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ORIGINAL ARTICLE

Effects of Growth curves on Performance and Body Conformation traits in broiler breeder pullets

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ABSTRACT
The present study was undertaken to evaluate the effects of two growth curves (concave and linear) during the growing period (6-20 weeks) on body weight (BW) and body conformation traits of broiler birds of coloured synthetic female line (CSFL). Two hundred eighty-eight CSFL pullets were divided into low body weight (LB) group (550-850g) and high body weight (HB) group (851-1120g) on the basis of 5th week BW. The pullets of each BW group were distributed in six replicate groups having 24 pullets each. Three replicate groups from each BW group were reared on a linear growth curve whereas other three groups were reared on a concave growth curve. Feed consumption was recorded at weekly interval. Body weight, shank length and keel length were measured at 5th, 15th and 20th week of age. The BW gain of LB groups was significantly higher than HB groups. At 15th week, BW of linear groups was significantly higher than concave groups. At 20th week, BW of all the treatment groups was lower than the target BW. The shank length and keel length of concave groups were lower than the linear groups. Lower values of cumulative feed conversion ratio, protein and energy efficiency ratios were recorded for the concave growth curve groups than linear growth curve groups. It was concluded that feeding broiler breeder pullets through a concave growth curve improved feed efficiency and reduced cost of feeding as compared to pullets raised under linear growth curve.
Keywords; *Feed efficiency, Growth curves, Keel length, Shank length*

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INTRODUCTION

Proper management practices of broiler breeders include feed restriction both during rearing and breeding periods to limit the body weight (BW) gains and reduce the incidence of obesity, so as to improve egg production. Broiler breeders are fed on a controlled diet from 3 or 5 weeks onwards to attain a target BW at 20 weeks of age to maximize egg production [1]. Feeding programs that best controlled BW during the growing and laying period resulted in improved female fertility. The target BW at maturity can be achieved by using various growth curves such as linear, concave, convex or sigmoid. The objective of following different growth curves is to allow desired BW gain during different stages of growth without compromising the final target BW. Different growth curves may result in changes in body composition and performance [2-5]. However, considering the findings of different workers on the effects of restricted feeding through different growth curves on the performance of breeder pullets, the present investigation was planned to study the effects of two growth curves (concave and linear) during the growing period (6 to 20 weeks) on the performance of female broiler breeders.

MATERIALS AND METHODS

Experimental birds and management

Two hundred eighty-eight (288) broiler breeder pullets of a coloured synthetic female line (CSFL) fed *ad libitum*, a common starter diet up to 5 weeks of age were divided into low body weight (LB) group (550g to 850g) and high body weight (HB) group (851g to 1120g) on the basis of 5th week BW. The pullets of each BW group were further distributed into six replicate groups having 24 pullets each. Three replicate groups from each BW group were reared on a linear growth curve [i.e. high body weight-linear (HB-L) and low body weight-linear (LB-L) groups] whereas the other three groups were reared on a concave growth curve [i.e. high body weight-concave (HB-C) and low body weight-concave (LB-C) groups]. Complete randomized design was followed. Before start of the experiment, the poultry house and floor was thoroughly cleaned, disinfected and dried. The birds were raised on floor under deep litter system of management. The chicks were exposed to 23 h of lighting and a dark period of 1 h per day from 0-5 weeks. From 6th week onwards, the birds were maintained under natural day light till 20th week of age. All the birds had access to clean and fresh drinking water round the clock. Routine vaccination and medication programme was carried out regularly. Starting from 8th week, deworming of the stock was carried out at every two months interval. The birds were beak trimmed during 10th week of age.

Feeds and feeding

Feed was offered *ad libitum* from 0-5 weeks and restricted feeding was practised from 6th to 20th week as per energy model by Sakomura et al (2003). All the chicks were fed a common starter diet [20% crude protein (CP) and 2850 Kcal metabolizable energy (ME)/kg) up to 5 weeks of age and a grower diet [14% CP and 2750 kcal ME/kg diet]. The experimental diets were analyzed for proximate composition according to AOAC International [6] procedures. Nitrogen free extract (NFE) was calculated by difference. The calcium content of the samples was determined by titrametric method [7], however, phosphorus content was estimated spectrophotometrically adopting the metavandate method [6]. The gross and proximate compositions of the grower diet have been presented in Table 1.

