Influence of Dietary Protein and Energy on the Performance of Commercial Egg-type Pullets Reared Under Summer Conditions

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ABSTRACT A total of 2400 commercial egg-type pullets was used in three trials to determine the feasibility of using dietary protein, amino acids or energy to increase 20-week body weights of pullets reared under linear, cyclic-temperature environmental conditions common during southeastern United States summers. A 24-hour linear temperature cycle of 24 to 35 to 24°C. and 9 hours of light per day were provided for the duration of the study.

Neither dietary protein nor energy influenced body weights at 20 weeks of age under a high-temperature condition. Furthermore, lysine and methionine plus cystine at levels of 100, 110 or 120% of National Research Council's requirement levels did not influence 20-week body weights under a high-temperature condition. Feed consumption per pullet was directly related to the energy content of the diet; whereas, lysine, methionine plus cystine or total protein did not appear to influence feed consumption. The same spread in body weights was noted at 20 weeks of age as that noted at 12 weeks of age.

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INTRODUCTION

Indications from industry are that egg-type pullets need to weigh at least 1225 grams at 20 weeks of age to sustain maximum egg production during the life span of laying hens. Field reports indicate difficulty in obtaining a 1225 gram pullet at 20 weeks of age under the hot conditions existing during the summer in the southern United States. Creger (1974) noted that for each strain of commercial egg-type pullet a certain weight range is necessary if laying performance is to be optimum. Krueger *et al.* (1976) demonstrated well-fleshed pullets at 20 weeks of age laid an average of 6% more eggs during the laying period than poorly fleshed pullets laid. Preliminary data collected at this laboratory showed that pullets reared in a 21°C. temperature weigh 86 grams more at 20 weeks of age than pullets reared in a 24-hour temperature regime of 24° to 35° to 24°C. The latter temperature would be typical of a spring-hatched and summer-reared group of pullets in the southern United States.

Therefore, indications from industry are that the pullet industry in the southern United States has a problem with the spring-hatched and summer-reared group of pullets in attaining enough body weight at the onset of production for maximum egg production during the laying period. The commonly accepted practice by industry in an attempt to overcome the pullet body weight problem during the summer growing period is to increase protein levels. If increasing protein levels during the summer months alleviated the growing period weight problem, then of course the problem is solved; but, if the pullet weight problem is not solved with higher protein levels during the summer months, then the industry is spending extra money for protein. Evidently some of the southern pullet industry personnel felt they were spending extra money for protein without getting any benefit from additional pullet weight during the growing period in the summer, because they came to us and asked us to conduct the experiment.

Blaylock (1956) reported that White Leghorn pullets from 12 to 20 weeks of age required no more than 12% protein for growth. Berg and Bearse (1958) indicated that growing pullets required not more than 15% protein from 8 to 12 weeks of age, less than 13% protein from 12 to 16 weeks of age and less than 12% protein from 16 to 20 weeks of age. Sunde and Bird (1959) demonstrated that growing pullets need a 20 to 21% protein level diet the first 6 weeks, 15% from 6 to 15 weeks of age, but only about 12% protein from 15 to 20 weeks of age to obtain optimum growth.

Stockland and Blaylock (1974a) found when egg-type replacement pullets were fed a 20% protein ration to 6 weeks of age, protein requirements were 14-14-12% or 16-12-12% protein level sequence fed from 6 to 10, 10 to 14 and 14 to 20 weeks of age, respectively, to maximize 20-week weight and efficiency of feed utilization and to minimize days required to reach 50% egg production. Stockland and Blaylock (1974b) indicated that pullets reared at 29.4°C. require more than 20-16-14-12% protein level sequence during the periods from 0 to 6, 6 to 10, 10 to 14 and 14 to 20 weeks of age, repsectively, but the 20-16-14-12% protein level sequence was adequate for birds reared at 18.3°C. temperature. However, these researchers used a constant temperature rather than a linear cyclic temperature that is common in southeastern United States during hot summer days and warm nights.

