Broiler breeders utilise body lipid as an energy source

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Abstract

The study was conducted to determine the extent to which broiler breeder hens could make use of excess body lipid reserves as a means of maintaining laying performance. The experiment was divided into two phases. In the first phase, the birds aged 37 weeks were allocated one of four daily allowances: 160, 175, 190 or 205 g of a commercial broiler breeder feed for a period of four weeks in order to achieve four levels of fatness in the hens. During the second phase, also lasting four weeks, the birds were given a high protein, low energy feed at three rates of allocation (120, 100 or 80 g/hen d). Performance was higher over the final two weeks of Phase 2 when birds were fed 120 g/d in this period, with production tending to decrease as allocations increased in Phase 1, although this was not significant. The same pattern of response was seen in birds given 100 g/d in the second phase of the trial, i.e. excessive lipid reserves tended to be detrimental to performance in these two treatments. However, where 80 g was allocated daily in Phase 2 this was clearly insufficient to sustain performance, but in this case egg production was considerably higher in birds that had been given larger amounts of food in Phase 1, and which could therefore draw on body lipid reserves as a source of energy. Rate of lay increased by 3.5% and egg output by 4.0 g/d for every additional 10 g of food given in Phase 1, as a result of lipid reserves having been utilised when daily food intake was severely depressed. Egg weight was not affected by any of the feed allocations until the last two weeks of the trial when birds fed 80 g/d started laying smaller eggs. Broiler breeders are capable of maintaining their egg production for short periods at an energy intake that is much lower than is recommended and this has implications when modelling the effect of food composition on performance of broiler breeder hens.

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Introduction

Regulation of food intake of broiler breeders during the laying period is an effective means of reducing costs and improving the efficiency of broiler chick production. Food allowances for breeder hens are manipulated according to the pattern of egg production. Thus, birds are generally fed a generous allowance early in lay followed by a period of mild regulation over peak production and a subsequent reduction in allowance as egg production declines in the latter part of lay. It is accepted that if broiler breeders are overfed they deposit the excess energy as carcass fat and this may lead to a marked reduction in egg production, fertility and hatchability (McDaniel et al., 1981; Pearson & Herron, 1981). However, it has been shown that fattened broilers utilise lipid reserves as an energy source provided the dietary protein intake is sufficient to allow this (Gous et al., 1992; 2012). Thus, contrary to the way in which amino acid requirements are calculated, when calculating the energy required by a broiler for maintenance and growth, account should be taken of the possibility that excess energy may be stored and later utilised by the bird. The same would apply to broiler breeders. If broiler breeder hens are able to draw on lipid reserves to supply the body with energy, it is less likely that energy will be the limiting factor in egg production, unless food intake is severely restricted, as lipid reserves would be built up on non-egg forming days, to be available when required. However, if the lipid stores are not labile reserves of energy, or if the hen cannot utilise these

stores, no assumptions could be made about the adequacy of dietary energy supply by observing the carcass fat content of broiler breeders. In the unlikely event that broiler breeder hens were incapable of making full use of lipid reserves, there would be no advantage in allowing the accumulation of such reserves, and the way in which the energy requirements are calculated would become more complex and critical.

The present study was designed to determine the extent to which broiler breeder hens could make use of excess body lipid reserves as a means of maintaining laying performance.

Materials and Methods

Three hundred and fifty two Cobb broiler breeder hens aged 37 weeks were used in the trial. The birds had been reared on two different growth curves, the first as recommended by the primary breeder (Cobb 500 breeding guide, 2001) designed to achieve 2100 g at 20 weeks, while the other was a fast growth curve to achieve the same weight, but at 15 weeks. One hundred and seventy six birds from each growth curve were randomly allocated to individual cages arranged in six rows, back to back, each row having two levels of 48 cages. Each cage was supplied with one nipple drinker and drip cup, and one feeder. The house was cross-ventilated using six fans. The lighting programme was 16L : 8D (04:00 - 20:00) throughout the experimental period.

