Effects of Dietary Nutrient Density on Broiler Performance at Low and Moderate Environmental Temperatures

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ABSTRACT Three broiler finishing rations with calculated metabolizable energy values (ME) of 3175, 3250, and 3325 kcal/kg and constant lysine and sulfur-bearing amino acid:energy ratios were evaluated at two environmental temperatures. Broiler chickens were reared from 3 to 7 weeks in either an 18.3 or 26.7 C temperature. At the 18.3 C temperature, 7-week body weights increased linearly 3.1% as energy level increased from lowest to highest level. Feed:gain ratio decreased linearly 5.0% as energy level increased from lowest to highest.

At the 26.7 C temperature, no significant differences were found in 7-week body weights due to energy level of the diet. Feed:gain ratio decreased 3.2% as energy level increased from lowest to highest, but the response was not linear.

Energy intake increased as dietary energy was increased in the cool temperature; energy intake was less in the warm temperature and did not change appreciably as dietary energy changed. Because lysine and methionine plus cystine were tied to dietary energy by a fixed ratio, the pattern for intake of these amino acids was the same as for energy. It appears that the procedures used to formulate the diets do not give uniform results for the range of environmental temperatures and energy levels tested.

(*Key words:* dietary energy, broiler growth, feed efficiency, and environmental temperature)

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INTRODUCTION

Extensive research has been conducted over the years on the effects of dietary energy levels and energy:protein ratios on broiler chicken performance. Over the past 30 years there has been a dramatic increase in broiler growth rate, a significant decrease in the feed:gain ratio, and a general increase in the dietary energy levels used. Hill and Dansky (1954) found that maximum growth at low dietary energy levels was made possible by marked increases in feed consumption. They concluded that the rate of feed consumption was determined primarily by the energy level of the ration.

Adams *et al.* (1962) measured the effects of two energy levels (2830 and 3300 kcal ME/kg) when broilers were reared at two temperatures (21 and 32 C) and attempted to offset the reduced growth rate caused by high temperature with increased energy, protein, or mineral levels. They concluded that the deleterious effects of the 32 C temperature could not be offset by increasing energy, protein, or minerals.

Dale and Fuller (1980) compared two energy levels, 3190 ad 3530 kcal ME/kg, with constant calorie:protein ratios in a cool (14 C) and hot (31 C) environment. Weight gain, 4 to 7 weeks, was 5.4% higher, and feed:gain was 12.4% lower for the high-energy diet in the cool environment. In the hot environment, the high-energy diet produced a 2.2% increase in weight gain and a 6.3% decrease in feed:gain compared to the low-energy diet. However, Olomu and Offiong (1980) concluded that for broilers reared in the 24 to 27 C range, energy levels of the ration had little effect on productive performance.

Bacon *et al.* (1981) evaluated the effects of diets with three energy levels ranging from 3090 to 3310 kcal ME/kg on broilers grown in a cool and a warmer environment. They concluded that energy level did not significantly affect body weights at 49 days in either environment; the average temperatures for both environments were in the 23 to 26 C range with only about 2.3 C difference between the two environments.

Hurwitz *et al.* (1980) developed models to determine energy requirements for maintenance and growth and to calculate the protein requirements from growth curves dependent upon environmental temperature. Using an experimental diet with 3100 kcal ME/kg and

TABLE 1. *Experimental diets used for the 3 to 4-week growing period for broilers*

Ingredient	Diet number 1	2	3
Yellow corn	61.67	58.50	55.39
Soybean meal (45.5)	29.03	30.13	31.19
Animal fat (7716 kcal/kg)	5.40	7.44	9.48
Dicalcium phosphate (18.5, 22)	1.83	1.84	1.84
Limestone	.99	.98	.97
Iodized salt	.48	.49	.49
Broiler trace element premix[a]	.25	.25	.25
MHA-Ca, 93%	.25	.27	.29
Coban (.052 g/kg)	.10	.10	.10
Calculated analysis			
Crude protein, %	18.51	18.74	18.95
ME, kcal/kg	3175	3250	3325
Lysine, %	.98	1.01	1.03
Meth + cystine, %	.81	.83	.85
Calcium, %	.90	.90	.90
Available phosphorus, %	.45	.45	.45

[a]The broiler premix furnished the following amounts of other ingredients per kilogram of feed: vitamin A, retinyl acetate, gelatin coated, 6614 IU; vitamin D_3, 1654 ICU; vitamin E, DL-alpha-tocopherol acetate, 2.2 IU; riboflavin, 4.4 mg; niacin, 27.6 mg; d-pantothenic acid, 8.8 mg; folic acid, 275.6 μg; vitamin B_{12}, 8.8 μg; choline chloride, 551 mg; ethoyquin, 55 mg; menadione sodium bisulfite complex, 2.8 mg or menadione sodium bisulfite 1.7 mg; pyridoxine, .55 mg; manganese (oxide form), 66.25 mg; zinc (oxide form), 44 mg; iodine, 1.25 mg; iron (in sulfate form), 20 mg; and copper (in sulfate form), 2 mg.

19.4% protein, weight gain for chickens was maximized in the 12 to 20 C range and decreased linearly over the 20 to 34 C range. Maintenance energy requirements were minimized at about 28 C and increased at both higher and lower temperatures. Feed efficiency was maximized in the 24 to 28 C range and lower at both higher and lower temperatures.

The objective of this research was to determine the productive response of broiler chickens to changes in dietary energy level at two environmental temperatures. The environmental temperatures were selected to be representative of the southeastern U. S. winter growing conditions and the warmer season of the year with the exception of the three hottest months (June, July, and August).

