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ORIGINAL ARTICLE

Effects of Growth curves on performance, Egg production and egg quality traits in broiler breeder hens

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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 on egg production and egg quality traits of broiler breeder hens 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). The pullets of each BW group were distributed into six replicate groups each with 24 pullets. 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. From 21 weeks of age, a pre-breeder diet with 16% CP and 2850 Kcal ME was fed up to 23 weeks. A breeder diet with 16% CP and 2750 kcal ME was fed from 24th week of age. Age at sexual maturity and age at different stages of egg production were recorded for all the groups. Egg production was recorded daily. Eggs were collected at 38th and 49th weeks of age to study the egg quality traits such as egg weight, shape index, yolk index, albumen index, shell thickness and Haugh unit. Fertility and hatchability were studied during 35th, 40th and 50th week of age. The HB groups reach sexual maturity, 10% egg production, 50% egg production and peak egg production at an earlier age than LB groups. Within the BW groups, the concave growth curve groups reach sexual maturity and peak egg production earlier than linear growth curve groups. There was lower feed consumption in concave groups than the linear groups. From the present study, it may be concluded that feeding broiler breeder pullets on a concave growth curve during growing period will be more economical than raising them on linear growth curve.
Keywords; *Egg production, Egg quality traits, Growth curves, Broiler breeder hens*

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INTRODUCTION

In the poultry industry, broiler breeders are selected for many diverse traits. In female lines, the primary trait for selection is egg production besides body weight (BW) and body conformation traits. The number of fertile eggs produced during hatching dictates the ultimate profitability of the breeder flock. Feeding broiler breeders for optimum performance is very crucial. Small degrees of over or under feeding can negatively impact egg and chick production [1-3]. Excessive BW gain has adverse effects on the reproductive performance of parent breeders [4, 5]. Having too many large ovarian follicles is a problem associated with obesity, or with pullets being exposed to a large positive energy balance after photo stimulation [6]. Therefore, during growing phase of broiler breeder flocks, restriction of feed in order to lower BW is a common industry practice [7]. 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 [8]. The target BW at maturity can be achieved by using various growth curves such as linear, concave, convex or sigmoid. Different growth curves may result in changes in body composition and differences in performance even though BW does not differ at sexual maturity [9-12]. Considering the findings of different workers on the effects of restricted feeding through different growth curves on the performance of breeder birds, the present study was planned to evaluate the effects of two growth curves (concave and linear) during the growing period (6 to 20 weeks) on the performance, egg production, egg quality traits, fertility and hatchability of broiler breeder hens of coloured synthetic female line (CSFL).

MATERIALS AND METHODS

Experimental birds and feeding

Two hundred eighty-eight (288) broiler breeder birds of CSFL genotype, on the basis of 5th week BW, were divided into low body weight (LB) group (550g to 850g) and high body weight (HB) group (851g to 1120g). The birds of each BW group were further distributed into six replicate groups each with 24 birds. Three replicate groups from each BW group were reared on a linear growth curve [i.e. low body weight-linear (LB-L) and high body weight-linear (HB-L) groups] and the other three groups were reared on a concave growth curve [i.e. low body weight-concave (LB-C) and high body weight-concave (HB-C) groups]. The birds were maintained under deep litter system of management up to 20 weeks. After 20 week onwards, birds were shifted to cage house. All birds had access to clean and fresh drinking water round the clock. Birds were immunized against Marek's disease on 1st day, Ranikhet disease (RD) on 5th and 28th day using LaSota strain, infectious bursal disease (IBD) on 14th and 35th day, fowl pox on 42nd day, RD using R2B strain at 8th week, ND-IBD killed at 18th week and ND-killed vaccine at 40th week. All the birds were fed a common grower diet [14% CP and 2750 kcal ME/kg diet]. Restricted feeding was practised from 6th to 20th week as per energy model by Sakomura et al [13]. From 21 weeks of age, a pre-breeder diet with 16% CP and 2850 Kcal ME was fed up to 23 weeks. From 24th week of age, a breeder diet with 16% CP and 2750 Kcal ME was fed to the birds following the energy requirement model of Sakomura [14]. The gross and proximate compositions of the pre-breeder and breeder diets have been presented in Table 1.

