EFFECT OF QUALITATIVE FEED RESTRICTION ON PULLET DEVELOPMENT AND SUBSEQUENT EGG PRODUCTION.

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ABSTRACT

The effect of feeding different protein levels during the rearing and development of egg-type pullets as well as on eventual egg production was investigated in two experiments. In experiment 1, the dietary crude protein (CP) regimens (and notations) in isocaloric diets for the periods 0-8 weeks and 9-20 weeks respectively for treatment 1: 20% and 16% (20:16), treatment 2: 16% and 16% (16:16), treatment 3: 12% and 12% (12:12), treatment 4: 16% and 12% (16:12), treatment 5: 20% and 12% (20:12) and for treatment 6 the regimens comprised 20% for 0-8 weeks, 16% for 9-16 weeks and 12% for 17-20 weeks (20:16:12). In experiment 2, treatments 1 to 5 for experiments 1 were repeated while three step- up dietary treatments 6,7 and 8 were evaluated in addition. For the periods 0-8 weeks and 9-20 weeks respectively, the CP regimens for treatments 6 were 12% and 16% (12:16); treatment 7, 12% and 20% (12:20) and for treatment 8, 16% and 20% (16:20). From 20 weeks in each experiment, a common layer diet containing 16% CP and 2,449 Kcals metabolisable energy per kg was fed *ad libitum* to all treatments and the subsequent egg production was monitored for a further 16 weeks. Both studies indicated that egg-type chickens fed diets with a drastic protein restriction (12%) in the starting period (0-8 weeks) had significantly reduced body weights at 20 weeks and delayed sexual maturity. However, when such birds were subsequently (9-20 weeks) offered diets with higher protein content, significant compensatory effects on weight gain and feed conversion were indicated. The step-up CP regimens in experiment 2 performed as well as their conventional step-down controls (i.e. 16:20 Vs 20:16, 12:20, Vs 20:12, 12:16 Vs 16:12). The single step 16% CP (16:16) regimen was found adequate for raising pullets from day old to point of lay.

INTRODUCTION

The constantly increasing cost of compounded animal feed coupled with the scarcity of most of the feed ingredients especially protein sources make research into feed restriction of both pullets and laying hens a necessity in developing countries. Reducing the protein levels of feed used in rearing pullets from day-old to point of lay will result in the reduction of the cost of producing eggs.

Considerable research effort has been devoted to the use of low dietary protein levels for growing egg-type pullets. Balnave (1973, 1974), Christmas *et al.* (1974) and Douglas *et al* (1973) have reported reduced body weight at laying age and delayed sexual maturity as a result of feeding low protein diets during the growing period. Little or no effect on subsequent rate of egg production was reported.

Summers and Leeson (1978) reported that protein intake was positively associated with the age of growing pullets and developed a step-up protein feeding programme for egg-type pullets that resulted in significantly smaller pullets at 20 weeks of age, having consumed less protein and energy to point of lay. In the laying house, the birds also consumed less feed, had smaller egg size, greater egg shell deformation and laid similar numbers of eggs when compared with conventionally (step- down protein) fed pullets.

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From further studies, Leeson and Summers (1980, 1982) and Doran *et al*. (1983) reported significantly depressed 20-week body weights from step-up protein feeding regimens that consisted of feeding a 12% crude protein diet for the first 12 weeks of life followed by a 16% crude protein diet through 16 weeks and 19% crude protein diet in 19 or 20 weeks of age. Using brown egg-type pullets, Maurice *et al*. (1982) did not demonstrate the significant depression in 20-week body weight from feeding a 12.5% crude protein diet for the first 6 weeks of life, a 16% crude protein to 14 weeks and 18.6% crude protein diet to 20 weeks of age.

This study was designed to evaluate the use of low protein diets as well as step-up protein feeding programme in the rearing of pullets. Also the effect of such regimens imposed during rearing on subsequent egg production was monitored.