Heywang *et al.* (1953) stated that the diet intake of chickens decreases during periods of high environmental temperatures. Because a decrease in total feed intake results in a decrease in the intake of nutrients needed for growth, the dietary level of protein for growing chickens should be higher during hot weather.

Therefore, the literature (Heywang *et al.*, 1953; Stockland and Blaylock, 1974b) states that the industry should increase protein levels during high temperature periods to get increased weight during the growing period. However, it should be noted that in Experiment 1 of Stockland and Blaylock's (1974b) work that, under high temperature conditions at 20 weeks of age, strain A responded to the higher protein regime by being 50 grams heavier; strain B responded to the higher protein regime by weighing 50 grams less; strain C responded to the higher protein regime by being 30 grams heavier; and strain D responded to the higher protein regime by being 10 grams heavier. These data in Experiment 1 show an average weight increase of only 10 grams across all strains from the high-protein regime as compared to the low-protein regime at 20 weeks of age under high temperature conditions.

In Experiment 2 of Stockland and Blaylock's (1974b) work, under high temperature conditions at 20 weeks of age, a 90 gram increase was noted for birds reared under the high protein regime. The data, however, were not reported for birds response at each protein level change (6-10 weeks, 10-14 weeks and 14-20 weeks) and the weight response could have occurred during the 6- to 14-week period, which would have been expected for the weight difference to carry through to 20 weeks of age. The dietary protein levels used in Experiment 2 by Stockland and Blaylock (1974b) were 20-16-14-12 and 20-20.8-18.2-15.6 from 0 to 6, 6 to 10, 10 to 14 and 14 to 20 weeks of age.

Stockland and Blaylock (1974b) show that high environmental temperature during the growing period significantly reduces 20-week body weight when compared to pullets reared under a moderate temperature regime. The objective of this study was to determine if protein and energy levels above those currently being used by some of the pullet industry personnel could be used to increase 20-week body weight under high temperature or summer rearing conditions in the southern United States.

EXPERIMENTAL PROCEDURE

A total of 2400 commercial egg-type pullets (Hyline W-36) was used in three trials to determine the effect of dietary protein, amino acids and energy on 12- to 20-week-old pullet performance reared under summer conditions. All pullets were floor-reared as a group from 1 day to 12 weeks of age on a common diet by commercially accepted practices.

In trials 1 and 2, 20 pullets per cage were placed in each of 36 pullet-rearing cages (51 × 122 × 35 cm. high) at 12 weeks of age. In trial 3, 960 pullets were divided on the basis of 12-week body weights into equal number groups at 12 weeks of age consisting of 50% below the median and 50% above the median weight. Each small- and large-pullet group was divided into 24 test groups consisting of 20 birds each and placed in pullet-rearing cages (51 × 122 × 35 cm. high). The small-pullet group had an average weight of 644 grams, and the large-pullet group had an average weight of 805 grams at 12 weeks of age. Within each small- and large-pullet group, equal weights were obtained in all test groups.

In trials 1 and 2, four groups of 20 pullets each were fed each experimental diet containing lysine and methionine plus cystine levels equal to 100, 110 or 120% of requirement (based on megacalories) recommended by the National Research Council (N.R.C., 1971) with energy levels of 2756, 2921 or 3086 kilocalories metabolizable energy (M.E.) per kilogram of feed (Table 1). Four small- and four large-pullet groups of 20 pullets each in trial 3 were fed

