S. Afr. J. Anim. Sci. 6, 49–52 (1976)

THE EFFECTS OF ALTERNATE FEEDING AND FASTING ON GROWTH AND FEED UTILIZATION BY BROILER CHICKENS FED DIETS DIFFERING IN PROTEIN AND ENERGY CONTENT

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Receipt of MS 9.10.75
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OPSOMMING: DIE INVLOED VAN AFWISSELENDE PERIODES VAN VOEDING EN VOERONTTREKKING OP DIE GROEI EN VOERVERBRUIK VAN BRAAIKUIKENS OP RANTSOENE MET VERSKILLENDE PROTEIN- EN ENERGIEPEILE

Drie rantsoene met verskillende peile van proteïen en energie, maar met dieselfde verhouding van energie:proteïen, is vir vier weke aan elk van drie groepe braaikuikens gevoer. Die drie groepe kuikens op elke rantsoen is soos volg gevoer: a) *ad libitum* voeding, b) toegang tot kos vir 12 h gevolg deur voeronttrekking vir 12 h, en c) opeenvolgende voedings- en vasperiodes van 6 h elk. Beligting is vir 24 h per dag voorsien. Die hoë proteïenrantsoen het onder al drie voedingspraktyke die beste groei en voerinname tot gevolg gehad. Onder ad libitum-voeding was die koste/kg massatoename hoër op die hoë proteïen- as op die laagste proteïenrantsoen. Die teenoorgestelde is gevind wanneer die kuikens vir net 12 h per dag toegang tot kos gehad het. Die resultate dui daarop dat 'n hoë proteïen-: hoë energierantsoen voordelig is as braaikuikens gedurende hul eerste vier weke nie vir 24 h per dag toegang tot kos het nie asook wanneer 'n maksimum getal braaikuikens elke jaar in 'n huis grootgemaak moet word.

SUMMARY:

An experiment is described in which three diets differing in protein and energy content but having a constant energy:protein ratio, were each fed to three groups of broiler chickens to four weeks of age. The three groups on each diet were fed *ad lib.*, for 12 h continuously followed by a 12 h fasting period each day, or for repetitive 6 h feeding and fasting periods. Lighting was supplied for 24 h/d. Broilers fed *ad lib* had in all cases a significantly greater body mass and consumed significantly more of each diet than those fed the corresponding diet for 12 h/d. The high protein diet proved superior to the other diets in promoting growth and food consumption, although when fed *ad lib* the cost per kg gain in body mass was greater for this diet than for the low protein diet. The converse was found when broilers were fed continuously for 12 h/d. There appears to be a definite advantage in feeding a high protein, high energy diet under conditions where broilers do not have access to food for 24 h/d during the first four weeks of age, and also if a maximum number of batches of broilers are to be reared in a broiler house each year.

A previous investigation (Gous & du Preez, 1975) showed that chickens fed a ration containing 12% crude protein for 12 hours per day consumed less food and had a higher net protein utilization (NPU) than chickens fed the same diet *ad lib.* Although the reason for the apparently greater N utilization with "periodic" feeding remained obscure it was thought that these results could have practical significance in the feeding of broiler chickens.

The aim of the experiment now reported was to assess the importance of this improved food utilization in the feeding of broiler chickens to four weeks of age. Three diets varying in protein content, but having the same energy:protein ratio, were fed in order to test their effect on growth rate and food utilization when chickens were fed either *ad lib* or for 12 hours per day. Two 12-hour feeding treatments were used; in one, food was supplied continuously for 12 hours per day and in the other six-hour feeding periods alternated with six-hour fasting periods.

Procedure

Day-old, sexed, Cornish Game X White Rock chickens were purchased from a commercial hatchery. These chickens were wingbanded and initial body mass was recorded for each bird. Brooding facilities consisted of four five-tier electrically heater brooders with four

Table 1

Composition (g/kg) of the diets fed to broiler chicken from day old to four weeks of age

	Diet		
Constituent	1	2	3
Yellow mealie meal	681	514	405
Sunflower meal	122		
Fishmeal	167	156	103
Lucernemeal	20	20	20
Pollard		300	456
Oil	7	3	
Molasses		5	10
Limestone flour			4
Vitamins & minerals*	0,8	0,8	0,8
Calculated analysis			
Crude Protein (%)	22,0	20,0	18,0
ME (MJ/kg)	13,12	11,78	10,68
ME/protein	0,60	0,59	0,59
Calcium (%)	0,83	0,77	0,70
Phosphorus (available) (%)	0,55	0,54	0,43
Lysine (%)	1,253	1,215	1,002
Methionine (%)	0,540	0,444	0,393
Methionine + cysteine (%)	0,905	0,770	0,700
Cost (S.A. cents/kg)	9,103	7,847	6,548

*Provides per kg of diet: 25 mg thiamin, 16 mg riboflavin, 20 mg pantothenic acid, 6 mg pyridoxine, 0,6 mg biotin, 4 mg pteroylmonoglutamic acid, 5 mg menaphthone, 0,02 mg cyanocobalamin, 150 mg nicotinic acid, 250 mg ascorbic acid, 4,2 mg α-tocopherol (25%), 150 mg retinol (1982 μg/g), 7,2 mg cholecalciferol(2000μg/g), 2 g choline chloride, 1 g KH_2PO_4, 800mg NaCl, 50 mg Fe, 250 mg $MgSO_4$, 20 mg $MnSO_4$, 1 mg KI, 1,28 mg $CuSO_4$, 20 mg $ZnCO_3$.

compartments per tier. Five chickens of each sex were housed in each compartment. The brooder room was fan-ventilated and maintained at approximately 25^{o} for the duration of the experiment. Lighting was supplied for 24 hours daily.