Protocol design

Daily maximum and minimum temperature of the experimental poultry shed were recorded. The daily effective temperature was calculated by using the following formula [8].

$$\text{Effective temperature} = [(\text{daytime high temperature} \times 2) + (\text{night low temperature})] / 3$$

The mean weekly minimum and maximum temperature of poultry sheds have been presented in Table 2. For all the treatment groups, the target 20th week BW was 2200 g. For the linear growth curve groups, the weekly target BWs were set by plotting a linear graph targeting a BW of 2200 g at 20th week. By subtracting the target BW at 20th week from the recorded 5th week BW and dividing it by the number of weeks, the weekly BW gain was calculated. For the concave growth curve groups, the 15th week target BW was fixed at 1600 g to allow high BW gain from 16th to 20th week as compared to the linear growth curve groups. The 5th week BW was subtracted from the target 15th week BW and divided by the number of weeks to determine weekly gain. After obtaining 15th week BW, the same procedure was followed to achieve target 20th week BW of 2200 g following the same energy model of Sakomura et al [9]. The BW of all the birds was recorded at 5th week, 15th week and on completion of 20th week using a digital electronic balance nearest to 1.0 g accuracy. During all other periods, weekly BW of sample birds (50% of the birds from each replicate group) was recorded. The BW gain and weekly cumulative BW gain were also calculated.

The uniformity of BW was calculated from the recorded weekly BW of all the replicate groups at different ages and expressed in terms of coefficient of variation (CV %) by using the following formula.

$$\text{CV (\%)} = \frac{\text{Standard deviation (g)}}{\text{Average BW (g)}} \times 100$$

The feed consumption of the experimental birds was recorded replicate-wise on weekly basis. Cumulative feed consumption was calculated by adding the feed consumption from 1st week up to the desired week. The CP and ME intakes were calculated from the feed intake values, taking the CP and ME content of the feed in to consideration. From the weekly BW, feed CP and ME consumption data, weekly and cumulative feed conversion ratio (FCR), protein efficiency ratio (PER) and energy efficiency ratio (EER) were calculated using the following formulae.

$$\text{Weekly FCR} = \frac{\text{Weekly feed consumption (g)}}{\text{Weekly BW gain (g)}}$$

$$\text{Cumulative FCR} = \frac{\text{Cumulative feed consumed (g)}}{\text{Cumulative BW gain (g)}}$$

$$\text{PER} = \frac{\text{Total BW gain (g)}}{\text{Total protein intake(g)}}$$

$$\text{EER} = \frac{\text{Total BW gain (g)} \times 100}{\text{Total ME intake (Kcal)}}$$

Various linear body measurements such as shank length and keel length were measured using a tailor's tape during different periods. Shank (tarso-metatarsus) length was measured as the distance from the hock joint to the middle of the foot pad on the left leg and keel length was measured from the point of fusion in the clavicle to the ventral portion of the sternum [10].

Data analysis

All data were analyzed using the General Linear Model (GLM) procedure of SPSS 16.0. Significant differences among treatment means were determined by Duncan's multiple range tests. All statements of significance are based on the 5% level of probability, unless and otherwise specified.

