

The effect of dietary protein on breast meat yield of broilers reared on different daylengths

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(Received 21 February 2014; Accepted 23 February 2015; First published online 2 March 2015)

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Abstract

The objective of the trial reported here was to determine whether breast meat yield would improve in broilers reared on short daylengths if higher levels of dietary protein were fed. To that end, 3200 Ross 308 International broilers were reared to 35 d in eight light-tight rooms, each room being divided into four pens which were populated with 100 feather-sexed male or female chicks. The lighting treatments used were 12, 16, 20 and 24 h light/d, and four balanced protein levels, being 0.85, 1.00, 1.15 and 1.30 of the Aviagen amino acid recommendations, were fed. At 35 d, three birds from each pen were sacrificed for measurement, individually, of physical and chemical characteristics. Body weight gain to 35 d was unaffected by both dietary protein content and light. FCE increased with dietary protein content to day 21. Feed intake to day 35 was not influenced by light or by dietary protein content. Birds on 24 h had a higher mortality compared with those on the three other lighting programmes, which did not differ from one another. Body protein content increased with both daylength and dietary protein content whereas body lipid content was influenced (decreased) only by dietary protein. Breast meat yield from birds reared on 12 h was not improved when these birds were fed high protein feeds whereas yields were increased in birds on the three longer daylengths used when feed protein was increased. The decreased breast meat yield in broilers given short daylengths is therefore not the consequence of a shortage of dietary protein.

Keywords: Thigh, drum, wing, carcass yield

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Introduction

Breast meat yield has been shown to be reduced when birds are exposed to daylengths shorter than 20 h whereas most other important biological parameters showed improved performance. Unpublished data from studies commissioned by Aviagen showed that breast yields at 31, 38 and 49 d progressively increased as photoperiod was lengthened from 14 to 23 h light, and Schwan-Lardner *et al.* (2006) noted that, at 38 d of age, birds given 23-h photoperiods had larger breasts than those on 14 h. Brickett *et al.* (2007) reported lower breast yield for 35-d Ross 308 birds given 12-h photoperiods than those given 20 h. The superior breast yields at 54 d in both Ross and Cobb genotypes given >21 h photoperiods (Lewis *et al.*, 2009) are in agreement with the findings of Renden *et al.* (1992; 1993; 1996) and Lien *et al.* (2007) for 49-d birds, and with Downs *et al.* (2006) for 56-d birds. Whilst continuous lighting increases breast meat yield it also increases physiological stress levels and mortality (Lewis *et al.*, 2008). As yet, no explanation has been given for the lower breast meat yield of broilers reared on shorter daylengths, but because of the welfare benefits of such a management procedure, it is worth finding a way of overcoming this hurdle. The new welfare regulations in the European Union stipulate that birds should be exposed daily to a minimum of 8 h of darkness, six of which must be un-interrupted within a 24-hour cycle (European Union, 2007). Therefore, a maximum of only 16 h of light will be permissible in the future.

Studies by Danisman & Gous (2011; 2013) have shown that body protein content is positively associated with breast meat yield and that this relationship is constant across genotypes and sexes. It is only when low protein feeds are offered to broilers that the relationship between body protein and breast meat yield changes (Danisman & Gous, 2011; 2013). Under these circumstances, excess energy is consumed by birds in their attempt to consume sufficient protein which results in an increase in lipid deposition in the various parts of the body (Gous *et al.*, 1990; Smith & Pesti, 1998) causing the allometric

relationship between breast meat yield and body protein to differ from that where high protein feeds are offered (Danisman & Gous, 2011; 2013). It is possible that the reduced feed intake of broilers reared on short daylengths (Ingram *et al.*, 2000, Lewis *et al.*, 2009) may result in less dietary protein being consumed than is necessary to meet the potential body protein growth of broilers, and this could be the cause of the lower breast meat yield in birds reared on short daylengths. Alternatively, the lower energy usage by birds on short daylengths would result in a surplus which would be deposited as body lipid (Lewis & Gous, 2007). Therefore, at the same body weight as broilers on long daylengths, broilers on short daylengths would have more body lipid and hence less body protein, and as a result, less breast meat.