MATERIALS AND METHODS

Two experiments were conducted to evaluate the effect of qualitative feed restriction (or dietary protein restriction) on the rate of pullet development and subsequent egg production. In the first experiment, single stage protein regimens and multiple stage step-down protein regimens were used while in the second experiment, a step-up protein regimen was introduced in addition to the two (single step-up and step-down) regimens used in experiment 1.

Experiment 1

Nine hundred day-old Babcock 380 pullets were obtained from a local hatchery and reared in 18 deep litter pens in a tropical-type open-sided poultry house providing 0.074m^2/bird. The birds were weighed in groups of 50 and alloted to each pen or replicate. Heat for brooding was supplied by kerosine fuelled lanterns; two were used in each pen. Three randomly selected replicates were fed one of the six protein regimens.

During the rearing period (0-20 weeks) different dietary protein regimens were fed. A conventional two-stage step-down protein regimen was fed as control in Treatment 1; single stage protein regimens were fed in treatments 2 and 3; two stage step-down regimens were fed in treatments 4 and 5 while a three-stage step-down protein regimen was fed in treatment 6. The protein levels fed for specific periods (and summary notation) in each treatment were as follows:

Treatment 1 (control): 20% protein diet (0-8 weeks), 16% protein diet (9-20 weeks (20:16).

Treatment 2: 16% protein diet (0-20 weeks), (16:16).

TABLE 1. COMPOSITION OF STARTER AND GROWER DIETS FED IN EXPERIMENTS 1 AND 2.

Ingredients	Diets 1	Diets 2	Diets 3
Maize	52.50	58.30	64.30
Groundnut cake	28.40	15.60	3.30
Wheat bran	15.70	23.70	30.00
Bone meal	3.00	2.00	2.00
Common salt	0.25	0.25	0.25
Premix[a]	0.15	0.15	0.15
Total	100.00	100.00	100.00
Calculated Analysis			
Crude Protein, %	20.00	1600	12.01
Metabolizable Energy (Kcals)	2649	2647	2649
Calcium, %	0.95	0.65	0.60
Phosphorus, available, %	0.55	0.43	0.42
Lysine, %	0.85	0.61	0.45
Methionine + Cystine, %	0.63	0.54	0.47
Crude Fibre, %	6.57	5.92	5.14
Feed cost in ₦/Kg diet	0.59	0.55	0.52

[a] Zoodry VM 201 was used and supplied the following per kg of ration: Vitamin A (stabilized) 10,005 I.U.; Vitamin D3 (stabilized) 2,250 I.U., Vitamin E (stabilized) 5.01 I.U.; Vitamin K (stabilized) 2.01 mg; Vitamin B2 4.50mg; Vitamin B6 3.0 mg; Nicotinic acid 22.005 mg; Calcium D-Pantotnenate 6.0 mg; Vitamin B12 0.012 mg; Choline chloride 200.10 mg; D.O.T. (3, 5-dinitro ortho-toluamide) 100.05 mg; Manganese 80.9 mg; Iron, 50.01, mg; Copper 2.4 mg; Iodine 1.40 mg; Cobalt 0.201 mg; Selenium 0.051 mg.

Treatment 3: 12% protein diet (0-20 weeks), (12:12).
Treatment 4: 16% protein diet (0-8 weeks), 12% protein diet (9-20 weeks) (16:12).
Treatment 5: 20% protein diet (0-8 weeks), 12% protein diet (9-20 weeks) (20:12).
Treatment 6: 20% protein diet (0-8 weeks), 16% protein diet (9-16 weeks) 12% protein diet (17-20 weeks) (20:16:12).

The compostition of the different diets fed during the experiment is shown in Table 1. Feed and water were provided *ad libitum* and conventional brooding and rearing procedures were adopted throughout the starting, growing and developing periods. The growth rate, feed intake and efficiency of the birds were monitored monthly.