Protocol design

Body weight of the birds was recorded at 20th, 22nd, 24th, 30th, 40th and 50th week using a digital electronic balance. The uniformity of BW was calculated in terms of coefficient of variation (CV %) by using the following formula.

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

Age at sexual maturity and age at different stages of egg production were recorded. Egg production was recorded daily and calculated on hen day basis.

$$\text{Hen day egg production } \% = \frac{\text{Total No. of egg produced}}{\text{No. of hen days}} \times 100$$

Eggs were collected at 38th and 49th weeks of age to measure the external characters such as egg weight, length and width and internal characters such as yolk index, albumen index, shell thickness and Haugh unit as described elsewhere [15]. Fertility and hatchability were studied during 35th, 40th and 50th week of age.

Data analysis

A completely randomized design was used to evaluate the dietary treatments. All data were analyzed using the General Linear Models procedure of SPSS 16.0 for windows. 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

BW and BW uniformity

The BW of the treatment groups at 20th, 22nd, 24th, 30th and 50th week did not differ significantly from each other (Table 2). The 40th week BW of the treatment groups did not differ within BW groups. But the 40th week BW of HB-C and LB-C groups differ significantly from each other. However, there was no significant difference between HB-L and LB-L groups for 40th week BW.

The CV% of treatment groups throughout the periods was not influenced by either growth curve or 5th week BW except at 24th week where growth curve significantly ($P \leq 0.05$) influenced the CV% of all the treatment groups (Table 3). At 24th week, CV% of LB-L groups (9.10) was significantly lower than HB-C group (14.59). In HB-C group, birds attain 5% egg production at this stage whereas birds of LB-L group attain the same level of production two weeks later. Considering the early egg production in HB-C group where some birds were in production and some were yet to produce, wide variation in BW is evident leading to high CV%. The CV% of the treatment groups during 22nd, 30th and 50th weeks did not differ significantly between the treatment groups which may be due to the fact that there were no differences in feed allocation, egg production or BW between the treatment groups during this period.

Egg production

The hen day egg production (%) of treatment groups has been presented in Table 4. The hen day egg production for the experimental period (24-49 week) of the treatment groups were 46.14, 46.91, 46.05 and 47.78 % respectively for HB-L, HB-C, LB-C and LB-L groups. The hen day egg production during the period from 24 to 30 weeks (pre-peak phase) did not differ between the treatment groups. However, for 31-40 weeks period (peak phase), the hen day egg production of HB-C group (58.42%) was significantly ($P \leq 0.05$) higher than all other treatment groups and was significantly influenced by 5th week BW and growth curve. During 41-49 weeks, the hen day egg production of LB-C group was significantly ($P \leq 0.05$) higher than all other treatment groups and was influenced by 5th week BW and interaction between 5th week BW and growth curve. In the present study, no significant difference was recorded for hen day egg production % between the treatment groups for the overall period (24-49 weeks) irrespective of the variations in 5th week BW as well as growth curve. Similar findings have been reported by several workers [10, 16-18]. In all these experiments, different growth curves were tried with groups of birds having different initial BW targeting similar BW at sexual maturity resulting in non significant difference in egg production. Gous and Cherry [19] using two growth curves i.e. convex or concave in broiler breeder during rearing period reported that the growth curve did not affect the laying performance of the birds. They suggested that nutritional stimulus late in rearing is only necessary for satisfactory egg production, if birds have not received a concurrent increment in photoperiod. In the present experiment the lighting hours for photo stimulation was same for all the treatment groups. Bruggeman et al [20] reported that chickens restricted during middle rearing period showed highest average weekly egg production in comparison to the ad libitum feeding or feed restriction during early or late rearing programme. Bajwa et al [12] compared egg production of broiler breeder hens reared on three growth curves (linear, concave and convex) and reported that birds reared on concave growth curve had significantly higher egg production as compared to birds reared on linear or convex growth curves. Lilburn and Myres-Miller [9] and Soller et al [21] suggested that different growth curves may result in difference in performance even though BW does not differ at sexual maturity and the total feed consumption remains the same.