The experiment was divided into two phases. In the first phase, the birds were allocated one of four daily allowances: 160, 175, 190 or 205 g of a commercial broiler breeder feed (11.9 MJ ME, 159 g protein and 24 g calcium/kg) for a period of four weeks in order to achieve four levels of fatness in the hens. During the second phase, also lasting four weeks, the birds were given a high protein, low energy feed (Table 1) at three rates of allocation (120, 100 or 80 g/hen d). During this second phase a feed with a high dietary protein content was used to ensure that the amino acid supply was adequate at the low food intakes applied, i.e. such that dietary energy was likely to be limiting and not other essential nutrients. In the second phase of the trial the 24 treatments (2 initial growth curves, 4 initial levels of fatness, 3 final feed allocations) were replicated using 14 hens per treatment (Table 2). The basal diet was analysed for AME, protein, digestible amino acids, calcium and phosphorus content. AME was measured using the method of McNab & Blair (1988) in which 50 g of the feed is given by tube (Sibbald, 1976) following a 48 h fasting period, and excreta are collected

Table 1 Ingredient and nutrient (determined) composition (g/kg) of the feed used in Phase 2 of the trial. Digestible amino acid contents are given

Ingredient	Basal feed
Maize	472
Soybean 48	318
Sunflower 37	31.3
Wheat bran	86.5
DL methionine	1.7
Vit + min premix	1.5
Limestone	76.1
Salt	4.5
Monocalcium phosphate	8.8
Nutrient	
AME (MJ/kg)	10.1
Crude protein	211
Lysine	9.5
Methionine	-
Threonine	5.1
Arginine	8.4
Calcium	36.9

over the following 48 h. The AME value was corrected to zero N retention and to reflect an intake of 80 g/d (AME_{n80}). Protein was measured as nitrogen x 6.25 using a LECO N analyser; amino acids by the method described by Dennison & Gous (1980); and calcium and phosphorus using the AOAC (1975) methods of analysis.

Bodyweight was recorded at the beginning of the trial, after four weeks and then weekly until the end of the trial (after eight weeks). Food intake was calculated by subtracting the amount remaining at the end of each week from the amount fed. Egg production was recorded daily, and egg weight on three days of each week. At the end of the first phase of the experiment, two birds from each daily allowance and from each growth curve (a total of 16 birds) were sacrificed and their carcasses, excluding feathers were minced and then analysed for gross energy (GE), protein, moisture and ash. The lipid content (LC) of the feather-free body was calculated from the GE content using the following equation (University of KwaZulu-Natal, unpublished) which was based on the feather-free analyses of 36 broiler and 24 broiler breeder carcasses and having an R^2 value of 0.929: LC = -0.8756 (±0.0763) + 0.04754 (±0.003) * GE. Fourteen birds thus remained on each of the 24 treatments. Two of these birds from each treatment were sacrificed at week 5, another two at week 6 and a further three at the end of the trial. The abdominal fat pad was removed from each bird and weighed and 10 of these birds were chosen for carcass analysis on the basis of the distribution of the weights of their abdominal fat pads. All results were converted to concentrations on a wet basis.

Table 2 A description of the dietary treatments used in the trial

| Treatment* | Food allocation | | Lysine intake | Energy intake |
	Phase 1 (g/bird d)	Phase 2 (g/bird d)	Phase 2 (mg/d)	Phase 2 (kJ AME/d)
1	160	80	760	805
2	160	100	950	1006
3	160	120	1140	1208
4	175	80	760	805
5	175	100	950	1006
6	175	120	1140	1208
7	190	80	760	805
8	190	100	950	1006
9	190	120	1140	1208
10	205	80	760	805
11	205	100	950	1006
12	205	120	1140	1208

* The 12 treatments shown were allocated to birds from two initial growth curves resulting in 24 treatments.

