57.2 ± 2.8[a]	50.0 ± 1.7[b]	41.0 ± 1.7[c]
Liver lipid, %	47.0 ± 3.1[a]	28.7 ± 2.0[b]	31.3 ± 2.0[b]
Ovary plus ovum weight, g	51.8 ± 1.7[a]	45.0 ± 1.8[b]	42.1 ± 2.0[b]

[a–c]Means in rows for each parameter with different superscripts are significantly different ($P \leq .05$).

[1]CON = Control (low fat, high carbohydrate diet); HF = high fat diet; CHO-HF = high carbohydrate diet until first egg, then high fat diet.

plemented laying ration after being fed a carbohydrate prelay diet had a lower hen-day egg production (HDP) than pullets fed either a carbohydrate or high-fat diet during both the prelay and production period. This decrease in egg production was due to the poor acceptance of the high fat diet by pullets assigned the CHO-HF treatment. This is congruent with findings by Waring *et al.* (1968) who reported that pullets fed high fat diets exhibited a later and lower peak egg production than the control group. They attributed this result to a poor acceptance of the high fat diet. During the last production period in the present study pullets receiving the CHO-HF diet produced eggs of greater weight than pullets fed the HF diet. The HDP was less for the pullets fed CHO-HF diet than those fed the HF diet, which result may be associated with the initial reduction in feed consumption by the CHO-HF treatment.

At Egg 60, body weights were not significantly different among treatments (Table 4). No significant differences were seen among the treatments for the abdominal adipose tissue weight although the HF and CHO-HF treatments had a 27 and 22% greater abdominal adipose tissue weight than the CON treatment, respectively. Ovary and liver weight and the lipid content of the liver were significantly greater for the CON treatment than for the HF or CHO-HF treatments. Previously, Treat *et al.* (1960) and Marion and Edwards (1962) reported that liver weight and lipid content are decreased with corn oil feeding compared with effects of feeding a low fat (1.0%) basal diet. In the present study, the decreased ovary plus ovum weight of pullets in treatments receiving a high fat diet was unexpected, as these treatments produced significantly greater egg weights. Jull (1924) reported that a positive correlation exists between yolk weight and egg weight. If ovum weight is influenced by the ovary plus ovum weight, then the ovary plus ovum weight would be expected to influence egg weight. However, in this study, the number and size of the developing ovum were not determined.

Results of this study show that the age and body weight of pullets at the time the first egg was produced were not affected by feeding a fat-supplemented diet just prior to Egg 1. Throughout the study, a fat-supplemented diet improved egg weight compared with a carbohydrate diet. Egg production was similar for the pullets fed the fat-supplemented or the carbohydrate diets during the prelay and layer periods.

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