EXPERIMENTAL PROCEDURE

Commercial broiler chicks (Arbor Acre × Peterson) and the following vaccination procedures were used: Marek's, Newcastle, and bronchitis at 1 day of age and infectious bursal disease at 8 days. In each experiment, 80 day-old chicks, 40 of each sex, were placed in each of 24 (1.5- by 3.7 m) pens in an environmentally controlled house. The house was divided into two sections, each capable of ± 1 C temperature control.

The chicks were brooded for 21 days using warm-room brooding where temperature started at 29 C and was decreased to 21 C over the 21-day period. A starter ration calculated to contain 22.3% protein and 3200 kcal ME/kg was fed. Continuous light at 75 lx was used for the first 9 days and 7.5 lx thereafter.

At 21 days of age, each of the three diets shown on Table 1 was started in three pens in both sections of the house. The lysine:energy ratio was held constant at .31% lysine/Mcal (kg),[1] with methionine plus cystine at 83% of lysine. One section was maintained at 18.3 C and the other section at 26.7 C for the next 4 weeks. At 7 weeks of age, the birds were

[1]Units commonly used are .68% lysine/Mcal (lb).

weighed and feed consumption determined. Two experiments were conducted using the 18.3 and 26.7 C temperatures, and a third was conducted using only 26.7 C.

A completely randomized block design was used in each experiment. Data were examined statistically by the analysis of variance (Steel and Torrie, 1960). Duncan's (1955) new multiple range test was used to determine significant differences between means. All statements of significance refer to the 5% level of probability.

RESULTS AND DISCUSSION

The 7-week body weights for the two temperatures and three dietary energy levels are shown in Table 2. When the broilers were reared in an 18.3 C temperature, both male and female weights increased as dietary energy level increased; with sexes combined, weights increased 3.1% from the lowest to highest energy level.

At the 26.7 C temperature, there was no significant response to dietary energy level for either males or females (Table 2).

The 0 to 7 week feed:gain ratios are shown in Table 3. For 18.3 C temperature, there was a linear response over the three energy levels tested; the change was 5.0% as energy level changed +4.7%.

For the 26.7 C temperature, the change in the feed conversion between the two lower energy levels was about the same as that for 18.3 C, but the change between the two higher energy levels was less at 26.7 C than for 18.3 C. The feed conversion for the 3325 kcal ME/kg energy level was slightly higher for 26.7 C than for 18.3 C, which was an unexpected result. For this reason, three trials were conducted at 26.7 C; results for all three trials were consistent.

Table 4 gives the calculated energy and lysine intake during the 3 to 7-week test period, along with measures of energy and lysine utilization. Although there was a trend to increased total energy intake as dietary energy was increased at 18.3 C that did not occur at 26.7 C, the obvious difference was in total

TABLE 2. *Seven-week weights for broiler chickens grown at two environmental temperatures using diets with three energy levels*

Diet	Dietary energy,	18.3 C[1] M	18.3 C[1] F	18.3 C[1] (M + F)/2	26.7 C[1] M	26.7 C[1] F	26.7 C[1] (M + F)/2
	(kcal ME/kg)	(g)					
1	3175	2038^{b}	1663^{d}	1851	1974^{a}	1650^{b}	1813
2	3250	2063^{ab}	1710^{c}	1887	1984^{a}	1647^{b}	1816
3	3325	2091^{a}	1729^{c}	1910	1978^{a}	1637^{b}	1807

^{a,b,c,d}For each sex, weights with the same letter are not significantly different (P>.05).

[1] Temperature, 3 to 7 weeks.

TABLE 3. *Feed:gain ratios for the 0 to 7-week period for broiler chickens grown at two environmental temperatures using diets with three energy levels*

Diet	Dietary energy	18.3 C Feed/gain	26.7 C Feed/gain
1	3175	2.016^{a}	1.984^{a}
2	3250	1.964^{b}	1.940^{b}
3	3325	1.915^{c}	1.919^{b}

^{a,b,c}Numbers with the same letter are not significantly different (P>.05).

[1] Temperature, 3 to 7 weeks.

TABLE 4. *Calculated energy and lysine intakes for the 3 to 7-week growing period for broiler chickens grown in two environmental temperatures with three dietary energy levels and constant lysine and methionine plus cystine to energy ratios*

ME	Weight gain	Feed consumption	Feed/gain	Energy intake		Lysine intake	BW/lysine
(kcal/kg)	(g)			(kcal)	(per g BW[2])	(g)	(g/g)
	18.3 C[1]						
3175	1354	2985	2.21	9477	(7.00)	29.3	46.2
3250	1390	2960	2.13	9620	(6.92)	29.9	46.5
3325	1413	2912	2.06	9682	(6.85)	30.0	47.1
	26.7 C[1]						
3175	1315	2850	2.17	9049	(6.88)	27.9	47.1
3250	1319	2777	2.11	9025	(6.84)	28.0	47.1
3325	1311	2723	2.08	9054	(6.91)	28.0	46.8

[1] Temperature, 3 to 7 weeks.

[2] Body weight.

energy intake between the two temperatures. Because the lysine (and methionine plus cystine) levels were related to the energy levels by a fixed ratio, the decrease in energy intake at 26.7 C resulted in a corresponding decrease in lysine (and methionine plus cystine). The question that arises is: what growth response to dietary energy level would be obtained at 26.7 C if the lysine:energy ratio is increased so that the lysine intake at 26.7 C would be the same as at 18.3 C?

These results suggest that the procedure used to formulate the diets as described does not produce uniform results for the range of dietary energy levels tested for the full range of temperatures expected in broiler production.

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