At 20 weeks of age, 40 pullets from each replicate were randomly selected and transferred from the growing house into two-tier laying battery cages in a tropical- type laying poultry house. The cages measured 30 x 35.5 x 41.5 cm and housed 2 birds per cell. The birds were left in the same treatment groups as in the growing phase. Artificial light was not provided during the laying period. A common layer ration shown in Table 2 was offered to all replicates from 20 weeks. Daily egg production and monthly feed intake records were kept on treatment groups. Also monitored were days to first egg (i.e. the average number of days for birds in each replicate to their first egg) and 50% egg production (the average of ages of birds for the three replicates when they first attained 50% production level for three consecutive days) as well as body weight changes at 36 weeks and egg weight (average weight of all eggs laid for three consecutive days in every week).

Experiment 2

This experiment was carried out to confirm the results of the first experiment as well as investigate the effect of stepping-up the level of protein in diets of growing pullets fed to birds initially placed on low dietary protein levels.

Four hundred and eighty day-old chicks were randomly allocated to twenty-four deep- litter pens with twenty birds per pen. Three such pens constituted a treatment and were fed one of the eight dietary protein regimens. Treatments 1 to 5 were the same as in Experiment 1, Treatment 6 in Experiment 1 was dropped and three step-up protein treatments were added as follows:
Treatment 6: 12% protein diet (0-8 weeks), 16% protein diet (9-20 weeks) (12:16).
Treatment 7: 12% protein diet (0-8 weeks), 20% protein diet (9-20 weeks) (12:20).
Treatment 8: 16% protein diet (0-8 weeks), 20% protein diet (9-20 weeks) (16:20).

As in experiment 1, 15 pullets from each replicate were randomly selected and transferred to battery cages at 20 weeks and fed a common laying diet (Table 2) for 16 additional weeks. The birds were not randomised among treatment

TABLE 2. COMPOSITION OF LAYER'S DIET IN EXPERIMENTS 1 AND 2.

Ingredients	%
Maize	52.15
Groundnut cake	18.25
Wheat bran	19.70
Bone meal	2.15
Limestone	7.10
Common salt	0.25
Premix[a]	0.20
Methionine	0.20
Calculated Analysis	
Crude Protein, %	16.01
Metabolizable Energy (Kcals/Kg diet)	2449
Calcium, %	3.41
Phosphorus, available, %	0.43
Lysine, %	0.63
Methionine + Cystine, %	0.61
Crude Fibre, %	5.69
Feed cost in ₦/Kg diet	0.71

[a]Zoodry VM 301 premix (from Messrs Roche Nigeria Ltd.) used supplied the following per kg of ration: Vitamin A (stabilized 10,000 I.U.; Vitamin D_3 (stabilized) 2,010 I.U.; Vitamine E (stabilized) 10,000 I.U.; Vitamin K 2.01 mg; Vitamin B_2 4.5 mg; Vitamin B_6 3.0 mg; Nicotinic acid 25.005 mg; Calcium D-Pantothenate 8.01 mg; Vitamin B_{12} 0.012 mg; Vitamin C 20.01 mg; Choline Chloride 200.1 mg; Manganese 100.005; Iron 50.01 mg; Zinc 40.005 mg; Copper 2.4 mg; Iodine 1.401 mg; Cobalt 0.201 mg; Selenium 0.051 mg.

TABLE 3: EFFECT OF QUALITATIVE FEED RESTRICTION ON GROWTH PERFORMANCE EVALUATED IN EXPERIMENT 1.