RESULTS AND DISCUSSION

Body weight

The mean BW of the treatment groups during different periods has been presented in Table 3. The 5th week BW of HB groups were significantly ($P \leq 0.01$) higher than the LB groups. However, within BW groups, the BW did not differ for growth curve treatments. The mean 15th week BW of HB-L, HB-C, LB-L and LB-C groups were 1668.09, 1594.26, 1575.15 and 1491.57 g, respectively. Within BW groups, the 15th week BW did not differ significantly for growth curves. The 15th week BW of LB-C group was significantly ($P \leq 0.01$) lower than all other treatment groups except LB-L group. The 15th week BW of LB-L group was similar to LB-C and HB-C group but differed significantly from HB-L group. The 15th week BW was influenced by 5th week BW and interaction between 5th week BW and growth curve. The 20th week BW of treatment groups were 2107.20, 2079.34, 2046.25 and 2037.47 g for HB-L, HB-C, LB-L and LB-C groups respectively. Highest BW (2107.20 g) was recorded in HB-L group. However, there was no significant difference between the treatment groups as regards 20th week BW is concerned.

Body weight gain

The BW gain of the treatment groups during different periods have been presented in Table 4. The BW gains from 6th to 15th week were 776.08, 699.85, 854.18 and 769.52 g for HB-L, HB-C, LB-L and LB-C groups, respectively. The BW gain of HB-L and LB-C groups did not differ significantly. The BW gain of LB-L group was significantly higher ($P \leq 0.01$) than all other groups and that of HB-C group was significantly lower ($P \leq 0.01$) than all other groups. The 5th week BW and interaction between 5th week BW and growth curve had significant effect on BW gain of the treatment groups during this period. The BW gain for 16-20 week of the treatment groups were similar except that of LB-C group which had the highest BW gain of 546.93 g and was significantly higher than that of HB-L group (439.51). However, the 16-20 week BW gains in concave growth curve groups were numerically higher than the linear groups. The BW gain for 16-20 week was influenced by interaction between 5th week BW and growth curve. The BW gains during the entire growing period (6-20 week) were significantly higher ($P \leq 0.01$) in LB groups than HB groups. However, there was no significant difference in BW gain within BW groups for growth curve. Table 5 presents a comparison between the target and actual BW of treatment groups at 15th and 20th week of age. The target BW was not achieved by any of the treatment groups at 20th week of age. Except HB-C groups, none of the treatment groups achieved the target BW at 15th week. In all other groups the achieved BW was 90.86 to 108.43 g less than the target BW. At 20th week the difference between the target and actual BW widened further, varying from 92.80 to 162.53 g for different treatment groups. However, when compared between BW groups, the difference was less in HB groups than the LB groups.

The birds could not achieve target BW which may be due to the fact that the growing period of the birds was during summer months. During this period, the environmental temperature as well as relative humidity (RH) was very high (maximum temperature 36-42^{0}C, maximum RH 80-98 %). To achieve the target BW, feeding was done based on the energy requirement model for broiler breeder pullets of Sakomura et al [9]. This model involved a linear effect of temperature, according to which, rise in environmental temperature above thermo-neutral zone reduced ME requirement. However, they recommended that the linear relationship should be considered at temperatures close to that, which would provide a thermatically comfortable environment. Lesson and Summers [8] reported that when the

temperature increases, the ME requirement also increases as the birds are under stress. As no other suitable energy model for broiler breeder pullets was available, the Sakomura et al [9] model was used in predicting energy requirement in the present experiment. Purswell et al [11] reported that the thermal environment is a controlling factor in energy metabolism and exchange. Sakomura [12] observed that with increase in ambient temperature, the efficiency of ME utilization for deposition as protein decreased. Besides environmental temperature, high RH also contributes to stress on the birds. Yahav [13] reported that at high environmental temperature, heat dissipation by evaporative cooling is impeded by high RH. Similar findings have been reported by several workers [8, 14]. Hormone tri-iodothyronine is affected by high environmental temperature influencing feed intake and BW gain adversely [13, 15]. The lower than target BW of the treatment groups in the present experiment could be due to high environmental temperature coupled with high RH during the period of growth.
The non-significant difference in the 15th week BW within BW groups in the present study could be due to the fact that the difference in the target set between HB-L and HB-C groups was only 158.95 g and between LB-L and LB-C groups was 78.35 g. Further, due to the adverse effects of high temperature and RH, the targeted difference could not be maintained. However, the BW of concave groups was lower than the linear groups for both the BW groups as targeted. The 20th week BW of all the treatment groups though was lower than the target (2200 g), did not differ from each other. This could be due to the fact that the target 20th week BW for all the treatment groups were the same and feeding was done following energy models to achieve the same target BW for all treatment groups at 20th week. Statistical analysis of the data revealed that the initial (5th week) BW and growth curve affected the BW and BW gain during growing stage. The findings of the present investigation on BW and BW gain agree with the findings of Wilson et al [3], Bajwa et al [5], Renema et al [16] and Emous et al [17].