During restricted feeding, the energy model of Sakomura et al [14] was designed to calculate the ME requirement of grower pullets. In the said energy model, the linear effect of temperature on ME requirement has been used where, with increase in temperature ME requirement decreases. Sakomura et al. [14] recommended that this linear effect of temperature should be used when the house temperature is around the thermo-neutral zone of poultry (18-24^{0}C). However, the present experiment was conducted during summer months when the temperature was much higher and maximum temperature ranged between 36^{0}C to 42^{0}C. During such summer stress, the ME requirements of the birds increased to compensate the energy loss in panting. The narrow difference in BW between concave and linear growth curve groups might have contributed to similar egg production in all the treatment groups without any significant variation.

Plethoras of data have been generated on the effect of BW of broiler breeders at different ages and its effect on egg production. Lacin et al [22] reported that birds with higher BW at 24 weeks produce more eggs during 1st cycle where as birds with low BW had higher egg production in the 2nd and 3rd egg production cycle. In the present study, the BW of treatment groups at 22nd, 24th, 30th and 50th weeks of age did not differ significantly. However, difference in BW between treatment groups was recorded only during 40th week. It is evident from the results of the present study that the egg production of the treatment groups was not affected by BW at any stage of the growth which could be due to the fact that the variation in BW at different stages were too less to produce any significant impact on egg production.

The beneficial effect of the high BW uniformity on egg production has been well documented [23-26]. In the present study, the CV% of BW at different ages (Table 3) did not differ ($P \geq 0.05$) between treatment groups except at 24th week. Considering the similarity in BW uniformity among treatment groups, its non-significant effect on egg production can be well justified.

Age at sexual maturity (ASM) and age at different stages of egg production

Table 5 presents the age at sexual maturity (ASM) and age at different stages of egg production. Age at 5% and 10% egg production of HB-L and HB-C group were similar and significantly ($P \leq 0.05$) higher than LB-L and LB-C group. Age at 5% and 10% egg production was influenced by 5th week BW, growth curve and the interaction between 5th week BW and growth curve. Age at 20% egg production or ASM of the treatment groups ranged between 192.33 and 194.67 days and did not differ from each other significantly ($P \geq 0.05$). Age at 20% egg production of the treatment groups was influenced by 5th week BW and interaction between 5th week BW and growth curve. Ages at 50% egg production were 212.33, 211.67, 219.67 and 215.33 days for HB-L, HB-C, LB-L and LB-C treatment groups. The LB-L group reached 50% egg production at 219.67 days which was significantly ($P \leq 0.05$) higher than all the treatment groups. The age at peak production of LB-L group was significantly ($P \leq 0.01$) higher (271.33 days) than other treatment groups followed by LB-C group (265 days). The age at peak production of HB-L and HB-C groups were 254.33 and 252.33 days respectively. The 5th week BW and interaction between 5th week BW and growth curve had significant effect on the age at peak egg production. Wilson et al [10], Bruggeman et al [20], Renema et al [16], Gous and Cherry [19], Beer and Coon [17], Bajwa et al [12] and Beer and Coon [18] reported that ASM is negatively correlated with BW at the end of rearing period. Gous and Cherry [19] and Bajwa et al [12] reported that the birds grown on a convex curve had higher ASM than the concave curve. Emous et al [27] reported that a higher BW at the end of the rearing period did not advance sexual maturity significantly. In the present experiment, HB groups reach sexual maturity, 20% egg production, 50% egg production and peak egg production at an earlier age than LB groups. Further, concave growth curve groups reach sexual maturity and peak egg production earlier than linear growth curve groups within BW groups.

Fertility, hatchability and saleable chicks

The fertility, hatchability and saleable chicks produced the different treatment groups for different periods have been presented in Table 6. The values did not differ between the groups at 35th, 45th as well as for overall period. However during 40th week, values for fertility, hatchability and saleable chicks were significantly ($P \leq 0.05$) higher in LB-L group than LB-C group and there was no significant difference among HB-L, HB-C and LB-C groups. During this period, LB groups had higher fertility than HB-L groups. Fertility, hatchability and saleable chicks were influenced by interaction between 5th week BW and growth curve during 40th week. Gous and Cherry [19] reported that birds with low BW at maturity had low hatchability of fertile eggs. Renema et al [16] reported that eggs from standard growth curve birds had a higher hatchability (82.7%) and hatchability of fertile eggs set (90.5%) than low (79.1%, 87.0%) or high growth curve birds (80.2%, 88.3%). Walsh and Brake [11] reported that birds raised on linear growth curve have better fertility over concave or convex groups. However, no such difference was recorded for growth curve within BW group in the present experiment. Wilson et al [10] reported that in early fast growth curve groups hatchability of all fertile eggs and number of chicks hatched per hen were higher as compared to standard or early slow groups. In our experiment the HB-C and LB-L groups had better hatchability and saleable chicks (%) than HB-L and LB-C groups during 40th week. In spite of non-significant difference in mature BW, feeding pattern (growth curve) could have influenced the fertility and hatchability during 40 weeks of age.