The mean response over the final two weeks of Phase 2 was used to calculate rate of lay, egg weight, egg output, body weight and change in body weight, using the general analysis of variance in Genstat (1997). The changes in body weight, rate of lay, egg weight and egg output over time were analysed by fitting a linear regression model to the data, using Genstat. A quadratic term was fitted initially in all cases, and where this was not significant only the linear term was used to describe the response. For the 16 birds that were sacrificed at the end of the first phase of the trial, a regression of carcass fat on body weight was performed. Mean body lipid content (g/kg body weight) for each treatment was calculated and used to predict the body lipid contents of all the remaining birds on each treatment at the end of the first phase. A regression analysis was performed of carcass fat content (g/kg bodyweight), calculated from GE, on abdominal fat content (g/kg bodyweight) for the 10 birds sacrificed at weeks 5, 6 and 8. The resultant regression equations were used to predict the carcass lipid contents from the abdominal fat contents of the remaining 288 birds at week 5, 240 birds at week 6 and 168 birds at week 8. The mean body lipid content for

each treatment was then used to calculate the body lipid content of all the remaining birds over the four-week period of Phase 2. An analysis of variance was then performed on these body lipid contents.

This trial was conducted in 2004, prior to ethical approval being required by the University of KwaZulu-Natal for such projects, but subsequent trials of this nature have been approved by their Animal Ethics committee.

Results

The individual results were grouped according to treatment. Three birds, which stopped laying during the trial and looked sick, were excluded from the analysis. Apart from the body water and body lipid contents of birds reared on the two growth curves, no differences were observed across treatments or within phases in any of the other variates measured, hence these data were pooled to increase the number of replications per dietary treatment. The effect of feeding four daily allowances (160, 175, 190 and 205 g/bird d) on body weight at the end of the four weeks and laying performance (rate of laying, egg weight and egg output) in the last week of Phase 1 of the trial is shown in Table 3. There were no significant differences in rate of lay, egg weight or egg output between birds fed these allocations during Phase 1. However, body weights at the end of the period were different. As was intended, the heaviest birds were those fed the highest daily feed allocation at the end of the first phase of the trial. During the four-week period the mean gain in weight of birds on each treatment, corrected for initial body weight, was 234, 346, 406 and 527 g.

The chemical composition of the hens sampled at the end of Phase 1 is shown in Table 4. Both body water and body lipid content differed ($P < 0.05$) between birds reared on the two growth curves, with the water content being lower and lipid content being higher in birds reared on the faster growth curve. However, there were no differences in carcass composition between birds on the four initial feeding treatments at the end of the first phase. There was also no relationship between carcass fat content and body weight in these 16 birds.

The mean responses in laying performance, body weight and gain in weight to the daily feed allowances in Phases 1 and 2 over the final two weeks of the trial are presented in Table 5, and the rates of change in rate of lay, egg output and change in body weight over the last four weeks (Phase 2) are presented in Table 6. Body weight of the breeders increased ($P < 0.05$) with feed allocation in both periods. However, body weight loss during the final four weeks of the trial was inversely related to the weight of the birds at the end of Phase 1 (the heaviest birds at the start of Phase 2 lost the greatest amount of body weight), but decreased with increasing feed allocation in Phase 2. There was a significant interaction between the amounts of feed allocated in the two periods during the last two weeks of the trial: the body weight of birds fed 100 and 120 g/d in Phase 2, following 160, 175 and 190 g/d in Phase 1, decreased linearly over time. On 160 and 175 g/d in Phase 1, the difference in body weight between birds fed 100 and 120 g/d in Phase 2 decreased over time and the mean body weight over the final two weeks was not significantly different. Birds fed 190 g/d in Phase 1 and 100 g/d in Phase 2 had body weights that decreased more rapidly (-281 vs. –141 g/week) and were lighter (3468 vs. 3715 g) over the last two weeks than birds fed 120 g/d. The mean body weight over the final two weeks was the same between birds fed 100 g/d in Phase 2 and 160, 175 and 190 g/d in Phase 1. Birds fed 120 g/d in Phase 2 and 190 g/d in Phase 1 were significantly heavier than those

Table 3 Mean body weight and laying performance of broiler breeders in the last week of Phase 1

	Food allocation, g/bird d			
	160	175	190	205
Body weight, g	3770 ± 29*	3884 ± 26	3946 ± 29	4046 ± 27
Rate of lay, eggs/100 bird d	69.0 ± 2.0	69.8 ± 2.3	70.6 ± 2.2	68.3 ± 2.2
Egg weight, g	70.1 ± 0.5	69.0 ± 0.6	70.0 ± 0.5	69.5 ± 0.5
Egg output, g/bird d	49.4 ± 1.4	50.7 ± 1.4	52.4 ± 1.2	49.4 ± 1.4

* Standard error.