The hypothesis tested in this trial was that breast meat yield would improve in broilers reared on short daylengths if higher levels of dietary protein were fed. In order to test this hypothesis, feeds ranging in dietary protein content were fed to broilers reared under a range of daylengths, with growth rate, feed intake, breast meat yield and body protein and lipid content being measured.

Materials and Methods

A total of 3200 day-old Ross 308 International broiler chicks was reared in eight light-tight rooms. Each room was divided into four pens using a mesh fence as a barrier. Each pen was populated with 100 feather-sexed male or female chicks. On the first day all chicks received continuous lighting, with the lighting treatments being implemented from the second day of age. Illumination was provided by 11W warm-white compact fluorescent lamps. Heating was provided initially using gas spot-brooders which were placed over two pens on either side of each room. The room temperature was set initially at 32 °C and was decreased by 3 °C at seven d and then linearly to reach 20 °C by 21 d of age. The Animal Ethics Committee approved, in 2010, the use of broiler chickens for this study (reference number: 086/10/Animal).

The four experimental diets used, were formulated to contain 0.85, 1.00, 1.15 and 1.30 of the Aviagen amino acid recommendations (Aviagen, 2009) in the starter and grower periods. Two basal feeds (lowest and highest balanced protein levels) (Table 1) were mixed at a commercial mill, and the chemical composition for these feeds is given in Table 2. The two intermediate levels of balanced protein were produced by blending the high and low protein basal feeds in the ratios 0.67 : 0.33 and 0.33 : 0.67, respectively. The basal feeds were sampled after mixing for the analysis of apparent metabolisable energy (AME) and digestible amino acid content, using the method of Fisher & McNab (1987) and a Waters amino acid analyser (AOAC, 2003). The experimental diets were provided in a crumbled form for the first two weeks and in a pelleted form thereafter. Feed and water were supplied *ad libitum* for the entire trial, and drinkers were cleaned daily.

On arrival, all chicks were weighed per box to obtain their mean initial body weight. Thereafter a random sample of the birds in each pen was weighed at seven-day intervals and these values were used to calculate BWG. On the same day, feed remaining in the troughs was measured from which feed consumption was calculated. Mortality was recorded daily and feed intake was corrected for mortality. Feed conversion efficiency (FCE) was calculated as g gain/kg feed consumed.

At 35 d, three birds from each pen were sacrificed for measurement of physical and chemical characteristics. Body weight of each bird was recorded three times, once before being electrically stunned and exsanguinated, the second after bleeding had ceased, and finally after the feathers had been removed using a rotatory drum plucker. Breast meat (without bone or skin), thigh, drum and wing (with skin and bone) were dissected and weighed and then all parts of each bird, other than feathers, were sealed in a plastic bag, marked and stored in a freezer until mincing took place. Each bird was minced twice using a medium sized mincing machine after which a sample of approximately 500 g was taken from each carcass for subsequent chemical analysis. Each carcass sample was freeze-dried and then milled using a Retsch ultracentrifugal mill. The crude protein content ($N \times 6.25$) of each milled sample was analysed with a LECO FP2000 Nitrogen analyser using the Dumas combustion method (AOAC, 2003). Gross energy (GE) content was determined using a DDS isothermal CP 500 bomb calorimeter. Lipid (L) content was calculated from GE using the equation $L = -0.8754 + 0.04754 \times GE$ (University of KwaZulu-Natal, unpublished). To determine the ash content, samples were placed in a furnace for four hours at 550 °C (AOAC, 2003).

Four lighting treatments, namely 12L : 12D, 16L : 8D, 20L : 4D and 24L : 0D were applied from day old for the duration of the trial, these being randomised between rooms, with each lighting treatment being replicated twice, resulting in a factorial design with two sexes, four dietary protein levels and four lighting treatments. Data were analysed using analysis of variance to determine treatment means. Simple linear regression with groups was used to evaluate the response to dietary protein content and daylength, using Genstat (2011). Birds were sexed at the hatchery and reared separately, but to allow for the maximum number of replications of the main effects (light and dietary protein), sex was not included in the statistical analysis and birds were treated as 'as-hatched'. The Chi-square test was used to determine the effects of photoperiod and dietary protein content on mortality (Morris, 1999).

