Br. J. Nutr. (1977), **40**, 311

Environmental temperature and choice feeding of the broiler

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(*Received* 29 *June* 1977 – *Accepted* 19 *October* 1977)

1. Broilers were kept under environmental temperature regimens of 16, 21, 26 or 31° and given, 22–57 d of age, either a complete diet or free-choice of whole wheat and a higher-protein food containing either 252 or 516 g crude protein (nitrogen × 6.25)/kg.

2. Broilers maintained at 16 and 21° consumed food at a significantly higher rate than those kept at 26° and the latter had a significantly higher food intake rate than broilers kept at 31°, for each feeding treatment. Compared with 21° the 57 d body-weight of broilers kept at 26° and 31° was significantly reduced.

3. When kept under the 16, 21, 26 and 31° regimens, the amount of whole wheat in the food consumed by the broilers choice-fed with wheat and the 252 g crude protein/kg food was 56, 55, 48 and 46% respectively. The corresponding values for the broilers on the second choice-feeding treatment were 80, 76, 79 and 72%.

4. Except for a single instance the choice-fed broilers grew at a significantly slower rate than broilers given the complete diet.

Cowan & Michie (1978*a*) reported a study in which broilers were offered a free-choice of whole wheat and a higher-protein food containing either 250 or 515 g crude protein (nitrogen × 6·25)/kg. The broiler apparently balances its intake of these foods well. The dietary energy intake of animals changes with environmental temperature (e.g. Vohra, Wilson & Siopes, 1975). When allowed to self-select from suitable protein and energy foods the domestic rat and mouse appear able to match their dietary energy and protein requirement under different environmental temperatures (Donhoffer & Vonotsky, 1947; Leshner, Collier & Squibb, 1971; Musten, Peace & Anderson, 1974). The present experiment was designed to evaluate the choice-feeding performance of the broiler kept under environmental temperature regimens of 16, 21, 26 or 31°.

EXPERIMENTAL

The 16° temperature regimen was started at 31° when the broilers were housed at 1 d old. The temperature was lowered by 1° on alternate days: 30° at 3 d old, 29° at 5 d old...20° at 23 d old, after which the temperature was dropped 1° every day until at 27 d old the temperature was 16°. This temperature was maintained until the end of the experiment at 57 d old. The 21 and 26° temperature regimens were established in the same way as the 16° temperature regimen, until the appropriate temperature was reached and maintained. The 31° temperature regimen was maintained at 31° from 1 d old.

Composition of the foods used is given in Table 1. Diets nos 2 and 3 were formulated by omitting respectively 500 g wheat/kg and all the wheat and maize from the specification of diet no. 1. The three feeding treatments were the 'finisher' diet (diet no. 1) with no choice, free-choice whole wheat and diet no. 2 and free-choice whole wheat and diet no. 3. Diets nos 1, 2 and 3 were fed in pellet form (3·175 mm pellet).

Ross 1 female broilers were used. The birds were initially housed in the top two tiers of a three-tier battery block in each of eight controlled-environment rooms and given 'starter' crumbs (50% wheat, 25% maize) containing, by calculation, 205 g crude protein and 11·99 MJ metabolizable energy (ME)/kg. Temperature regimens were randomly assigned to individual rooms, two rooms per regimen.

Table 1. *Composition of the experimental foods*

Ingredients (g/kg)	Complete diet (diet no. 1)	Diet no. 2	Diet no. 3
Ground wheat	715	430	—
Ground maize	100	200	—
White fish meal	58·3	116·7	315·3
Meat-and-bone meal	58·3	116·7	315·3
Soya-bean meal	58·3	116·7	315·3
DL-methionine	0·41	0·81	2·20
L-lysine hydrochloride	1·0	2·0	5·4
Sodium chloride	0·5	1·0	2·7
Ground limestone	3·1	6·2	16·8
Vitamin-mineral supplement†	5·0	10·0	27·0
By calculation‡			
Crude protein (nitrogen × 6·25) (g/kg)	178	252	516
ME (MJ/kg)	11·90	11·62	10·12
Determined analysis			
Crude protein (g/kg)§	183	241	470

ME, metabolizable energy.

† Standard broiler finisher supplement (Cowan & Michie, 1978*a*).

‡ Based on values from published tables (Bolton & Blair, 1974; De Groote, 1974 for synthetic amino acids). Whole wheat, the alternative food for the free-choice treatments, was considered to contain 104 g crude protein and 12.18 MJ ME/kg (Bolton & Blair, 1974).