Table 4 Mean carcass composition (g/kg) of the broiler breeders reared on the control (C) and fast (F) growth curves at the end of Phase 1

Food allocation g/bird d	Water		Protein	Lipid*		Ash
	Control	Fast		Control	Fast	
160	661	636	151	135	167	23.3
175	631	611	186	179	193	21.0
190	645	620	169	145	193	23.6
205	662	612	168	143	192	20.3
SEM[1]	17.7		21.7	20.7		3.33

SEM: standard error of mean.

* Predicted from gross energy of carcass using equation given in text.

fed 120 g/d in Phase 2 and either 160 or 175 g/d in Phase 1 (3715 vs. 3463 vs. 3499 g, respectively). Body weight decreased quadratically with age (rapidly at first, and slowing down thereafter) in all birds fed 80 g/d and in those fed either 100 or 120 g/d in Phase 2 following 205 g/d in Phase 1.

Table 5 Responses of broiler breeders to feed allowances in Phases 1 and 2, over the last two weeks of Phase 2, in rate of lay (ROL), egg weight (EW), egg output (EO), body weight (BW) and daily change in body weight (dW)

Food allocation (g/d)		ROL (%)	EW (g)	EO (g/d)	BW (g)	dW (g/d)
Phase 1	Phase 2					
160	80	39.6	68.6	19.6	3281	-9.3
160	100	58.9	69.7	41.0	3470	-11.5
160	120	69.6	69.5	48.2	3463	-4.0
175	80	33.4	67.8	21.9	3368	-8.6
175	100	55.4	70.2	39.0	3411	-11.2
175	120	64.3	68.2	45.8	3499	-6.6
190	80	41.2	68.0	27.8	3343	-11.8
190	100	61.3	69.9	42.8	3468	-14.6
190	120	63.7	70.7	47.0	3715	-6.7
205	80	49.4	68.4	37.1	3452	-14.6
205	100	51.2	68.5	36.2	3461	-9.4
205	120	66.1	69.4	45.9	3780	-6.0

There were no significant differences in rate of lay or egg output at the end of the first phase of the trial, i.e. hens on food intakes ranging from 160 to 205 g/d had the same egg output. However, the amount of food allocated during Phase 1 significantly influenced both rate of lay and egg output of some birds in Phase 2. In hens fed only 80 g/d in Phase 2, rate of lay and egg output increased at a rate of 3.5% and 4.0 g/d, respectively, for every additional 10 g of food given in period 1. However, these variables remained the same over the last two weeks when birds were fed either 100 or 120 g/d, irrespective of the amount fed in Phase 1. The result is presented graphically in Figure 1. Rate of lay and egg output both increased ($P < 0.05$) with increasing feed allocation in Phase 2. There was also a linear decline ($P < 0.001$) in rate of lay and egg output over time. Mean rate of lay and egg output over the last two weeks of Phase 2, of all hens fed 80 g/d in Phase

2 other than those fed 205 g/d in Phase 1, were lower ($P <0.001$), and declined more rapidly, than those fed 100 g/d in Phase 2. Where hens were fed 120 g/d in Phase 2, rate of lay and egg output remained the same throughout the four-week period.
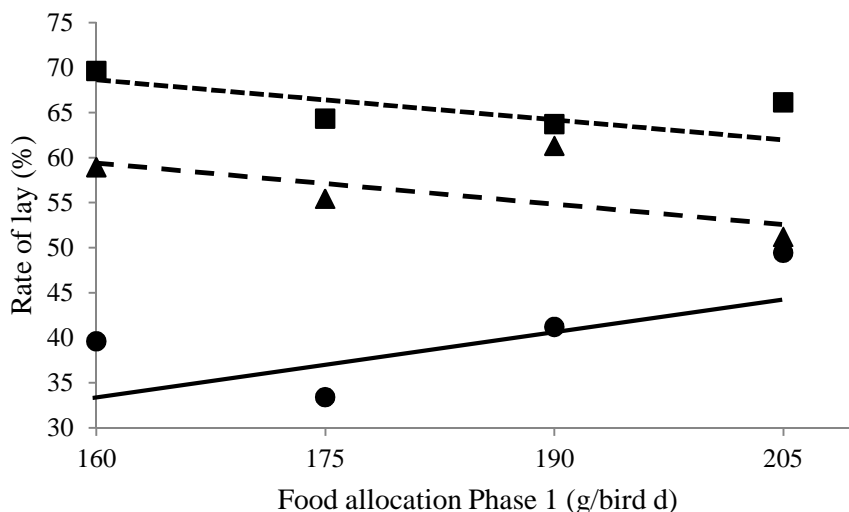