A factorial experiment design was used in which the three diets were each fed at three "time" levels (see Table 1). The three time levels refer to treatments in which food supplied a) *ad lib.*, b) continuously for 12 hour feeding periods each day (referred to as "12 h"), and c) for feeding and fasting periods alternating every 6 hours (referred to as "6 + 6 h"). Each of the nine treatments was replicated eight times.

Individual body mass and the food consumption per group was measured after two weeks, and again when the broilers were four weeks of age. Gain in body mass and food conversion ratios were calculated and analysed statistically.

Results

Mean values for the gain in body mass of the chickens from day old to four weeks of age are presented in Table 2. Gains in body mass were in all cases significantly (P < 0,01) greater when broilers were fed *ad lib.* than when fed for 12 hours/day. The difference in body mass gain between the two 12-hour feeding treatments was significant in only one instance, namely, when the diet containing the lowest level of protein was fed. The overall mean value for the time treatment where chickens were fed continuously for 12 h was significantly (P < 0,01) lower than that of either of the two remaining time levels.

Table 2

Mean gain in body mass per broiler from day old to four weeks of age (g)

Dietary protein level (%)	Time level*			Mean
	ad lib.	6 + 6 h	12 h	
22	571,36	496,55	480,19	516,03
20	482,05	411,15	396,29	429,83
18	393,44	319,51	295,10	336,02
MEAN	482,28	409,07	390,52	427,29

S.E. of a single treatment mean (body of table) = 7,337
(means) = 4,236

C.V. = 4,85%

L.S.D. for body of table
(0,05) = 17,354
(0,01) = 24,850

L.S.D. for treatment means
(0,05) = 10,019
(0,01) = 14,347

*Refer to Materials and Methods for a description of the time levels.

Table 3

Mean food consumption per broiler from day old to four weeks of age (g)

Dietary protein	Time level			Mean
22	927,40	813,27	763,59	834,75
20	893,60	792,46	724,46	804,51
18	847,69	732,40	693,19	757,76
Mean	889,56	779,38	728,08	799,01

S.E. of a single treatment mean (body of table) = 16,2664
(means) = 9,3914

C.V. = 5,75%

L.S.D. for body of table
(0,05) = 38,474
(0,01) = 55,094

L.S.D. for treatment means
(0,05) = 22,213
(0,01) = 31,809

The diet containing the highest protein level was responsible in all cases for a significantly improved rate of gain in body mass compared to the other two diets. Similarly, the diet containing 20% protein gave significantly better results than the diet containing the lowest protein level. There was no interaction between protein levels and time levels in the case of gain in body mass.

The values in Table 3 reflect the mean food consumption by the chickens from day old to four weeks of age. The lower food intake by chickens fed for 12 hours/day compared with those fed *ad lib.*, proved to be significant at P < 0,05 in the case of the 6 + 6 h group, and highly significant (P< 0,01 in the case of the 12 h group). Differences in food consumption between the two restricted feeding treatments were significant at the 5% level for the diets of highest and lowest protein content and highly significant (P < 0,01) when the 20% diet was fed.

In two instances there were significant differences in food intakes between values adjacent to each other within the same "time" level. Food intake by chickens fed the 20% protein diet was higher than when the 18% diet was fed either *ad lib.* (P < 0,05) or for 6 + 6 h/day (P < 0,01). Consumption of the diet containing the highest protein level was in all cases significantly (P < 0,01) greater than the intake of the diet with the lowest protein content. No significant interaction between time level and protein level was evident.

Food conversion ratios, food consumed per unit gain in body mass, are presented in Table 4. In only two instances did the time levels result in significant differences in food conversion. For the 18% protein ration, *ad lib.* feeding resulted in a better food conversion than obtained with the 6 + 6h treatment (P < 0,05) or the 12 h treatment (P< 0,01). For this ration, food conversion was similar for the two 12-hour feeding

Table 4

Food conversion ratio (food consumed (g)/g gain in body mass) for broilers from day old to four weeks of age

Dietary protein	Time level			Mean
	Ad lib.	6 + 6 h	12 h	
22	1,623	1,639	1,588	1,617
20	1,858	1,929	1,839	1,875
18	2,157	2,296	2,355	2,270
MEAN	1,879	1,955	1,927	1,921

S.E. of a single treatment mean (body of table) = 0,0439
(means) = 0,0253

C.V. = 6,45%

L.S.D. for body of table
(0,05) = 0,1038
(0,01) = 0,1487

L.S.D. for treatment means
(0,05) = 0,0598
(0,01) = 0,0857

Table 5

A comparison of mean food intake per broiler (g) between the first two and the last two weeks of the experiment