§ The mean of thirteen (diet no. 1), seven (diet no. 2) and six (diet no. 3) samples.

At 22 d of age the broilers in each room were distributed amongst the cages of each tier in that room, twenty-six birds per cage. Six cages per room were randomly assigned to the three feeding treatments of the present experiment, two cages per room per feeding treatment. The cages were 'through' rearing cages (1·2 m × 0·9 m) with a food trough along each long side. A 'nipple' water line was present parallel to and half-way between the food troughs. For the choice-feeding treatments the whole wheat was placed in one trough and the higher-protein food (diets nos 2 or 3) placed in the opposite trough. The position of the foods was balanced between the two replicates in each room. Cages receiving the complete diet, diet no. 1, received it in both troughs. All foods were supplied *ad lib.* Regulated quantities of flint grit were supplied during both early rearing and from 22 d; the amount per cage being provided as two approximately equal portions, one portion per food trough. The broilers were maintained under continuous lighting from 1 d old and weighed at 22 and 57 d of age.

The average rate of growth, food intake, whole-wheat intake and higher-protein food (diets nos 2 or 3) intake per bird was determined for each cage for the period 22 to 57 d of age. Results were statistically analysed by analysis of variance. The data from birds which received diet no. 1 were also used in the analysis of a separate experiment to investigate the feeding of diets with increased levels of protein at different temperatures (Cowan & Michie, 1978*b*).

RESULTS

The treatment means and results of the statistical analyses are shown in Tables 2 and 3.

Growth rate. Broilers which received the complete diet grew at a significantly faster rate than the choice-fed broilers for the 16, 21 and 26° temperature regimens. There was no significant difference in growth rate between the complete diet and the whole-wheat diet no. 2 feeding treatment for the 31° temperature regimen. For each feeding treatment broilers

Table 2. *Treatment means and results of the statistical analyses for the rate of growth and food intake (g/d per bird) 22–57 d, body-weight at 57 d (kg/bird) and mortality (%) 22–57 d, of broilers given different environmental temperatures and feeding treatments*

Temperature regimen†	Feeding treatment‡	Growth	Food intake	57 d§ body-wt	Mortality††
16°	Complete diet	44·6	111·7	1·992	2·0
	Whole wheat and diet no. 2	42·7	109·7	1·919	1·9
	Whole wheat and diet no. 3	38·8	99·8	1·777	1·9
21°	Complete diet	43·1	106·9	1·935	0
	Whole wheat and diet no. 2	40·7	104·1	1·852	1·0
	Whole wheat and diet no. 3	38·9	97·3	1·779	0
26°	Complete diet	39·5	93·4	1·795	2·9
	Whole wheat and diet no. 2	37·3	89·3	1·726	0
	Whole wheat and diet no. 3	36·8	87·7	1·696	1·9
31°	Complete diet	30·9	77·4	1·454	1·0
	Whole wheat and diet no. 2	30·0	75·4	1·430	1·9
	Whole wheat and diet no. 3	28·5	69·7	1·370	1·9
Main effect‖	Temperature regimen	***	***	***	NS
	Feeding treatment	***	***	***	NS
Critical difference¶ ($P < 0·05$)	1	1·9	5·3	0·067	2·8
	2	2·2	7·6	0·082	4·4

NS, not significant; *** $P < 0·001$.

† For details, see p. 311.

‡ For details, see Table 1.

§ 22 d body-weight (kg/bird): 16° 0·424, 21° 0·424, 26° 0·414, 31° 0·375; critical difference 0·037 ($P < 0·05$).

‖ The interactions were not significant.

¶ 1, Between feeding treatments for same temperature regimen; 2, between the same or different feeding treatments for different temperature regimens.

†† Including culls.

kept at 16, 21 and 26° grew significantly faster than those kept at 31°. Broilers on the complete diet and the whole-wheat diet no. 2 feeding treatment grew significantly faster at 21° compared with 26° (Table 2).

Food intake. Birds on the complete diet consumed food at a significantly higher rate than those on the whole-wheat and diet no. 3 free-choice feeding treatment, for each temperature treatment. Broilers kept at 16 and 21° consumed food at a significantly higher rate than those kept at 26° which, in turn, had a significantly higher food intake rate than those kept at 31° for each feeding treatment (Table 2).