Table 1 Ingredient and nutrient composition (g/kg) of low and high protein basal feeds used in the starter and finisher periods of the trial

Feed ingredients	Starter		Finisher	
	LP	HP	LP	HP
Maize	591	320	730	553
Wheat middlings			23.2	
Soybean full fat	300	300	202	300
Soybean oilcake	60.8	255		92.3
Fish meal		45.0		
L-lysine HCl	3.00	2.40	2.00	1.80
DL methionine	1.60	2.3	0.50	1.90
L-threonine	0.80	1.00	0.40	0.70
Choline chloride 60%	0.80		1.40	0.70
Vit+min premix	1.50	1.50	1.50	1.50
Limestone	17.1	12.8	18.1	17.0
Salt	2.00	1.20	2.00	2.20
Monocalcium phosphate	16.5	12.6	16.5	16.5
Sodium bicarbonate	2.40	1.80	2.50	2.00
Oil – sunflower	2.10	44.4		10.9
Composition (calculated)				
AMEn adult (MJ/kg)	12.6	12.6	13.0	13.0
Crude protein (g/kg)	194	290	143	204
Lysine ¹	11.6	17.4	7.60	11.4
Methionine	4.20	6.20	2.70	4.60
Methionine+cystine	6.90	9.70	5.00	7.40
Threonine	7.10	10.7	5.00	7.40
Tryptophan	1.80	2.90	1.20	2.00
Arginine	11.7	18.5	8.00	12.6
Isoleucine	7.50	11.9	5.20	8.00
Valine	8.40	12.6	6.10	8.90
Calcium	10.0	10.0	10.0	10.0
Avail. Phosphorous	5.00	5.00	5.00	5.00

¹ The amino acid composition is measured on a digestible basis.

Results

Protein contents of the four starter feeds were measured to be 194, 226, 258 and 290 g/kg, and in the finisher feeds, 143, 164, 184 and 204 g/kg, respectively, confirming that the blending of the intermediate feeds had taken place accurately. Mean body weight gain (BWG), feed intake and FCE of birds on the four dietary protein levels and subjected to four lighting treatments to 35 d of age is given in Table 2. There were no significant interactions between lighting programme and dietary protein content for any of the measured variables ($P > 0.05$). BWG to 35 d was unaffected by both dietary protein content ($b = 0.84 \pm 1.12$ g/g protein) and light ($b = 5.78 \pm 5.46$ g/h light). FCE increased with dietary protein content to day 21 only ($b = 0.626 \pm 0.266$ g gain/kg feed intake/g protein). Feed intake to day 35 was not influenced by light ($b = 7.61 \pm 7.18$ g/h light) or by dietary protein content ($b = -0.41 \pm 1.4$ g/g protein).

Birds on 24 h had a higher ($P < 0.05$) mortality (5.58%) compared with those on the three other lighting programmes, which did not differ from one another. Dietary protein content did not affect mortality ($P > 0.05$).

Mean breast weights of the broilers sampled at 35 d are given in Table 3. There was no change in breast weight with dietary protein content (-0.338 ± 0.518 g/g) except when birds were subjected to 20 h light, when breast meat increased by 2.541 ± 0.733 g/g dietary protein (Figure 1). However, the slope of the response to increasing daylengths differed depending on the dietary protein offered: for the lowest protein content (143 g/kg) this decreased linearly by $(-)2.12 \pm 1.09$ g/h light. On the next two highest protein levels (164 and 184 g/kg) the increasing linear response was the same (5.35 ± 2.72 g/h); and at the highest dietary protein content the response was curvilinear, increasing to the highest weight on 20 h light and then decreasing, the coefficients being 99.6 ± 27.9 for the linear term, and -2.63 ± 0.77 for the quadratic term. These responses are illustrated in Figure 2. Birds on 20 h of light and fed the highest protein content had the heaviest breast weights.