CP Regimens Traits	Treatments[1] 1 20:16	2 16:16	3 12:12	4 12:12	5 20:12	6 20:16:12	SEM[2]
Feed intake (0-8 weeks), g/bird	1219[a]	1131[ab]	1039[b]	1171[a]	1198[a]	1193[a]	32
Feed efficiency (0-8 weeks), g feed/g gain	3.79[b]	4.10[b]	5.61[a]	4.15[b]	3.75[b]	3.83[b]	0.15
Weight gain (0-8 weeks), g.	323[a]	277[b]	186[c]	284[b]	319[a]	311[ab]	10
Feed Cost/Kg gain (0-8 weeks), N	2.24[b]	2.27[b]	2.90[a]	2.27[b]	2.21[b]	2.26[b]	0.08
Feed intake (9-20 weeks), g/bird	4926[ab]	4727[ab]	4275[c]	4650[b]	4630[b]	4981[a]	98
Feed efficiency (9-20 weeks), g feed/g gain	5.65[ab]	4.49[b]	6.05[a]	6.77[a]	6.53[a]	6.53[a]	0.377
Weight gain (9-20 weeks), g	881[ab]	1024[a]	708[b]	698[b]	712[b]	795[b]	55
Feed Cost/Kg gain (9-20 weeks), N	3.12	2.59	3.13	3.51	3.38	3.41	0.21
Feed intake (0-20 weeks), g/bird	6146[a]	5857[a]	5314[b]	5821[a]	5827[a]	6174[a]	107
Feed efficiency (0-20 weeks), g feed/g gain	5.12[bc]	4.50[c]	5.96[a]	5.96[a]	5.66[a]	5.60[ab]	0.23
Weight gain (0-20 weeks), g	1204[a]	1301[a]	894[c]	982[bc]	1031[bc]	1106[ab]	49
Feed Cost/Kg gain (0-20 weeks), N	5.36[bc]	4.86[c]	6.04[a]	5.73[b]	5.59[b]	5.67[b]	0.20
Mortality (0-20 weeks), %	4.00[b]	5.33[b]	6.67[b]	10.00[b]	6.00[b]	4.00[b]	0.90

[1]Means within rows with different superscripts are significantly different (P.05).
[2]SEM = Standard error of the means.

but made to retain their original treatment groups.

Management and data collection

Brooding, rearing and laying house management programmes as well as variables monitored were similar to those decribed for Experiment 1. Data obtained from both experiments were summarised and subjected to analysis of variance and the New Multiple Range Test was used to separate means when statistical significance was indicated for treatment.

RESULTS

Experiment 1

The results obtained in this experiment are summarized in Tables 3 and 4. For the starting period (0-8 weeks), the level of crude protein (CP) offered to the birds is crucial to the initial growth of the birds. A significant depression ($P < 0.05$) in weight gain was obtained when 12% CP diet (Treatment 3) was fed. Chicks fed starter diets containing 20% CP (Treatments 1,5 and 6) had significantly ($P < 0.05$) higher weight gains among the treatments but did not significantly vary from those fed 16% CP (Treatments 2 and 4) in feed efficiency. Birds started on 12% CP (Treatment 3) showed significantly ($P < 0.05$) depressed body weight gain and feed efficiency when compared to the other treatments. For the period, 9-20 weeks, birds on treatments 4 (16:12) and 5(20:12) fed 12% CP diet were comparable in measured parameters to those fed the control dietary treatment (20:16) containing 16% CP. There was also no significant ($P > 0.05$) difference between treatments 1 (20:16) and 6 (20:16:12) in all measured parameters indicating that no advantage was obtained in using a two-step protein regimen (in treatment 6) over the conventional single step protein in the control (treatment 1) during the period 9-20 weeks.

Comparing the overall effects of the different protein levels fed from day old to 20 weeks, performances of treatments 2 (16:16) and 6 (20:16:12) were similar ($P > 0.05$) to that of treatment 1 (20:16) while treatment 3 (12:12) significantly ($P < 0.05$) depressed weight gain, feed