Body weight uniformity

Table 6 presents the coefficient of variation (CV %) of treatment groups at 15th and 20th week. The CV% of treatment groups throughout the periods was not influenced by either growth curve or 5th week BW. The CV% of the treatment groups during 15th and 20th weeks did not differ significantly between the treatment groups. However, during the growing period the CV% of the concave growth curve groups were numerically higher than the linear growth curve groups within BW groups. Similar findings have been reported by Emous et al [17] and Renema et al [18] who opined that severe degree of feed restriction in concave groups as compared to linear groups would have resulted in higher CV% in these concave groups.

Body conformation traits

Table 7 presents the mean shank length and keel length of treatment groups at 5th, 15th and 20th week of age. The 5th week shank length ranged between 7.41 and 7.74 cm and did not differ between groups. However, the 5th week keel length of HB groups were significantly ($P \leq 0.01$) higher than the LB groups without any significant difference between growth curves within BW groups. The 15th week shank and keel lengths of HB groups were significantly ($P \leq 0.01$) higher than LB groups. Within BW groups, the shank length and keel lengths of concave groups were lower than the linear groups. The 20th week shank length did not differ within BW groups. But the 20th week shank length of HB-L group was significantly ($P \leq 0.05$) higher than LB-C group. The 20th week shank length was influenced by growth curve. The 20th week keel length of LB groups was significantly ($P \leq 0.05$) lower than HB-L groups but similar to HB-C groups. There was no significant difference between HB-C and HB-L groups for 20th week keel length.
The shank length and keel length are influenced by BW as reported by Lilburn and Myres-Miller [2], who observed that the frame size or skeletal growth in broiler breeder bird is primarily a function of BW gain. Difference in dietary protein and energy can influence the rate of gain and in this way indirectly influence skeletal growth. Ojedapo et al [19], Amao et al [20], Yahaya et al [21] reported that the correlation between BW and shank and keel length are high, positive and significant. The effect of different growth curves on shank and keel length have been reported by Wilson et al [3], who reared broiler breeder females from 1-24 weeks on three growth curves: a conventional relatively linear growth curve (standard), an early slow programme characterized by slow growth rates during early rearing period followed by more generous feed allocation after 19th week and an early fast programme with BW above normal early in rearing followed by more conservative BW gains late in rearing. Throughout most part of the experiment, the early slow hens had numerically lower values for shank length than the other two groups. Romero-Sanchez et al [22] in two experiments evaluated the effects of 2 planes (low and high) of cumulative nutrient intake during the rearing period on performance of broiler breeder males and reported that the high plane of nutrition increased shank length during the rearing period, but the differences disappeared after 28 week of age. The shank length and keel length of birds of different

treatment groups as obtained in the present experiment are in agreement with these findings indicating a variation in shank length and keel length due to manipulation of growth by regulating nutrient intakes.

Feed and nutrient intake

Feed and nutrient intake of different treatment groups during the experimental period has been presented in Table 8. The feed, CP and ME intake of HB-L groups during 6th to 15th week was significantly ($P \leq 0.05$) higher than all other groups which had similar intakes of feed, CP and ME. The feed, CP and ME intake during this period was influenced by 5th week BW, growth curve and interaction between 5th week BW and growth curve. During 16-20 weeks, the feed intake of LB-L groups was highest (3.15 kg) followed by LB-C groups (3.11 kg). The feed and nutrient intake of HB-L and HB-C groups did not differ. Similarly, there was no significant difference between feed and nutrient intake of LB-C and HB-L groups. From 6-20 weeks, the feed and nutrient intake of HB-L groups was highest among all the groups and differ significantly ($P \leq 0.05$) from HB-C groups but was similar to LB-L and LB-C groups. During this period, feed intake and nutrient intake of treatment groups were influenced by growth curve and interaction between 5th week BW and growth curve. The feed intake was predetermined to incorporate variations in growth curve in different treatment groups as per the experimental design and energy model of Sakomura et al [9] was followed. The feed and hence the nutrient intake variations as observed were induced as per the need of the experiment.