Egg quality traits

Egg weight and egg shape index

The values for egg weight and egg shape index (ESI) during 30th, 35th, 40th and 45th weeks have been presented in Table 7. During 30th week, highest egg weight (52.09 g) was recorded in HB-L group followed by HB-C (51.06 g), LB-L (50.76 g) and LB-C (49.85 g) groups. Significant difference ($P \leq 0.05$) was recorded in egg weight between HB-L and LB-C groups. Lowest ESI (75.60%) was recorded in HB-C group which was significantly lower than LB-L and LB-C groups but similar to HB-L group. During 35th week, egg weight and ESI values did not differ between treatment groups. During 40th week, egg weight did not differ between treatment groups, but significantly lower ESI was recorded in LB-L group than other groups. Growth curve had significant effect on ESI during this period. During 45th week, ESI of all the groups were similar, but egg weight of LB groups was significantly lower than HB groups. The egg weight of LB groups were lower than those of the HB groups during all the periods for which egg weights were recorded even though it was not significant for 35th and 40th week. Gous and Cherry [19] and Emous et al [27] reported that the mean egg weight of broiler breeder hens was not affected by BW or growth curve. Beer and Coon [17] reported that egg weight of broiler breeders had high positive correlation with BW. Lacin et al [22] reported that as BW increases, ESI decreases and egg weight increases. In the present experiment, there was not any significant variation in egg weight and ESI of treatment groups throughout the laying period.

Haugh unit, yolk index, albumen index and shell thickness

Table 8 presents Haugh unit, yolk index, albumen index and shell thickness of treatment groups during 38th week and 49th week. For both the periods, the values did not differ between treatment groups except for albumen index and shell thickness at 49th week. The 49th week albumen index and shell thickness were significantly lower in LB groups than HB groups. The 49th week albumen index and the shell thickness were influenced by BW. The non significant effect of egg qualities between different treatment groups may be due to similarity of BW throughout the laying period. The low value for albumen index and shell thickness in LB groups at 49th week may be due to the fact that 50th week BW of LB groups was numerically lower than HB groups. Lacin et al [22] reported that high BW group birds had a higher albumen index value than low or medium BW group birds. Hens in low BW group had the highest Haugh unit and value was significant in the whole laying period. They further reported that effect of BW on yolk index and shell thickness was not significant. Leeson et al [24] reported that BW throughout the laying period did not affect albumen index. Alkan et al [28] reported that the Haugh unit of high 5th week BW group was significantly higher than low BW groups.

Table 1; Gross and proximate composition of experimental diets

Ingredient	Experimental diets	
	Pre-breeder (16% CP)	Breeder (16% CP)
Maize	64.5	60
Soya bean meal	19.5	19.5
DORB	10	12
Mineral mixture[1]	3	3
oyster shell meal	2.5	5
Common salt	0.3	0.3
L-Lysine (98.5%)	0.03	0.03
DL- Methionine (99%)	0.05	0.05
Trace mineral[2]	0.12	0.12
Choline chloride	0.5	0.5
Toxin binder	0.2	0.2
Layvit	0.5	0.5
Vitamin premix[3]	0.3	0.3
V-fur	2	2
Calculated values		
ME-(Kcal/Kg)	2846.36	2754.06
CP (%)	16.02	16.16
Lysine (%)	0.835	0.842
Methionine (%)	0.348	0.345
Meth. + Cystine (%)	0.65	0.66
Energy: Protein	178	170
Cost/kg feed (Rs)	28.6	27.2
Analyzed values		
Moisture	9.24	9.17
Crude Protein	16.01	15.98
Ether extract	4.16	4.2
Crude fibre	4.92	4.82
Total ash	10.54	10.61
Acid insoluble ash	2.66	2.54
Nitrogen free extract	64.37	64.39
Calcium	1.17	2.97
Av. phosphorus	0.57	0.42
ME-(Kcal/Kg)	2852.75	2751.25