TABLE 1.—*Composition and calculated analyses of diets (Trials 1 and 2)*

Ingredient	Diet 1	2	3	4	5	6	7	8	9
Corn	67.53	66.02	64.65	72.47	70.95	69.41	77.29	75.67	74.06
Soybean meal (49% protein)	13.58	15.84	17.92	14.45	16.74	19.03	15.50	17.93	20.36
Dicalcium phosphate (22% Ca – 18.5% P)	1.98	1.97	1.95	1.96	1.94	1.93	1.93	1.92	1.90
Limestone	1.04	1.04	1.04	1.06	1.06	1.07	1.08	1.08	1.08
Salt	.25	.25	.25	.25	.25	.25	.25	.25	.25
Premix[1]	.25	.25	.25	.25	.25	.25	.25	.25	.25
Animal fat	.50	.50	.50	.50	.50	.50	.50	.50	.50
MHA-Ca, 93%	...	...	...	...	...	.01	...	...	...
Rice mill feed (6% protein)	14.87	14.13	13.44	9.06	8.31	7.55	3.20	2.40	1.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis:									
Crude protein, %	13.49	14.42	15.28	14.00	14.98	15.89	14.51	15.59	16.59
Metabolizable energy, Kcal./kg.	2756	2756	2756	2921	2921	2921	3086	3086	3086
Lysine, %	.625	.690	.750	.660	.726	.792	.700	.770	.840
Methionine + Cystine, %	.454	.481	.510	.482	.519	.540	.511	.540	.571
Calcium, %	.88	.88	.88	.88	.88	.88	.88	.88	.88
Avail. phos., %	.45	.45	.45	.45	.45	.45	.45	.45	.45

[1] The premix furnished the following amounts of other ingredients per kilogram of feed: Vitamin A, 5512 I. U.; vitamin D_3, 1653 I.C.U.; vitamin E, 1.1 I.U.; riboflavin, 4.4 mg.; niacin, 27.6 mg.; d-pantothenic acid, 8.8 mg.; folic acid, 137.8 mcg.; vitamin B_{12} 8.8 mcg.; choline chloride, 496 mg.; ethoxyquin, 55 mg.; menadione sodium bisulfite, 1.4 mg.; manganese 66.25 mg.; zinc, 44 mg.; iodine, 1.25 mg.; iron, 20 mg.; copper, 2 mg. and cobalt, 0.2 mg.

TABLE 2.—*Composition and calculated analyses of diets.* *(Trial 3)*

Ingredient	Protein (%)—Energy (Kcal.M.E./kg.) 14-2700	20-2700	14-2900	20-2900	14-3100	20-3100
Yellow corn	64.88	61.16	71.96	66.59	79.17	72.38
Soybean meal (49% protein)	12.36	17.83	11.93	19.86	11.49	21.54
Menhaden fish meal	2.00	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate (22% Ca-18.5% P)	1.38	1.40	1.36	1.36	1.34	1.33
Limestone	0.87	0.88	0.89	0.91	0.92	.93
Salt	0.25	0.25	0.25	0.25	0.25	.25
Premix[1]	0.25	0.25	0.25	0.25	0.25	.25
MHA-Ca (93%)	0.20	0.12	0.18	0.07	0.16	.02
Animal fat	0.50	0.50	0.50	0.50	0.50	.50
L-lysine•HC1(98%)	0.37	0.17	0.38	0.08	0.37	...
Rice mill feed, 6% protein	16.94	15.44	10.30	8.13	3.55	.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis:						
Metabolizable energy, Kcal./kg.	2700	2700	2900	2900	3100	3100
Crude protein, %	14	20	14	20	14	20
Lysine, %[2]	.96	.96	.96	.96	.96	.96
Meth. + Cyst., %[2]	.65	.65	.65	.65	.65	.65
Calcium, %	.80	.80	.80	.80	.80	.80
Avail. phos., %	.40	.40	.40	.40	.40	.40

[1] The premix furnished the following amounts of other ingredients per kilogram of feed: Vitamin A, 5512 I. U.; vitamin D_3, 1653 I.C.U.; vitamin E, 1.1 I.U.; riboflavin, 4.4 mg.; niacin, 27.6 mg.; d-pantothenic acid, 8.8 mg.; folic acid, 137.8 mcg.; vitamin B_{12} 8.8 mcg.; choline chloride, 496 mg.; ethoxyquin, 55 mg.; menadione sodium bisulfite, 1.4 mg.; manganese 66.25 mg.; zinc, 44 mg.; iodine, 1.25 mg.; iron, 20 mg.; copper, 2 mg. and cobalt, 0.2 mg.