Figure 1 Rate of lay of broiler breeder hens over the final two-week period of the trial according to their daily feed allowances in Phases 1 and 2. Solid line and ● represent 80 g/d in Phase 2, dashed line and ▲ represent 100 g/d, and dotted line and ■ represent 120 g/d.

The mean abdominal fat and carcass lipid contents of the 10 birds sampled from each treatment 5, 6 and 8 weeks after the start of the trial are presented in Table 8 together with their standard errors. The relationship between these components was found to be highly significant ($P <0.001$) (Table 7) at each sampling time, with the regression coefficients for weeks 43 and 45 being the same (4.887 ± 0.619). These regressions were used to estimate the carcass lipid contents of the remaining birds sampled where only the abdominal fat contents were measured. No effect of dietary treatment on abdominal fat or carcass lipid content was discernible at week 5. However, by weeks 6 and 8 abdominal fat pad and carcass lipid contents increased with feed allocation in Phase 2. The rate of change in body lipid content over time for each of the treatments applied is presented in Table 9. The mean abdominal fat pad and body lipid contents of birds fed 80 g/d in Phase 2 decreased most rapidly, followed by those fed 100 and then 120 g/d on the treatments in which 160, 175 and 190 g was allocated/d in Phase 1. Birds fed 205 g/d in Phase 1 showed a same rate of decline in abdominal fat and body lipid content on all treatments in Phase 2.

Discussion

Meeting the energy requirement of broiler breeder hens throughout their various stages of production is difficult because their food intake is restricted. The problem of overfeeding broiler breeders is a real concern to any broiler breeder manager, because it leads to the deposition of body lipid which has a negative effect on reproductive performance (McDaniel et al, 1981; Pearson & Herron, 1981). Underfeeding these birds is also of concern, especially with day-to-day fluctuations in temperature. If broiler breeder hens were found to utilise their body lipid reserves as an energy source, it would certainly assist in alleviating these difficulties. It appears from the results of this trial that they are capable of doing so.

The intention of allocating a range of feed intakes to the breeder hens during Phase 1 of the trial was to create four groups of birds with varying levels of body lipid. However, whereas body weight at the end of this period was directly related to food allocation and to energy intake, there was no relationship between body weight and carcass fat content among the birds sampled. We have shown (Nonis & Gous, unpublished) that broiler breeder hens do not deposit body protein once they have started laying, and that the changes that occur in body weight after sexual maturity are a reflection of changes in body lipid content. This in turn is a

response to changes in dietary energy supply and that required for maintenance and egg output. Because of the large variation in weight and carcass composition between birds it is possible that the sample size was too small to make meaningful deductions about the relationship between body weight and lipid content. Because weight gain of breeders during lay has been reported to be primarily related to excessive energy intake (Pearson & Herron, 1980; 1982; Wilson & Harms, 1986) it is likely that the lipid reserves in the heaviest birds were greater than in the lighter birds at the end of Phase 1. This is borne out by the subsequent laying performance of hens in the second phase, which essentially followed expectations based on feed allocations in Phases 1 and 2.