TABLE 4: EFFECT OF QUALITATIVE FEED RESTRICTION ON VARIOUS LAYING PERFORMANCE TRAITS EVALUATED IN EXPERIMENT 1

CP Regimens	Treatmets[1] 1 20:16	2 16:16	3 12:12	4 12:12	5 20:12	6 20:16:12	SEM[2]
Characteristics							
Hen day production, %	61.7	56.3	54.09	59.87	57.5	60.8	4.12
Hen housed production, %	60.6	55.3	52.5	58.00	55.2	58.6	4.1
Days to first egg	170[b]	173[ab]	179[a]	176[ab]	171[b]	172[b]	1.98
Days to 50% production	188[b]	190[b]	197[a]	192[b]	191[b]	193[ab]	1.80
Feed consumption to 50% production, kg/bird	12.14	11.92	12.37	12.60	12.32	12.75	0.53
Cumulative Feed Consumption (0-36 weeks), kg.bird	19.88	19.42	19.41	19.85	19.87	19.83	0.67
Feed conversion, kg. feed/doz. eggs	1.62	1.68	1.86	1.78	1.69	1.92	0.44
Feed conversion, kg feed/kg eggs	2.53	2.62	2.89	2.83	2.68	3.05	0.45
Egg weight g	53.50	54.43	52.67	52.98	52.60	53.19	4.36
Weight of birds at 20 weeks, kg	1.24[a]	1.34[a]	0.93[bc]	1.02[bc]	1.07[bc]	1.14[ab]	0.14
Weight of birds at 36 weeks, kg	1.74	1.69	1.72	1.73	1.67	1.70	0.08
Laying House mortality, %	0.70	0.00	0.00	0.00	0.00	0.00	0.28

1Means within rows with different superscripts are significantly different (P < 0-.05).
2SEM = Standard Error of the means.

intake and conversion. Among the treatments fed 12% CP in the period 9-20 weeks (i.e treatments 3, 4, 5) no significant differences were evident in weight gain and feed efficiency at 20 weeks irrespective of the protein level fed in the starter period. The overall effect of feeding 12% CP to starting and developing pullets was in general significantly restrictive in weight gain and feed conversion to 20 weeks when compared to treatments in which either 16% or 20% CP was fed (treatments 1,2 and 6). In terms of cost of feed used in raising the birds to 20 weeks of age, treatment 2 (16:16) was the least expensive but was not significantly (P > 0.05) cheaper than the cost of using the control treatment (20:16). However, birds on treatments in which 12% CP was fed at any stage of development (treatments 3, 4, 5, 6) were significanlty more expensive to feed to 20 weeks than treatment 2 (16:16). Mortality rates showed significant (P < 0.05) differences but it was indeed unclear if the differences were attributed to dietary regimens.

For the laying phase (Table 4), the use of different protein regimens in the pre- lay period (0-20 weeks) resulted in significant effects in age to sexual maturity (first eggs) but not in total egg production in 16 weeks of lay. Birds on treatment 3 (12:12) laid their first egg nine days later (P < 0.05) than the controls (20:16). It is however noteworthy that the cummulative feed consumption from day-old to 36 weeks of age did not vary among treatments nor did the weight of birds at 36 weeks even though the 20-week weights showed significant differences. This may have been indicative of compensation in feed intake and weight gain resulting from increased CP content of the layer diet (16% CP) for the groups to which 12% CP diets were fed from 0- 20 weeks (treatment 3) or 9-20 weeks (treatments 4 and 5). Other evaluated characteristics such as egg weight, laying house mortality, feed conversion and hen- housed egg production did not differ significantly (P > 0.05) among treatments.

Experiment 2

Results from this experiment are summarized in Tables 5 and 6. Performances obtained for treat-