Table 2 Mean body weight gain (g), feed intake (g) and feed conversion efficiency (g gain/kg feed consumed) at 21 and 35 d, of birds fed four levels of dietary protein under four lighting treatments

Light (h)	Dietary protein content (g/kg feed)									
	194	226	258	290	Mean	143	164	184	204	Mean
Body weight gain										
0 - 21 d										
12	941	866	845	942	899	1363	1363	1389	1450	1391
16	866	857	866	911	875	1311	1402	1405	1425	1386
20	889	883	914	935	905	1359	1397	1465	1579	1450
24	913	947	952	953	941	1440	1461	1406	1481	1447
Mean	902	888	894	935		1368	1406	1416	1484	
RMS	2534					29879				
Feed intake										
0 - 21 d										
12	1200	1107	1006	1147	1115	2488	2363	2244	2492	1685
16	1129	1088	1057	1071	1086	2409	2401	2424	2357	1669
20	1159	1163	1117	1139	1144	2418	2467	2463	2490	1729
24	1190	1118	1131	1139	1145	2531	2503	2423	2453	1737
Mean	1169	1119	1078	1124		2462	2434	2389	2448	
RMS	4664					54780				
Feed conversion efficiency										
0 - 21 d										
12	750	746	799	788	770	548	576	619	583	582
16	730	749	780	811	768	544	584	579	604	578
20	731	725	781	783	755	562	565	593	633	588
24	732	809	805	799	786	569	583	579	601	583
Mean	736	757	791	795		556	577	592	605	
RMS	580					643				

RMS: Residual mean square; n = 32.

When breast weight was expressed as a proportion of body weight (BRW/BW) both feed protein content and daylength influenced this ratio ($P > 0.05$) although there was no significant interaction between the two factors (Table 4). When breast weight was expressed as a proportion of body protein weight (BRW/BPW), the only observed difference was between lighting treatments (Table 4). These differences were reduced even further when the allometric relationship between breast meat and body protein weight was analysed: The slope of the regression was the same for all treatments (0.988 ± 0.444) but the constant term differed for those birds fed 204 g protein/kg, being 1.447 ± 0.115 for birds on 12 h light and 1.701 ± 0.139 for birds on 20 h light. For all other combinations of light and feed protein the constant term was 1.562 ± 0.435 .

Mean thigh weights (average weight per bird) for broilers at 35 d are shown in Table 3. Males had higher mean weights than females (136 vs. 114 g, $P < 0.001$). There was no effect of dietary protein content ($b = 0.123 \pm 0.087$ g/g protein) or light ($b = -0.065 \pm 0.440$ g/h light) on thigh weight, but an interaction between these factors resulted in thigh weights increasing, in birds fed dietary protein levels of 164, 184 and 204 g/kg, as daylength was increased, but with birds on the lowest protein (143 g protein/kg feed) showing reduced thigh weights ($P < 0.05$). The allometric relationship (constant term and regression coefficient) between (\ln) mean thigh weight and (\ln) body protein weight was the same over all dietary protein and lighting treatments, being represented by the equation $0.034 \pm 0.418 + 0.8336 \pm 0.0729$ g/g.

Drum weights (mean per bird) are in Table 3. Again, the weights were heavier in males (118 g) than in females (100 g) at 35 d. Neither dietary protein content ($b = 0.0595 \pm 0.0717$ g/g protein) nor daylength (-0.245 ± 0.364 g/h) influenced drum weight, and there was also no interaction between the two factors. However, when the allometric relationships between (\ln) drum weight and (\ln) body protein weight on different daylengths were compared, the equation for the three longest daylengths ($0.087 \pm 0.834 + 0.805 \pm 0.145$ g/g) differed from that for the 12 h treatment ($-2.303 \pm 1.18 + 1.224 \pm 0.207$ g/g). Such differences did not occur when the relationships on the different feed protein levels were compared, nor was there an interaction between daylength and feed protein level.

Table 3 Mean breast, thigh, drum and wing weights (g) of broilers at 35 d fed four levels of dietary protein and subjected to four lighting programmes

Light (h)	Feed protein content (g/kg)				Mean
	143	164	184	204	
Breast					
12	412	362	385	383	385
16	380	391	402	433	401
20	364	444	455	532	449
24	390	416	449	413	417
Mean	386	403	423	440	
RMS ¹			3409		
Thigh					
12	132	122	118	126	123
16	121	127	122	122	123
20	112	132	133	147	131
24	114	125	123	121	121
Mean	119	126	124	129	
RMS			359		
Drum					
12	109	107	98	120	108
16	112	112	104	117	111
20	104	116	108	111	110
24	98.2	118	105	103	106
Mean	105	113	104	113	
RMS			251		
Wing					
12	87.0	86.7	80.8	94.9	86.3
16	86.4	91.6	87.0	95.8	90.2
20	85.5	87.4	90.8	94.6	89.6
24	81.0	95.8	86.7	90.8	88.6
Mean	83.9	90.4	86.3	94.0	
RMS			139		

¹ RMS: Residual mean square, n = 96.