[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 gram: 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 body weight of treatment groups during experimental period

Treatment	Body weight (g)				
	22nd Week	24th week	30th week	40th week	50th week
HB-L	2334	2710.86	3018.33	3456.82^{bc}	3846.6
HB-C	2336.86	2623.92	2974.71	3690.60^{c}	3750.2
LB-L	2344.24	2614.54	2874.35	3385^{ab}	3671.3
LB-C	2328.59	2633.87	2972.33	3114.3^{a}	3524.6
Source of variation	Probability				
BW§	0.984	0.381	0.261	0.002	0.332
GC†	0.849	0.281	0.277	0.013	0.488
BW*GC	0.896	0.493	0.675	0.85	0.042

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

Table 3; CV (%) of treatment groups during different periods

Treatment	22nd week	24th week	30th week	40th week	50th week
HB-L	12.47	10.54^{ab}	7.68	11.57	5.13
HB-C	14.96	14.59^{b}	9.12	6.22	7.97
LB-L	10.40	9.10^{a}	8.52	5.85	8.54
LB-C	12.23	11.82^{ab}	13.59	8.71	12.56
Source of variation	Probability				
BW§	0.114	0.169	0.391	0.410	0.246
GC†	0.148	0.041	0.299	0.523	0.314
BW*GC	0.813	0.644	0.553	0.058	0.859

^{ab} Means within a column without common superscript differ significantly (P≤0.05); §BW, body weight; †GC, growth curve

Table 4; Hen day egg production % of treatment groups during different periods

Treatment	24-30 weeks	31-40 weeks	41-49 weeks	24-49 weeks
HB-L	17.92	58.17^{a}	54.72^{a}	46.14
HB-C	16.34	61.95^{b}	53.98^{a}	46.91
LB-L	20.23	56.26^{a}	54.81^{a}	46.05
LB-C	18.29	58.83^{a}	58.42^{b}	47.77
Source of variation	Probability			
BW§	0.308	0.014	0.019	0.796
GC†	0.399	0.002	0.172	0.407
BW*GC	0.931	0.555	0.024	0.754

^{ab} Means within a column without common superscript differ significantly (P≤0.05); §BW, body weight; †GC, growth curve

Table 5; Age of treatment groups at different stages of production (in days)

Treatment	Age at 5% egg production	Age at 10% egg production	Age at 20% egg production	Age at 50% egg production	Age at peak egg production
HB-L	173.00^{b}	180.33^{b}	194.67	212.33^{ab}	254.33^{a}
HB-C	167.67^{a}	174.67^{a}	192.33	211.67^{a}	252.33^{a}
LB-L	181.67^{c}	187.33^{c}	194.67	219.67^{c}	271.33^{c}
LB-C	181.67^{c}	186.67^{c}	192.33	215.33^{b}	265.00^{b}
Source of variation	Probability				
BW§	0.000	0.000	1.000	0.001	0.017
GC†	0.024	0.058	0.029	0.120	0.156
BW*GC	0.024	0.023	1.000	0.045	0.000

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

Table 6; Mean fertility and hatchability (%) of treatment groups during different periods