TABLE 5: EFFECT OF QUALITATIVE FEED RESTRICTION ON GROWTH PERFORMANCE EVALUATED IN EXPERIMENT 2

CP Regimens	Treatments[1]								SEM[2]
	1 20:16	2 16:16	3 12:12	4 16:12	5 20:12	6 12:16	7 12:20	8 16:20	
Traits									
Feed intake (0-8 weeks), g/bird	1111^{ab}	065^{b}	996^{c}	1118^{ab}	1158^{a}	955^{c}	937^{c}	1093^{ab}	24
Feed efficiency (0-8 weeks), g feed/g gain	3.37^{c}	3.98^{b}	4.82^{a}	4.03^{b}	3.17^{c}	4.88^{a}	4.71^{a}	4.19^{b}	0.12
Weight gain (0-8 weeks), g.	331^{ab}	268^{c}	212^{d}	277^{c}	366^{a}	196^{d}	199^{d}	294^{bc}	15
Cost/Kg gain (0-8 weeks), N	1.99^{a}	2.20^{b}	2.50^{cd}	2.23^{b}	1.87^{a}	2.53^{d}	2.44^{cd}	2.32^{bc}	0.06
Feed intake (9-20 weeks), g/bird	4869^{cd}	4958^{cd}	4968^{cd}	4936^{cd}	5128^{bc}	4757^{d}	5525^{a}	5325^{ab}	106
Feed efficiency (9-20 weeks), g feed/g gain	5.60^{c}	6.17^{b}	7.45^{a}	7.31^{a}	7.14^{a}	5.78^{bc}	5.94^{bc}	6.19^{b}	0.17
Weight gain (9-20 weeks), g	870^{ab}	804^{b}	667^{c}	675^{c}	719^{a}	825^{b}	932^{a}	865^{ab}	25.00
Cost/Kg gain (9-20 weeks), N	3.10^{a}	3.41^{bc}	3.86^{c}	3.79^{c}	3.70^{de}	3.19^{ab}	3.50^{cd}	3.65^{cde}	0.08
Feed intake (0-20 weeks), g/bird	5980^{bc}	6020^{bc}	5992^{bc}	6054^{bc}	$6286b^{ab}$	5712^{c}	6461^{a}	6418^{a}	117
Feed efficiency (0-20 weeks), g feed/g gain	4.99^{d}	5.62^{c}	6.82^{a}	6.36^{b}	5.80^{d}	5.60^{f}	5.72^{c}	5.72^{c}	0.14
Weight gain (0-20 weeks), g	1201^{a}	1071^{bc}	879^{c}	952^{de}	1085^{bc}	1021^{cd}	1131^{ab}	1126^{ab}	28
Cost/Kg gain (0-20 weeks), ₦	5.09^{a}	5.60^{a}	6.36^{a}	5.01^{a}	5.57^{b}	5.71^{bc}	5.94^{bc}	5.97^{bcd}	0.14
Mortality (0-20 weeks), %	2.78	5.00	3.33	0.00	6.67	0.00	3.33	2.20	1.88

[1]Means within rows with different superscripts are significantly different ($P < .05$).
[2]SEM = Standard Error of the means.

TABLE 6. EFFECT OF QUALITATIVE FEED RESTRICTION ON VARIOUS LAYING PERFORMANCE TRAITS EVALUATED IN EXPERIMENT 2

CP Regimens	Treatments[1]								SEM[2]
	1 20:16	2 16:16	3 12:12	4 16:12	5 20:12	6 12:16	7 12:20	8 16:20	
Traits									
Hen-day production, %	63.2	63.2	60.7	61.3	62.2	62.1	61.7	66.7	3.20
Hen-housed production, %	61.3	62.8	57.8	58.9	60.3	60.9	59.4	65.8	2.99
Days to first egg	160^{b}	160^{b}	172^{a}	168^{ab}	160^{b}	170^{a}	165^{ab}	161^{b}	2.70
Days to 50% production	183^{b}	185^{b}	195^{a}	190^{a}	183^{b}	190^{a}	189^{ab}	188^{ab}	2.83
Feed consumption to 50% production, kg/bird	10.44^{c}	11.36^{ab}	11.87^{a}	11.21^{ab}	10.79^{bc}	10.87^{bc}	11.54^{ab}	11.28^{ab}	0.39
Feed Consumption (0-8 weeks), kg/bird	19.25	19.60	19.02	19.64	20.03	18.49	19.68	19.46	0.48
Feed conversion, kg feed/dozen eggs	3.19	3.45	4.28	3.98	3.10	3.59	3.40	3.04	0.40
Feed conversion, kg feed/kg eggs	2.10	2.10	2.42	2.21	2.05	2.10	1.91	1.74	0.36
Egg weight, g	54.45	55.41	53.21	53.14	53.01	54.16	55.01	55.16	1.45
Weight of birds at 20 weeks, kg	1.24^{a}	1.11^{bc}	0.92^{c}	0.99^{de}	1.12^{bc}	1.12^{cd}	1.17^{ab}	1.16^{ab}	0.16
Weight of birds at 36 weeks, kg	1.74	1.71	1.70	1.69	1.73	1.71	1.74	1.67	0.04
Laying House mortality, %	8.51	1.66	7.12	5.19	7.22	5.00	8.33	5.00	2.28