[2] Approximately 30% additional lysine and methionine plus cystine above the National Research Council (1971) requirement levels were added to balance all diets in essential amino acids.

diets containing either 14 or 20% protein with energy levels of 2700, 2900 or 3100 kcal. M.E. per kg. of feed (Table 2). All diets were calculated to meet N.R.C. (1971) requirement levels for all essential nutrients except protein and energy.

The temperature regime used for the 12- to 20-week period was a 24-hour linear cycle of 24 to 35 to 24°C. Nine hours of light per day at an average intensity of 6 lux at pullet level were provided for the duration of the study. Feed and water were provided *ad libitum.* Trough-type hand feeders and three Hart cup waterers* were provided for each cage. Mortality was recorded as it occurred. Body weights were obtained when pullets were 12 and 20 weeks old, and feed consumption was checked for the 12- to 20-week test period.

A factorially arranged randomized complete block design was used to analyze data. Data were examined statistically by the analysis of variance (Steel and Torrie, 1960). Duncan's (1955) new multiple range test was used to separate significant differences between means. All statements of significant differences refer to the 5% level of probability.

RESULTS AND DISCUSSION

Trials 1 and 2. Effect of dietary energy and amino acids on performance of commercial egg-type pullets during the 12- to 20-week growing period is shown in Table 3. Pullet body weights at 12 weeks of age averaged 792 grams in Trial 1 and 837 grams in Trial 2. Dietary levels of lysine and methionine plus cystine did not significantly affect body weights in either trial. In Trial 1, quantity of feed consumed per pullet was not significantly affected by dietary lysine and methionine plus cystine. However, in Trial 2, feed consumption was significantly lower on diets containing 110% lysine and methionine plus cystine of N.R.C. (1971) requirement level than on diets containing 100% of N.R.C. (1971) requirement levels.

Body weights were not significantly affected by energy level; however, the quantity of feed consumed per pullet decreased when pullets were fed 3086 kilocalories of metabolizable energy (M.E.) per kilogram of diet in Trials 1 and 2. Total kilocalories of M.E. consumed per pullet at 20 weeks of age were 7,625 for diets containing 2756 kcal. of M.E. per kg. of feed, 7,994 for diets containing 2921 kcal. of M.E. per kg. of feed and 8,085 for diets containing 3086 kcal. of M.E. per kg. of feed. Pullets receiving the lowest energy diet used energy more efficiently. Mortality was not significantly altered by dietary energy or protein.

Blaylock (1956), Berg and Bearse (1958) and Sunde and Bird (1959) concluded that 12 to 15% dietary protein is required during the 12- to 20-week growing period to maximize egg-type pullet weights at 20 weeks of age. Stockland and Blaylock (1974a) found that egg-type replacement pullets when fed a 20% protein ration to 6 weeks of age require a 14-14-12% or 16-12-12% protein level sequence fed from 6 to 10, 10 to 14 and 14 to 20 weeks of age, respectively, to maximize 20-week body weight and feed efficiency and to minimize days required to reach 50% egg production. However, Stockland and Blaylock (1974b) indicated that birds reared at 29.4° C. require no more than 20-16-14-12% protein levels during the periods from 0 to 6, 6 to 10, 10 to 14 and 14 to 20 weeks of age, respectively; whereas, the 20-16-14-12% protein levels sequence were adequate for birds reared at 18.3° C. Therefore, one can conclude from data in Trials 1 and 2 that additional dietary energy and amino acids above N.R.C. (1971) requirement levels do not result in additional weight gains.

Because Stockland and Blaylock (1974b) concluded that more than 12% protein is required to maximize weight at a temperature of 29.4° C. and because results of the first two trials indicate that additional amino acids above N.R.C. (1971) requirement levels did not result in weight gains, a third trial was conducted to determine the effect of excess levels of protein on 20-week body weights.

Trial 3. Results of Trial 3 are shown in Table 4. Twenty-week results indicate that body weights of pullets were not affected by either dietary energy or protein reared under summer conditions of 24 to 35 to 24° C. linear cyclic temperatures. These results do not substantiate data reported by Stockland and Blaylock (1974b) who concluded that pullets reared at 29.4°C.

*Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply its approval to the exclusion of other products that may be suitable.

TABLE 3.—*Effect of dietary energy and amino acids on pullet performance for the 12- to 20-week growing period (Trials 1 and 2)*

Metabolizable energy, kcal./kg.	12- to 20-week results: Body weight, g. — Amino acid (% req.)[1] 100	110	120	Mean[2]	Feed consumption, kg./bird — Amino acid (% req.)[1] 100	110	120	Mean[2]
Trial 1								
2756	1111	1129	1136	1125a	2.81	2.96	2.93	2.90b
2921	1142	1142	1132	1139a	2.87	2.85	2.78	2.83b
3086	1112	1142	1138	1131a	2.72	2.73	2.63	2.69a
Mean[2]	1122a	1138a	1135a		2.80a	2.85a	2.78a	
Trial 2								
2756	1212	1215	1198	1208a	2.74	2.56	2.64	2.65b
2921	1205	1226	1216	1216a	2.70	2.61	2.64	2.65b
3086	1220	1216	1200	1212a	2.53	2.55	2.58	2.55a
Mean[2]	1212a	1219a	1205a		2.66b	2.57a	2.62ab	

[1] Percent of requirement for lysine and methionine plus cystine recommended by National Research Council (N.R.C., 1971).

[2] Means within a column grouping or row and without a common superscript are significantly different ($P<0.05$).

TABLE 4.—*Effect of dietary energy and protein on pullet performance for the 12-20-week growing period (Trial 3)*

Pullet size[1]	Metabolizable energy, kcal./kg.	12-20 week results: Body weight, g. Dietary protein, % 14	20	Mean[2]	Feed consumption, kg./bird Dietary protein, % 14	20	Mean[2]
Small	2700	1174	1162	1168b	2.98	3.02	3.00a
Small	2900	1190	1185	1188b	2.90	2.94	2.92a
Small	3100	1190	1162	1176b	2.92	2.83	2.88a
Mean[3]		1185	1170		2.93	2.93	
Large	2700	1346	1346	1346a	3.28	3.25	3.26b
Large	2900	1330	1318	1324a	3.16	3.25	3.20b
Large	3100	1327	1363	1345a	3.07	2.98	3.02a
Mean[3]		1334	1342		3.17	3.16	

[1] Pullet size was determined when the pullets were 12 weeks old by dividing pullets into two groups consisting of 50% below and 50% above the median weight.

[2] Means within a column and without a common superscript are significantly different ($P<0.05$).

[3] No significant differences in body weight or feed consumption resulting from dietary protein.

constant temperature require more than 12% protein between 14 and 20 weeks of age. However, improvements in 20-week pullet body weights with additional protein reported by Stockland and Blaylock (1974b) could have occurred between 6 and 14 weeks of age, which could carry over to 20 weeks of age, because diets were not standardized between 6 and 14 weeks. In this study diets were standardized between 0 and 12 weeks of age and then placed on dietary regimes.

In Trial 3 small pullets gained approximately the same weight from 12 to 20 weeks as large pullets gained. Additional energy did no alter the difference in body weights. Trial 3 data show no significant differences in feed consumption per small pullet at 20 weeks of age with varying energy levels. However, the feed consumption per large pullet was significantly lower with 3100 kcal. of M.E. per kg. of feed than with either 2900 or 2700 kcal. Dietary protein had no significant effect on feed consumption per pullet.

Results of this study indicate that dietary protein, amino acids or energy above the levels recommended by N.R.C. (1971), Blaylock (1956), Berg and Bearse (1958), Sunde and Bird (1950) or Stockland and Blaylock (1974a) could not be used to increase body weights under summer conditions. Although Stockland and Blaylock (1974b) indicated that more than 12% protein is required for replacement pullets under high environmental temperatures when compared to lower temperatures during the latter portion of the growing period, results of this study do not substantiate these findings.

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