Feed and nutrient utilisation efficiency

Table 9 presents the feed and nutrient utilisation efficiency of treatment groups during different periods. The FCR, PER and EER values of LB-L group for 6-15 week were 4.55, 0.64 and 12516.8 respectively which were significantly ($P \leq 0.05$) lower than all other groups. There was no significant difference between FCR, PER and EER values of HB-L and HB-C groups. In general, the feed and nutrient utilization efficiency of LB groups was superior to HB groups. The feed and nutrient utilisation efficiency of treatment groups during this period was influenced by both 5th week BW and growth curve. During 16-20 weeks, significantly ($P \leq 0.05$) lower values for FCR, PER and EER were obtained for LB-C group as compared to LB-L, HB-C and HB-L groups. The FCR, PER and EER values for HB-L group was significantly higher than all other treatment groups. The 5th week BW and interaction between 5th week BW and growth curve had significant effect on feed and nutrient utilisation efficiency of treatment groups during 16-20 week.

While considering the overall growing period of 6-20 weeks, significantly lower FCR, PER and EER values were obtained for LB groups indicating better nutrient utilisation efficiency irrespective of growth curve. The FCR, PER and EER values for HB-L group was significantly ($P \leq 0.05$) higher than all other treatment groups. The feed and nutrient utilisation efficiency of treatment groups during this period was influenced by both 5th week BW and interaction between 5th week BW and growth curve.

As observed from the findings, the feed efficiency, protein and energy utilization efficiencies of LB groups were better than the HB groups in spite of the facts that there was hardly any significant variation in feed intake between the treatment groups. Moreover, as same feed was fed to all the treatment groups, the ME and CP intakes of all the treatment groups were comparable. The maintenance requirement of the birds constitutes a major part of the total energy requirement and increases with increase in BW [12]. Considering the similar feed and nutrient intake, the high BW of birds of HB groups might have contributed to lower feed and nutrient utilization efficiencies in those groups.

Table 1; Gross and proximate composition of grower diet

Ingredient (%)	Grower Diet
Maize	58.5
Soya bean meal	17.5
De-oiled rice bran	21
Mineral mixture[1]	3
Common salt	0.3
L-Lysine (98.5%)	0.1
DL-Methionine (99%)	0.1
Trace mineral[2]	0.1
Choline chloride	0.5
Toxin binder	0.2
Vitamin premix[3]	0.3
V-fur	2
Calculated value	

ME (Kcal/Kg)	2753.58
CP (%)	14
Lysine (%)	0.81
Methionine (%)	0.38
Meth.+Cystine (%)	0.66
Energy: Protein	196
Cost/kg feed (Rs)	25.8
Analysed value	
Moisture	9.27
Crude protein	14.12
Ether extract	4.55
Crude fibre	4.91
Total ash	10.17
Acid insoluble ash	2.63
Nitrogen free extract	66.25
Calcium	0.93%
Av. phosphorus	0.45%
ME (Kcal/Kg)	2748.35

[1] Supplied: Ca 32%, P 6%, Mn 0.27%, Zn 0.26%, I 0.01%, Cu 0.01%, Fe 0.01%, F 0.03%
[2] Supplied per kg: Cu 15 g, I 1 g, Fe 60 g, Mn 80 g, Se 0.3 g, Zn 80 g
[3] Supplied per g: Vit A 82500 IU, Vit B_2 50 mg, Vit D_3 16500 IU, Vit K_3 10 mg, Folic acid 10 mg, Vit E 200 mg, Se 400 µg, Vit B_1 4 mg, Vit B_6 8 mg, Vit B_{12} 40 µg, Ca pantothenate 40 mg, Niacin 60 mg.