[1]Means within rows with different superscripts are significantly different ($P < .05$).
[2]SEM = Standard Error of the means.

ments 1-5 show as for corresponding treatments in experiment 1 that treatment 3 (12:12) depressed growth rate, feed conversion to 20 weeks and delayed sexual maturity, that the birds fed the 16% CP diet from day old to 20 weeks (treatment 2) reached sexual maturity, laid similar number of eggs, had comparable feed conversion as the conventional control (treatment 1).

For the period, 0-8 weeks, 12% CP diets as fed in treatments 3, 6 and 7 consistently significantly (P.05) depressed growth rate, feed intake and conversion when compared to treatments in which 16% CP diet (treatments 2, 4 and 8) or 20% CP diet (treatments 1 and 5) was fed. In the growing - developing period (9-20 weeks), treatments fed 12% CP (3, 4 and 5) had comparable feed intakes and conversion as well as weight gain; the weight gain and feed efficiency being significantly $(P<0.05)$ lower than in treatments in which 16% or 20% CP diet was fed. For the cummulative period (0-20 weeks), dietary regimens in which 12% CP was fed in the starter period (0- 8 weeks) and a higher CP diet fed in the period 9-20 weeks (i.e. treatments 6 and 7) had significantly $(P<0.05)$ higher weight gain and better feed efficiency than treatment 3 (12:12) suggesting a compensatory effect of the higher dietary protein level fed in the period 9-20 weeks.

Among the step-up regimens, the treatments fed 20% CP from 9-20 weeks (treatments 7 and 8) cumulatively consumed more feed and gained more weight $(P<0.05)$, non-significantly $(P>0.05)$ varied in feed conversion and cost of feed per unit of gain when compared to treatment 6 (12:16).

For the laying phase (Table 6), the use of different dietary protein regimens during the growing phase of the pullets had a significant $(P<0.05)$ effect on the attainment of sexual maturity when measured as days to first egg or to 50% production. Birds started with 12% CP (treatments 3, 6 and 7) were significantly late in attaining sexual maturity and this delay was reduced if higher CP diet was fed from 9-20 weeks. For example, treatments 3 (12:12), 6 (12:16) and 7 (12:20) laid first eggs at 172, 170 and 165 days respectively. On the other hand, birds started with 16% CP in treatments 2 (16:16), 4 (16:12) and 8 (16:20) laid first eggs on days 160, 168 and 161 respectively. It is significant to note that treatment 5 (20:12) laid the first egg at 160 days and attained 50% egg production at 183 days, times similar to those of the control treatment 1 (20:16) indicating that 12% CP can be used for growing birds from 9-20 weeks provided the diet in the starting period (0-8 weeks) was 20% CP. While the body weight of the pullets at 20 weeks was affected by dietary protein regimen, the weights at 36 weeks following *ad libitum* feeding of 16% CP laying chicken diet were comparable for all treatments, again indicating some compensation.

Comparing the step-up protein regimens with their corresponding step-down regimens (12:16 Vs 16:12), (12:20 Vs 20:12) and (16:20 Vs 20:16), it was evident that there was no significant difference in the measured characteristics.

DISCUSSION

In the two experiments, a crude protein level of 12% was found to be inadequate to support the growth of the birds between 0-8 weeks, but could be used for birds between 9-20 weeks. This is in agreements with the findings of Carlson and Nelson (1981), who recommended that diets not higher than 12% protein need be used for growing layer type pullets after 10 weeks of age. Birds on treatments in which 12% CP diet was fed from 0-8 weeks grew poorly, consumed significantly $(P<0.05)$ less feed than their counterparts on 20 or 16% protein probably because of their relatively smaller size. The less the feed consumed, the less the weight gained by these birds. This clearly shows that pullets require a protein level higher than 12% between 0-8 weeks for proper growth as indicated by Scott *et al.* (1976) and NRC (1984).