Time level	0–2 weeks of age		3–4 weeks of age	
	Food intake (g)	Intake as % of *ad lib*	Food intake (g)	intake as % of *ad lib.*
Ad lib	216	100	673	100
6 + 6 h	190	87,96	589	87,52
12 h	180	83,33	548	81,43

Table 6

Food cost (S.A. cents) per kg gain in body mass

Dietary protein level (%)	Time level			Mean
	Ad lib.	6 + 6 h	12 h	
22	14,774	14,922	14,456	14,717
20	14,577	15,139	14,429	14,715
18	14,124	15,069	15,424	14,872
MEAN	14,492	15,043	14,770	14,768

S.E. of a single treatment mean (body of table) = 0,3129
(means) = 0,1807

C.V. = 5,99%

L.S.D. for body of table
(0,05) = 0,7402
(0,01) = 1,0600

L.S.D. for treatment means
(0,05) = 0,4273
(0,01) = 0,6119

treatments. The three protein levels resulted in highly significant ($P < 0,01$) differences between all mean values of food conversion, the diet containing the highest protein level proving superior in all cases to the other two diets. A small interaction, not quite reaching significance at the 5% level, was evident between protein and time levels.

A comparison of mean food intake values between the first two and the last two weeks of the experiment is presented in Table 5. It is evident that the relative food intake of the chickens fed for 12 hours daily did not increase during the final two weeks of the experiment. In fact, their relative food consumption declined slightly during the latter period of the experiment.

In Table 6 values of food cost per kg gain in body mass are presented for each of the nine treatments. The cost for broilers fed the 22% protein ration *ad lib.* is very nearly significantly greater than the cost for those fed the low protein ration. Conversely, the low protein diet, when fed continuously for 12 h/d, costs significantly more ($P < 0,05$) per kg gain in body mass than do either of the other diets fed in like manner.

Discussion

The gain in body mass of chickens in the present experiment showed the same trend as in the previous trial (Gous & du Preez, 1975). Chickens grew more rapidly when fed *ad lib.* than when the daily feeding periods were restricted. The 12 h/d feeding regime approximates the condition encountered under natural daylight, and proved to be more inhibitory to growth than alternate feeding and fasting periods of six hours each. Significantly less food was consumed by the chickens on the former than on the latter feeding sequence (Table 3). The differences in food intakes between these two feeding regimes are sufficient to account for the differences in gains by the chickens and may be regarded as arising from the fact that birds on the 6 + 6 h treatment experienced the stimulus for food consumption due to a period of fasting twice as frequently as the birds on the 12 h treatment.

Attempts to control the rate of gain of replacement pullets by means of limited time or skip-a-day feeding systems have generally not been successful (for a review see Lee, Gulliver & Morris, 1971) because birds adapt rapidly by overconsuming food when this is again made available. In the present case such adaptation did not occur, and the relative food intake remained constant for the duration of the experiment. The four-week period of the experiment was presumably too short for broilers to become accustomed to the feeding schedules.

The energy:protein ratio was the same for all three diets used in this experiment, but gain in body mass, food consumption and food conversion all favoured the high energy, high protein diet (diet 1). Similarly, diet 2 gave significantly better growth and food conversion than diet 3. It has previously been shown that diets high in protein provide the greatest gains per unit of food intake when body mass is low, while diets lower in protein content are more efficient later (Heady, Balloun & McAlexander, 1961).

In terms of food cost per kg gain in body mass for the groups fed *ad lib.*, diet 3 was the most profitable (Table 6). The markedly lower unit cost of diet 3 (Table 1) was primarily responsible for this result, and the advantage of low food cost was not eliminated by the relatively poor feed conversion measured for diet 3 (Table 4). Feed restriction of birds fed diet 3 resulted in a further depression of food conversion with consequent increases in food costs, making the low protein diet fed for 12 h/d the most costly diet per unit of gain in body mass. Changes in food costs with restricted feeding are less evident for the remaining diets. Indeed, for diets 1 and 2, feeding for 12 h/d was more economical of food than *ad lib.* feeding. The food costs per kg gain in body mass indicate that in broiler production under conditions where the birds are not allowed access to food at all times a high-protein diet will be more economical than a diet lower in protein content.

Diet 1 (22% crude protein) can be regarded as a least-time diet when fed *ad lib.*, and is the preferred diet for raising the maximum number of batches of broilers in a given time; it is also the indicated diet for the broiler producer faced with seasonal or cyclical declines in broiler prices. On the other hand, if faced with the prospect of rising broiler prices a least-cost diet, such as diet 2 (20% crude protein) or diet 3 (18% crude protein) may be more economical. For the same reasons a broiler producer who is unable to supply additional lighting in a broiler house should feed a least-time diet in order to increase growth rate and to gain the advantage of good food conversion ratios and reduced food costs per kg gain in body mass.

Acknowledgement

The authors are indebted to Mrs Jean Lavers and the staff of the Poultry Section, Ukulinga, for assistance in the care of the experimental chickens.

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