Table 6 Rate of change in performance (rate of lay and egg output) and in body weight over the last four weeks of the trial as influenced by the feed allocated in Phase 1 and Phase 2

Food allocation (g/d)		Rate of lay (% /d)		Egg output (g/bird d /d)	
Phase 1	Phase 2	Linear coefficient	SE	Linear coefficient	SE
160	80	-1.5***	1.4	-1.3***	0.2
160	100	-0.5**	1.1	-0.3**	0.1
160	120	0.2		0.1	
175	80	-1.5***	1.7	-1.1***	0.2
175	100	-0.7***	1.3	-0.5***	0.1
175	120	-0.4*	1.4	-0.2	
190	80	-1.4***	1.3	-1.0***	0.1
190	100	-0.5**	1.2	-0.4***	0.1
190	120	-0.1		-0.1	
205	80	-1.0***	1.5	-0.6**	0.1
205	100	-0.9***	1.4	-0.6***	0.1
205	120	0.2		0.01	

Food allocation (g/d)		Body weight loss (g/bird d)			
Phase 1	Phase 2	Linear coefficient	SE	Quadratic effect	SE
160	80	-34.7***	7.1	0.584*	0.259
160	100	-14.8***	3.26		
160	120	-8.4***	2.4		
175	80	-40.0***	7.9	0.741*	0.286
175	100	-17.1***	2.2		
175	120	-15.5***	2.5		
190	80	-40.1***	8.5	0.700*	0.306
190	100	-20.1***	2.3		
190	120	-10.3**	3.4		
205	80	-44.9***	10.0	0.863*	0.363
205	100	-41.8***	7.8	0.710*	0.282
205	120	-35.1***	7.1	0.918***	0.259

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.
SE: standard error.

The method used to calculate body lipid content from the GE content of the body is based on a substantial dataset collected in our laboratory. Apart from being highly positively correlated with actual body lipid, the lipid content derived in this way has been shown to be highly negatively correlated with body water content. This is another variable that could have been used to predict lipid content without incurring the expense and time involved in determining the lipid content of the body using a Soxhlett apparatus. But both

Table 7 Main effects of abdominal fat pad and body lipid contents (g/kg body weight) of broiler breeders 5, 6 and 8 weeks after the trial commenced, according to the feed allowances in Phase 1 and 2

Feed allowance (g/d)	Week 5		Week 6		Week 8	
	Fat pad g/kg	Body lipid g/kg	Fat pad g/kg	Body lipid g/kg	Fat pad g/kg	Body lipid g/kg
Phase 1						
160	18.0	159	16.1	152	14.5	126
175	20.0	165	19.0	167	15.3	131
190	19.0	162	14.3	143	17.1	138
205	22.2	173	19.1	167	14.8	128
SEM	0.86	2.87	0.69	3.33	0.64	3.00
Phase 2						
80	19.3	163	15.0	147	12.8	119
100	19.7	164	16.7	155	14.6	127
120	20.5	167	19.7	170	19.0	147
SEM	0.87	2.91	0.70	3.38	0.61	2.82

SEM: standard error of mean.

Table 8 The relationship between carcass lipid (g/kg) and abdominal fat content (g/kg) of the carcasses analysed 5, 6 and 8 weeks after the start of the trial

Age (week)	Constant term	SE	Linear coefficient	SE	R^2 (%)
42	103***	11.8	3.3***	0.417	87.3
43	76.5***	8.1	4.9***	0.383	94.8
45	63.3***	7.5	4.6***	0.325	95.6

*** $P < 0.001$.
SE: standard error.

these methods of analysis require the whole bird to be minced thereby incurring considerable expense when the carcass composition of so many broiler breeders is required. Consequently we used yet another, less destructive method of predicting carcass lipid, namely, to dissect out and weigh the abdominal fat pad only, which we have also shown to be an accurate predictor of the body lipid content of broiler breeders.

All birds lost weight during Phase 2, reflecting the low energy intake in relation to requirement during this period. The amount of weight lost appeared to be unrelated to the food allocated during Phase 1, but was least with the highest allocation in Phase 2. It can be assumed that the loss in weight was predominantly lipid, for the reasons given above.

Hens fed either 100 or 120 g/d in Phase 2 were able to maintain their performance over the four weeks of this phase, with mean rates of lay of 57 and 66 eggs/100 birds per d, respectively, over the final two weeks of the trial. Birds from the same flock were kept on the floor, and on 160 g/bird d of a commercial broiler breeder feed (11.9 MJ ME/kg, 159 g protein/kg) their rate of lay over this period was 63 eggs/100 birds per d, thus confirming that the performance of birds on these two feed allocations was acceptable. Rate of lay of birds fed 80 g/d was directly related to daily energy intake in Phase 1, and clearly demonstrated that egg production could be sustained for a short period of time if lipid reserves were available, and the daily food allocation provided sufficient nutrients (other than energy).