Table 2; Mean weekly minimum and maximum ambient temperature during 6-20 weeks

Weeks	Predicted temperature (^{0}C)		
	Minimum	Maximum	Effective
6	19	36	30.3
7	18	36	30.0
8	17	38	31.0
9	19	39	32.3
10	21	40	33.7
11	24	41	35.3
12	25	41	35.7
13	26	42	36.7
14	23	40	34.3
15	21	38	32.3
16	26	40	35.3
17	27	40	35.7
18	24	40	34.7
19	28	41	36.6
20	27	42	37

Table 3; Mean body weight of pullets during experimental period

Treatment	Body weight (g)		
	5th week	15th week	20th week
HB-L	891.99[a]	1668.09[c]	2107.20[a]
HB-C	894.75[a]	1594.26[bc]	2079.34[a]
LB-L	723.94[b]	1575.15[ab]	2046.25[a]
LB-C	721.97[b]	1491.57[a]	2037.47[a]
Source of variation	*Probability*		
BW[§]	0.000	0.001	0.152
GC[†]	0.795	0.872	0.790
BW*GC	0.965	0.01	0.609

[abc] Means within a column without common superscript differ significantly (P≤0.05); [§]BW, body weight; [†]GC, growth curve

Table 4; Mean body weight gain of pullets during the experimental period

Treatment	Body weight gain (g)		
	6-15 week	16-20 week	6-20 week
HB-L	776.08[b]	439.51[a]	1215.58[a]
HB-C	699.85[a]	485.04[ab]	1184.89[a]
LB-L	854.18[c]	468.12[ab]	1322.30[b]
LB-C	769.52[b]	546.93[b]	1316.46[b]
Source of variation	*Probability*		
BW[§]	0.000	0.105	0.004
GC[†]	0.727	0.521	0.687
BW*GC	0.000	0.036	0.556

[abc] *Means within a column without common superscript differ significantly ($P \leq 0.05$); [§]BW, body weight; [†]GC, growth curve*

Table 5; Target and actual body weight (g) of pullets at 15th and 20th week

Treatment	15th week			20th week		
	Target BW	Actual BW	Difference	Target BW	Actual BW	Difference
HB-L	1758.95	1668.09	90.86	2200	2107.20	92.80
HB-C	1600.00	1594.26	5.74	2200	2079.34	120.66
LB-L	1678.35	1575.15	103.20	2200	2046.25	153.75
LB-C	1600.00	1491.57	108.43	2200	2037.47	162.53

Table 6; CV% of treatment groups during different periods

Treatment	15th week	20th week
HB-L	11.88[a]	14.07[a]
HB-C	13.48[a]	14.92[a]
LB-L	13.78[a]	13.31[a]
LB-C	13.73[a]	15.58[a]
Source of variation	*Probability*	
BW[§]	0.385	0.960
GC[†]	0.531	0.162
BW*GC	0.502	0.502

[ab] *Means within a column without common superscript differ significantly ($P \leq 0.05$); [§]BW, body weight; [†]GC, growth curve*

Table 7; Body conformations (cm) of treatment groups at different periods of experiment

Treatment	5th week		15th week		20th week	
	Shank length	Keel length	Shank length	Keel length	Shank length	Keel length
HB-L	7.68[a]	8.25[b]	11.26[c]	12.50[b]	11.35[b]	14.50[b]
HB-C	7.70[a]	8.29[b]	11.21[c]	12.36[b]	11.24[ab]	14.31[ab]
LB-L	7.74[a]	7.73[a]	10.87[b]	11.58[a]	11.12[ab]	14.02[a]
LB-C	7.41[a]	7.54[a]	10.68[a]	11.51[a]	11.08[a]	14.01[a]
Source of variation	*Probability*					
BW[§]	0.402	0.000	0.000	0.000	0.362	0.003
GC[†]	0.245	0.512	0.065	0.741	0.020	0.469
BW*GC	0.187	0.359	0.285	0.363	0.657	0.463