Mean wing weights of birds fed four levels of dietary protein content and reared under four lighting treatments to day 35 are given in Table 3. The mean weight for females was 84 g and for males, 94 g ($P < 0.001$). Whereas there were differences in wing weights between feed protein treatments ($P < 0.01$), when these weights were regressed against feed protein content the regression coefficient was not different from zero (0.116 ± 0.052 g/g). There was also no trend when wing weight was regressed against daylength (0.084 ± 0.270 g/h). There was no interaction between treatments for wing weight. The allometric regression between (\ln) wing weight and (\ln) body protein weight of $0.467 \pm 0.372 + 0.6995 \pm 0.0649$ g/g remained the same over all dietary protein and daylength treatments, and the interaction between them.

Table 4 Mean breast weight (g) as a proportion of body weight (g) and body protein weight (g) of broilers at 35 d fed one of four protein feeds and grown under different daylengths

Light (h)	Dietary protein content (g/kg feed)				Mean
	143	164	184	204	
Breast weight/body weight					
12	0.186	0.174	0.196	0.175	0.183
16	0.180	0.182	0.200	0.199	0.190
20	0.182	0.196	0.208	0.222	0.202
24	0.197	0.190	0.212	0.197	0.199
Mean	0.186	0.185	0.204	0.198	0.193
RMS					0.031
Breast weight/body protein weight					
12	1.35	1.25	1.33	1.19	1.28
16	1.30	1.24	1.36	1.29	1.30
20	1.27	1.36	1.45	1.50	1.40
24	1.34	1.29	1.40	1.29	1.33
Mean	1.32	1.28	1.38	1.32	
RMS					1.695

RMS: Residual mean square, n = 96.

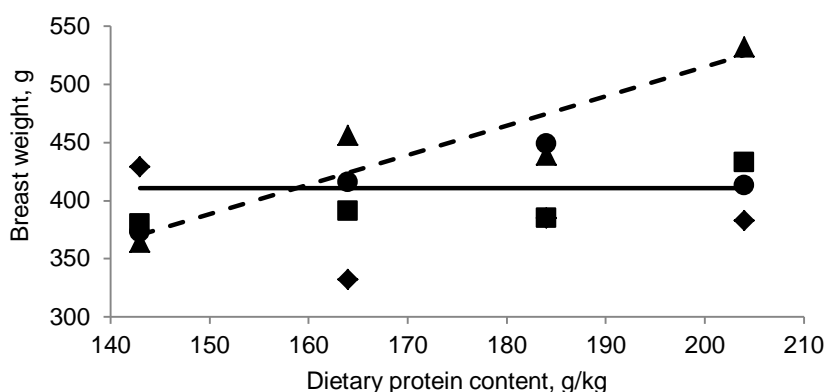


Figure 1 Response in breast weight (minus skin and bone) to increasing levels of dietary protein content for different daylengths. 12 h ♦; 16 h ■; 20 h ▲; 24 h ●. Broken line represents 20 h treatment; solid line represents the other three treatments.

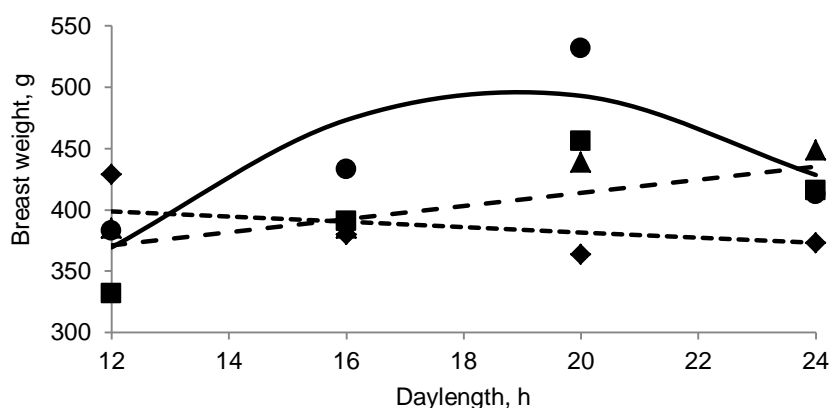


Figure 2 Response in breast weight (minus skin and bone) to increasing daylength on four dietary protein contents. Protein 143 ◆-----◆; 164 ■-----■; 184 ▲-----▲; 204 ●-----●.