For the period 9-20 weeks, the results of the two experiments showed that a grower mash of 12% protein was able to support pullet growth. Birds that received 12% protein from 0 to 20 weeks (treatment 3) consumed the least feed and gained the least weight at the end of 20 weeks. Similar results were reported by Douglas *et al.* (1973), Christmas *et al.* (1974) and Carlson and

Nelson (1981). Efficiency of feed utilization and cost per unit gain were also poor for these birds. From the two experiments, it was evident that dietary protein restriction reduced 20-week body weights of the birds, particularly in the birds fed 12% CP in the growing period (9- 20 weeks) as was also reported by Blair *et al.* (1970), Douglas and Harms (1976) and Carlson and Nelson (1981).

For the step-up protein regimens in experiment 2, treatment 6 (12:16) reduced the body weight of the birds at 20 weeks while treatments 7 (12:20) and 8 (16:20) produced weights comparable to that of the control treatment (20:16). This was contrary to results of Leeson and Summers (1980, 1982); Doran *et al.* (1983); and Robinson *et al.* (1986). These workers observed significant decreases in the weight of chickens fed step-up regimens to 20 weeks. The differences in results may be due to the type of strain used. These workers used white egg-type strain of pullets while brown egg strain of pullets was used for this study. Results reported by Maurice *et al.* (1982) who used brown egg strain pullets were similar to the results of this experiment, as they did not observe a significant reduction in weight gain.

The single-stage 16% crude protein diet (treatment 2) was found to be comparable in effect to the control treatment and in addition had the advantage of simplicity. Leeson and Summers (1982) reared pullets on 14% protein from day old and obtained comparable body weights at 20 weeks with the control birds which were fed the conventional step-down protein regimen. This performance was therefore achieved with a lower protein intake during the rearing phase.

In experiment 1, the effect of protein restriction on subsequent egg production indicated that birds fed 12% CP in the starter phase (0-8 weeks) reached sexual maturity late. The single-stage 16% protein regimen (treatment 2) performed as well as the conventional step-down protein regimen fed to the control birds (Treatment 1). No reduction in body weight was recorded at 20 weeks nor at 36 weeks. Interestingly, birds fed 20% CP during 0-8 weeks and 12% CP from 9-20 weeks (Treatment 5) came into lay about the same time as the control birds a trend confirmed in experiment 2. A calculation of protein intake to 20 weeks in experiment 1 indicates that the birds on the control treatment consumed about 1032 g protein as against 795 g for the birds on treatment 5. This clearly supports the contention of Leeson and Summers (1982) that unrestricted birds consume more protein than they require.

In Experiment 2, birds fed the restricted diets had lower 20-week body weights than the conventional control and these were significant for treatments 2 to 5. Despite this, treatments 2 (16:16) and 5 (20:12) did not delay sexual maturity and eventually laid as well as the control birds.

It is therefore evident from both experiments that a single-stage 16% dietary protein regimen is adequate to raise birds to point of lay. Also a 12% dietary crude protein level is adequate for raising birds from 9 weeks to point of lay, with no negative effects on eventual egg production. However, the birds must be started (0-8 weeks) on a diet containing 20% crude protein. This study also indicates that while dietary protein restriction reduces the body weight of birds at 20 weeks, the birds have the capacity to compensate for lost feed intake and body weight when *ad libitum* feeding is introduced during lay as the cumulative feed consumption (0-36 weeks) and final body weights for all treatments were comparable in both experiments. Bish *et al.* (1984) had indicated compensatory growth in pullets fed 12% CP from 0 to 6 weeks and subsequently fed higher protein levels, a trend similar to that described in this study. To sustain the advantages from feed restriction during rearing, it seems necessary that some controlled feed restriction, may be imposed during the laying phase to reduce overconsumption of protein and energy.

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