[abc] *Means within a column without common superscript differ significantly ($P \leq 0.05$); [§]BW, body weight; [†]GC, growth curve*

Table 8; Feed and nutrient intake (kg) of treatment groups during experimental period

Treatment	6-15 week			16-20 week			6-20 week		
	FI[#] (kg)	CPI[♦] (kg)	MEI[◊] (kcal)	FI (kg)	CPI (kg)	MEI (kcal)	FI (kg)	CPI (kg)	MEI (kcal)
HB-L	4.34[b]	0.61[b]	11939.6[b]	3.04[ab]	0.43[ab]	8352.9[ab]	7.38[b]	1.03[b]	20292.5[b]
HB-C	4.11[a]	0.58[a]	11287.7[a]	3.01[a]	0.42[a]	8278. 9[a]	7.12[a]	0.996[a]	19566.6[a]
LB-L	4.09[a]	0.57[a]	11244.2[a]	3.15[c]	0.44[c]	8650.8[c]	7.24[ab]	1.01[ab]	19895.1[ab]
LB-C	4.16[a]	0.58[a]	11427.2[a]	3.11[bc]	0.435[bc]	8553.4[bc]	7.27[ab]	1.02[ab]	19980.6[ab]
Source of variation	*Probability*								
BW[§]	0.025	0.025	0.025	0.002	0.002	0.002	0.954	0.954	0.954
GC[†]	0.003	0.003	0.003	0.856	0.856	0.856	0.019	0.019	0.019
BW*GC	0.048	0.048	0.048	0.207	0.207	0.207	0.050	0.050	0.050

[abc] *Means within a column without common superscript differ significantly ($P \leq 0.05$); [#]FI, feed intake; [♦]CPI, crude protein intake; [◊]MEI, metabolizable energy intake; [§]BW, body weight; [†]GC, growth curve*

Table 9; Feed and nutrient utilization efficiency of treatment groups during experimental period

Treatment	6-15 week			16-20 week			6-20 week		
	FCR[#] (g:g)	PER[♦] (g:g)	EER[◊] (g: 100 kcal)	FCR	PER	EER	FCR	PER	EER
HB-L	5.23[c]	1.37[c]	14.38[c]	4.65[c]	1.54[c]	12.78[c]	4.97[c]	1.49[c]	13.67[c]
HB-C	5.16[c]	1.39[c]	14.18[c]	4.47[b]	1.59[b]	12.30[b]	4.84[b]	1.47[b]	13.32[b]
LB-L	4.55[a]	1.56[a]	12.52[a]	4.38[b]	1.64[b]	12.04[b]	4.48[a]	1.59[a]	12.31[a]
LB-C	4.73[b]	1.51[b]	13.00[b]	4.07[a]	1.75[a]	11.18[a]	4.42[a]	1.61[a]	12.16[a]
Source of variation	*Probability*								
BW[§]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GC[†]	0.020	0.020	0.020	0.055	0.055	0.055	0.271	0.271	0.271
BW*GC	0.261	0.261	0.261	0.000	0.000	0.000	0.020	0.020	0.020

[abc] *Means within a column without common superscript differ significantly (P≤0.05); [#]FCR, feed conversion ratio; [♦]PER, protein efficiency ratio; [◊]EER, energy efficiency ratio; [§]BW, body weight; [†]GC, growth curve*

CONCLUSION

From the present investigation, it may be concluded that feeding broiler breeder pullets through a concave growth curve improved feed efficiency and reduced cost of feeding as compared to pullets raised under linear growth curve. The growth curves (linear or concave) did not have any significant effect on body weight, body weight gain and body weight uniformity. Considering the lower feed consumption in concave groups than the linear groups, it may be suggested that feeding broiler breeder pullets on a concave growth curve from 6-20 weeks will be more economical than raising them on a linear growth curve.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.
All institutional guidelines for the care and use of birds were followed.

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