Treatment	35th week				40th week				45th week				Overall period			
	Fertility⁺	Hatchability¶		Saleable chicks	Fertility	Hatchability		Saleable chicks	Fertility	Hatchability		Saleable chicks	Fertility	Hatchability		Saleable chicks
		TES♦	FES◊			TES	FES			TES	FES			TES	FES	
HB-L	80.09	66.13	82.43	64.97	89.88^{a}	77.28^{ab}	85.99^{a}	76.24^{ab}	92.14	79.86	86.65	79.17	87.37	74.42	85.02^{ab}	73.46
HB-C	81.17	62.2	76.58	60.85	91.83^{ab}	81.31^{ab}	88.58^{ab}	81.01^{ab}	94.07	87.65	93.14	87.11	89.02	77.06	86.10^{ab}	76.32
LB-L	82.12	69.29	84.61	67.4	93.74^{b}	83.29^{b}	88.90^{b}	82.59^{b}	94.78	86.3	91	85.54	90.21	79.63	88.17^{b}	78.51
LB-C	85.75	69.75	81.25	67.4	91.45^{ab}	75.47^{a}	82.57^{a}	74.64^{a}	94.87	82.56	87.03	81.93	90.69	75.93	83.62^{a}	74.88
Source of variation	Probability															
BW§	0.473	0.319	0.351	0.434	0.086	0.899	0.588	0.970	0.083	0.873	0.656	0.886	0.287	0.591	0.594	0.661
GC†	0.521	0.618	0.285	0.674	0.767	0.332	0.053	0.431	0.286	0.555	0.668	0.489	0.616	0,830	0.255	0.886
BW*GC	0.797	0.530	0.815	0.563	0.047	0.013	0.005	0.013	0.284	0.079	0.065	0.07	0.644	0.271	0.054	0.285

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

$$^{+}\text{Fertility }\% = \frac{\text{Number of fertile eggs}}{\text{Total number of eggs set}} \times 100$$

$$^{\blacklozenge}\text{Hatchability }\%\,(\text{on total number of eggs set}) = \frac{\text{Number of chicks hatched out}}{\text{Total number of eggs set}} \times 100$$

$$^{\lozenge}\text{Hatchability }\%\,(\text{on fertile eggs set}) = \frac{\text{Number of chicks hatched out}}{\text{Total number of fertile eggs set}} \times 100$$

Table 7; External egg qualities of treatment groups during the experimental period

Treatment	30 week		35 week		40 week		45 week	
	Egg weight (g)	Egg shape index (%)	Egg weight (g)	Egg shape index (%)	Egg weight (g)	Egg shape index (%)	Egg weight (g)	Egg shape index (%)
HB-L	52.09^{b}	76.37^{ab}	53.11	77.13	54.90	76.56^{ab}	60.31^{b}	76.67
HB-C	51.06^{ab}	75.60^{a}	53.41	77.10	56.28	78.15^{b}	60.40^{b}	76.66
LB-L	50.76^{ab}	76.80^{b}	52.38	77.75	56.00	76.07^{a}	59.10^{ab}	76.41
LB-C	49.85^{a}	77.10^{b}	53.41	77.14	54.79	78.29^{b}	58.20^{a}	76.31
Source of variation	Probability							
BW§	0.023	0.014	0.469	0.461	0.813	0.777	0.01	0.533
GC†	0.082	0.55	0.191	0.477	0.912	0.002	0.54	0.92
BW*GC	0.913	0.176	0.469	0.522	0.112	0.607	0.453	0.926

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

Table 8; Internal egg qualities of treatment groups during different parts of the experimental period

Treatment	38th week				49th week			
	Haugh unit	Yolk index	Albumen index	Shell thickness (mm)	Haugh unit	Yolk index	Albumen index	Shell thickness (mm)
HB-L	66.36	0.448	0.053	0.405	80.47	0.420	0.088^{b}	0.472^{c}
HB-C	65.86	0.415	0.055	0.406	70.72	0.439	0.088^{b}	0.475^{c}
LB-L	64.02	0.429	0.050	0.397	81.74	0.435	0.066^{a}	0.415^{b}
LB-C	57.35	0.429	0.044	0.436	71.69	0.412	0.063^{a}	0.359^{a}
Source of zvariation	Probability							
BW§	0.163	0.873	0.200	0.526	0.751	0.638	0.002	0.000
GC†	0.352	0.235	0.712	0.281	0.011	0.899	0.825	0.139
BW*GC	0.423	0.248	0.462	0.300	0.966	0.086	0.817	0.106

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

CONCLUSION

The growth curves (linear or concave) did not have any significant effect on body weight, body weight gain and body weight uniformity. The high body weight groups reach sexual maturity, 10% egg production, 50% egg production and peak egg production at an earlier age than low body weight groups. Within the body weight groups, the concave growth curve groups reach sexual maturity and peak egg production earlier than linear growth curve groups. Considering the lower feed consumption in concave groups than the linear groups and without having any difference in egg production, fertility and hatchability, it may be suggested that feeding broiler breeder pullets on a concave growth curve during growing period will be more economical than raising them on 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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