Egg weight was not affected by any of the feed allocations until the third week of Phase 2. At this stage, eggs laid by hens given 80 g/d (805 kJ AME/d, 16.8 g CP/d) reduced in size. Protein intake would

have been marginally limiting for reproductive performance at this daily feed allowance, but this would also have been due to a shortage of energy *per se*. As suggested by Miller & Payne (1961) and Pearson & Herron (1980), energy requirements might be satisfied preferentially to protein requirements, reflecting an increase in the utilisation of protein as an energy source. This would result in a decrease in protein available for egg formation.

Table 9 Rate of change in body lipid content (g/kg body weight /d) of broiler breeders over the last four weeks of the experiment according to the feed allowance in Phases 1 and 2

Food allocation (g/d)		Change in body lipid (g/kg body weight d)	
Phase 1	Phase 2	Linear term	SE
160	80	-2.1***	0.57
160	100	-1.7**	0.57
160	120	-1.0	
175	80	-2.2**	0.73
175	100	-2.0***	0.54
175	120	-1.3	
190	80	-1.9*	0.69
190	100	-0.8	
190	120	-0.3	
205	80	-2.1**	0.66
205	100	-2.9***	0.60
205	120	-1.8*	0.79

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.
SE: standard error.

This trial was not designed to determine the energy requirements of broiler breeder hens, but rather to ascertain whether, for a short period of time, such hens could maintain their egg production at an energy intake that is lower than recommended. To measure this, the changes in rate of lay during Phase 2 of the trial were therefore of greater importance than were the changes in body lipid content, so the relative uncertainty of the magnitude of these latter changes resulting from the use of GE and abdominal fat as measures of the body lipid content is of lesser importance. However, these changes nevertheless reflect a reduction in body lipid content in all treatments during Phase 2. Energy intake on each of the three treatments in Phase 2 of this trial was only 805, 1006 and 1208 kJ/bird d, respectively, whereas recommended energy intakes range from 1730 (Pearson & Herron, 1981) through 1840 and 1955 (Cobb, 2005) to 2000 kJ ME/bird d (Bowmaker & Gous, 1991). The birds in this study clearly obtained the balance of energy required for egg production from body lipid reserves, the birds receiving 80, 100 and 120 g/d in Phase 2 losing body weight at a rate of 2.3, 1.9 and 1.1 g/d respectively.

As was expected, the use of body lipid reserves increased with decreasing feed allocations in Phase 2. Assuming that 8.4 kJ ME is required per g egg output (Emmans, 1974), an output of 48 g/d would require 403 kJ ME/d. The difference in intake between birds given 80 g and those given 100 g/d is 201 kJ ME, half the amount required for 48 g egg output/d, and the difference between the intakes of 80 and 120 g is 403 kJ, the equivalent of one egg. Consequently, the additional energy provided to birds on 120 g/d was sufficient to enable them to lay at the given rate throughout the second phase of the trial compared with the birds given 80 g/d. It is assumed that the energy required for maintenance was essentially the same for hens on all treatments, as this is related to the body protein content and not the energy content of the body, and it appeared that body protein content remained constant in all treatments.

Broiler breeder hens would be unable to make use of all their lipid reserves to enable them to continue to lay when food intake is severely restricted because a minimum amount of body lipid is needed to maintain the birds (Wellock *et al.*, 2003). This trial suggests that the minimum lipid content would be around 110 g/kg body weight, given that the amount in the hens fed 80 g/d was close to this concentration. This concentration of lipid in the body could be used as the minimum lipid content when modelling energy utilisation of broiler breeders after sexual maturity.

Conclusion

Broiler breeder hens can maintain their egg production for a number of days at an energy intake that is lower than is required for maintenance and egg production by utilising body lipid reserves as an energy source.

Acknowledgements

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