Mean body protein and lipid contents of broilers at 35 d are in Table 5. There was no interaction ($P > 0.05$) between lighting programme and dietary protein content for either of these variables. Body protein content increased at the rate of 0.146 ± 0.035 g/kg as dietary protein content increased whereas body lipid content decreased (-0.696 ± 0.089 g/kg). Body protein also responded to daylength, increasing at the rate of 0.444 ± 0.188 g/kg per h, but body lipid was unaffected ($P > 0.05$).

Table 5 Mean body protein and lipid contents (g/kg) at 35 d of broilers fed four levels of dietary protein and subjected to four lighting treatments

Light (h)	Feed protein content (g/kg feed)				Mean
	143	164	184	204	
Body protein content (g/kg)					
12	138	140	148	146	143
16	139	147	147	155	147
20	143	145	144	148	145
24	146	148	152	153	149
Mean	141	145	148	150	
RMS					58.7
Body lipid content (g/kg)					
12	165	133	115	121	134
16	171	146	135	117	142
20	153	145	132	120	138
24	153	143	123	116	134
Mean	160	142	126	118	
RMS					403

RMS: Residual mean square; n = 96.

Discussion

The objective of the trial reported here was to determine whether breast meat yield would improve in broilers reared on short daylengths if higher levels of dietary protein were fed. This was in response to reports in the literature indicating that breast meat yield is reduced when short daylengths are used in rearing (Renden *et al.*, 1992; 1993; 1996; Downs *et al.*, 2006; Schwan-Lardner *et al.*, 2006; Brickett *et al.*, 2007; Lien *et al.*, 2007). Lewis *et al.* (2009) showed that feed intake was reduced on short days, suggesting that

insufficient protein may be consumed under these conditions to enable broilers to express their potential breast meat yield.

Neither BWG to 35 d nor feed intake was affected by the amount of light given to the birds. It has been demonstrated (Lewis *et al.*, 2009) that broilers learn to eat in the dark when subjected to daylengths shorter than 16 h, and this enables them to compensate for the reduced daylength. These results confirm those of Lewis *et al.* (2009; 2010) that broilers grow as well on short as on long days, and that their welfare, as judged in this case by mortality to 35 d, is jeopardised when long daylengths are used in the rearing period. FCE to 21 d was improved with the use of short daylengths although this advantage disappeared by 35 d, the lack of a significant trend possibly being the result of too few replications of the main treatments. Whereas the number of replications may have been insufficient for measuring differences in growth rate and FCE, significant differences between treatments were observed in the physical and chemical composition of broilers on the different treatments, this being the objective of the exercise.

The effects of the dietary and environmental treatments on breast meat yield were complex, and largely dependent on the method used to describe these effects. When viewed over all lighting treatments dietary protein content had no effect on breast meat yield except in those broilers receiving 20 h light/d. However, breast meat yield on the lighting treatments differed considerably depending on the dietary protein content given; decreasing on the lowest protein, increasing linearly on the next two protein levels (164 and 184 g/kg), and showing a curvilinear trend on the highest protein feed. Birds on 20 h of light and fed the highest protein content had considerably heavier breast weights than on any other treatment and could therefore have been regarded as being outliers, these results having a significant effect on the response to 20 h and 204 g protein/kg. However, these birds were also the heaviest birds sampled, thus, when breast weights were expressed as a proportion of body weight, or of body protein weight, differences between treatments were not as apparent. These differences all-but disappeared when the allometric relationship between breast weight and body protein weight were compared between treatments: the slope of this regression was the same in all treatments, but was adjusted upwards (higher constant term) in the case of broilers given 20 h light/d.