Whole wheat and higher-protein food intake. Broilers which received free-choice whole wheat with diet no. 2 consumed the whole wheat at a significantly lower rate and the higher-protein food at a significantly higher rate than the broilers given whole wheat and diet no. 3, for each temperature regimen. For the broilers which received whole wheat and diet no. 2 those kept at 16 and 21° consumed whole wheat at a significantly higher rate than those kept at 26° which, in turn, consumed whole wheat at a significantly higher rate than those kept at 31°. For the broilers offered whole wheat and diet no. 3 those kept at 16° had a significantly higher whole-wheat intake rate than those kept at 26° while those at 21 and 26° consumed whole wheat at a significantly higher rate than the broilers kept at 31°. Differences in the rate of consumption of the higher-protein food between temperature regimens were not significant for broilers fed on whole wheat and diet no. 3 (Table 3).

Table 3. *Treatment means and results of the statistical analyses for the rate of whole-wheat (g), higher-protein food (g) (diet no. 2 or 3), protein (g) and metabolizable energy (ME) (MJ) intake (/bird per d) 22–57 d for broilers given different environmental temperatures and feeding treatments*

Temperature regimen†	Feeding treatment‡	Whole wheat	Higher-protein food	Protein§	ME§
16°	Complete diet	—	—	19·9	1·329
	Whole wheat and diet no. 2	60·9	48·8	18·6	1·309
	Whole wheat and diet no. 3	80·3	19·6	18·4	1·175
21°	Complete diet	—	—	19·0	1·272
	Whole wheat and diet no. 2	56·9	47·2	17·8	1·242
	Whole wheat and diet no. 3	74·2	23·1	19·7	1·137
26°	Complete diet	—	—	16·6	1·112
	Whole wheat and diet no. 2	42·9	46·4	16·2	1·062
	Whole wheat and diet no. 3	69·2	18·4	16.7	1·030
31°	Complete diet	—	—	13·8	0·921
	Whole wheat and diet no. 2	34·9	40·5	13·9	0·896
	Whole wheat and diet no. 3	50·4	19·4	15·2	0·809
Main effect‖	Temperature regimen	***	*	***	***
	Feeding treatment	***	***	NS	***
Critical difference¶ ($P < 0·05$)	1	5·9	5·4	1·5	0·064
	2	7·4	5·6	2·0	0·090

NS, not significant.
* $P < 0·05$, *** $P < 0·001$.
† For details, see p. 311
‡ For details, see Table 1.
§ Results obtained using calculated values for crude protein and ME from Table 1.
‖ The interactions were not significant.
¶ 1, Between feeding treatments for same temperature regimen; 2, between the same or different feeding treatments for different temperature regimens.

DISCUSSION

Previous studies with broilers fed on a complete diet have shown that food intake of the broiler is inversely related to environmental temperature, growth rate, however, being depressed above approximately 23° (Prince, Potter & Irish, 1961; Milligan & Winn, 1964 Huston, 1965; Prince, Whitaker, Matterson & Luginbahl, 1965; Winn & Godfrey, 1967; Deaton, Reece, McNally & Tarver, 1969; Deaton, Reece, Lott, Kubena & May, 1972; Deaton, Reece, Kubena, May & Vardaman, 1973). The reduced food intake with increase in environmental temperature implies a reduced intake of protein which may account for the growth rate depression.

Table 3 presents the protein and ME intake rates of the present experiment, calculated using food analysis values from standard tables (Table 1). The choice-fed broiler apparently does not select to maintain its intake of protein regardless of environmental temperature. Indeed the results of Adams, Andrews, Rogler & Carrick (1962*a*, *b*); Adams, Andrews, Gardiner & Carrick (1962); Adams & Rogler (1968); Kubena, Deaton, Reece, May & Vardaman (1972) and Cowan & Michie (1978*b*), who fed broilers kept under different temperature regimens with diets containing increased levels of either protein, sulphur amino acids, or energy, suggest that much of the growth rate depression is non-nutritional. At temperatures above 23° the choice-fed broiler may still be selecting to match its protein requirement.

The reason for the reductions in growth rate and food intake rate of the choice-fed broilers

compared with those fed on the complete diet is not clear. Cowan & Michie (1978*a*) reported less pronounced reduced growth rates for the choice-fed broiler. Replacement pullets choice-fed with whole wheat and a higher-protein food containing either 321 or 490 g crude protein/kg had similar growth rates on average to birds fed on a complete diet regimen (Cowan, Michie & Roele, 1978).

The authors thank their staff for their assistance and the ARC Unit of Statistics, Edinburgh for carrying out the analyses of variance.

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Printed in Great Britain