Emmans & Fisher (1986) and Danisman & Gous (2011) have argued that the logical way to predict the effects of genotype, feed and environment on the growth of breast meat and other body components is to express the component as a proportion of body protein growth. Potential protein growth rates have been described for various genotypes (Hancock *et al.*, 1995; Gous *et al.*, 1996) using a Gompertz growth function (Gous *et al.*, 1999) and simulation models already exist for predicting the actual growth of body protein as influenced by genotype, feed and environment (Emmans, 1981; EFG Software, 2007). Such models may therefore be used to predict the growth of any scaled component of the body, as any components that share the same rate of maturing can be scaled allometrically (Emmans, 1987; 1988). What is needed for each genotype is a description of the potential rates of growth of body protein and of the different components of the body so that the allometric relationships between the important components of the body and body protein can be determined. Differences in the allometric relationships between genotypes, or those brought about through nutritional or environmental manipulation would enable these effects to be modelled. The results reported here do not disprove the hypothesis that the allometric regression coefficient between breast weight and body protein weight is the same under all circumstances, and that differences in the constant term may be brought about by different nutritional or environmental conditions.

Danisman & Gous (2011; 2013) suggested that the shift in constant term was due to an increased amount of body lipid being deposited in the different components of the body when birds are placed on low protein feeds. In this trial, body lipid content decreased, as predicted, but in addition, body protein content increased with dietary protein content. Body protein also increased with daylength whereas body lipid was unaffected. Increases in body protein would result in increased breast weights, as described by the allometric coefficient given above, whereas increased body lipid growth would change the constant term in the allometric equation. Because body lipid was unaffected by daylength, these results do not provide substantial underlying evidence that the constant term in the allometric equation may be altered by different daylengths. Some other explanation is needed to model the reduction in breast meat yield in broilers reared on daylengths shorter than 20 h.

The response in thigh weight to dietary protein and to daylength was interesting, and similar to that in breast weight, with the weights increasing with daylength in birds fed the three highest dietary protein levels, but with birds on the lowest protein exhibiting reduced thigh weights as daylength was increased. Unlike the case with breast meat, the allometric relationship between thigh weight and body protein weight was the same over all dietary protein and lighting treatments, differences in lipid content between treatments presumably being less than in the trials by Danisman & Gous (2011; 2013) where the constant term in this relationship was shifted upwards when broilers were fed the lowest protein feeds.

Drum weights were unaffected by dietary protein content and daylength, and there was also no interaction between the two factors. However, the allometric equation describing drum weight in terms of body protein weight for the three longest daylengths differed from that for the 12 h treatment, the latter starting at a lower constant term but with a steeper slope than the equation for the other treatments. It is unusual for the slope of the allometric regression for drum weight to differ between treatments: when comparing different genotypes, sexes and feed protein levels in two extensive trials, Danisman & Gous (2011; 2013) showed only one instance where the allometric regression coefficients differed, and this was between four genotypes and not between sexes or dietary protein levels. In this trial also, no differences in the allometric relationship between drum and body protein were evident between different feed protein levels, nor was there an interaction between daylength and feed protein level. The difference observed here may have been an anomaly of the data collected rather than a true effect of different daylengths, given both the prior evidence with drum weight and the lack of such differences with the other component weights in this trial.

Whereas there were differences in wing weights between feed protein treatments as revealed using ANOVA, when these weights were regressed against feed protein content the regression coefficient was not different from zero. There was also no trend when wing weight was regressed against daylength. It is important to bear in mind that the trial conducted here was a response trial where the levels of the treatments are not independent, and hence the trends resulting from the imposition of dietary protein levels and daylengths are of importance, and not whether there are differences between treatment means (see Morris, 1983; 1999). As with thigh weight, the allometric regression between wing weight and body protein weight remained the same over all dietary protein and daylength treatments. This confirms the results of the trials reported by Danisman & Gous (2011; 2013) although Brickett *et al.* (2007) reported that drum and wing weights at 35 d were heavier on their low protein diet.

Conclusion

Breast meat yield from birds reared on 12 h was not improved when these birds were fed high protein feeds whereas yields were increased in birds on the three longer daylengths used when feed protein was increased. The decreased breast meat yield in broilers given short daylengths is therefore not the consequence of a shortage of dietary protein. Nevertheless, the allometric regression between breast meat and body protein content remained the same for all daylengths used thus confirming that breast meat yield may be accurately predicted from body protein weight.

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