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Efficacy of pre-lay diets on pubertal growth spurt of commercial Leghorn pullets under humid tropical climate

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Multi-phasic growth theory is that pullet growth is a discontinuous process where 3 distinguishable growth waves or spurts existed. The third phase, the pronounced 'pubertal growth spurt' between 14 weeks and 20 weeks in layer pullets predicts point of lay (Kwakkal *et al.* 1997). During this transition time the pre-layers nutrient requirement which has plateaued as she approaches a mature pullet weight will now begin to increase and change as well. Hence, traditional method of feeding layer pullets (Bureau of Indian Standards) by offering starter diet up to 8 weeks and grower diet up to 18/20 weeks needs to be reviewed for better productivity and good health. In this regard, a concept of pre-lay feed was introduced in the existing traditional feeding system of Bureau of Indian Standard for layers and a biological experiment was designed and conducted to study the effect of pre-lay feeding strategy during transition period (15 weeks to sexual maturity) on pullet growth and laying performance under a hot and humid tropical climate.

Day-old, Bovans white commercial strain of White Leghorn pullets were raised in conventional floor pens up to 13 weeks. Pullets were vaccinated against Newcastle and infectious bursal disease. At 13 weeks of age, pullets were transferred from the floor pens to cages with 4 birds / cage (309.6 cm^2) and acclimatized to the cage for 1 week prior to receiving the experimental pre-lay rations. At the age of 5 % egg production to 43 weeks of age, each pullet was provided with 412cm^2 of cage space. A mild gradient was provided on the floor for gentle and easy rolling of eggs from the cage to the outer extended arm of the welded mesh to facilitate easy collection of the eggs.

During the chick stage (0-2 weeks) 23 h light with 20 lux intensity and 1h darkness were provided. After the brooding period, the birds were reared under natural day light that extended to 11 h with 10 lux intensity. Thereafter at 18 weeks (5% egg production) of age the lighting period was increased ½ h each week to 16 h with 3 lux of intensity / sqft.

Experimental design: All birds were fed *ad lib.* feed as per BIS (2007) recommendation from 0 to 14 weeks of age. The birds were provided with 20 % CP and 2800 kcal ME/kg chick ration for the first 8 weeks and fed a 16 % CP and 2500 kcal ME/kg grower ration from 9 to 14 weeks of age. At 15 weeks of age, pre-lay pullets were randomly assigned to 1 of 5 pre-lay dietary treatments in a completely randomized design. Each diet was given to 6 replicates consisting of 12 birds / replicate. Dietary treatments comprised T1 (BIS control): diet formulated with crude protein of 16 % and metabolizable energy of 2500 kcal/kg; T2 (high energy diet): dietary treatment with crude protein of 16 % and metabolizable energy of 2700 kcal/kg; T3 (high energy + high protein diet): dietary treatment with crude protein of 18 % and metabolizable energy of 2700 kcal/kg; T4 (high energy with 10% extra methionine and lysine): dietary treatment with crude protein of 16 % supplemented with synthetic lysine and DL-methionine by 10 % higher than BIS recommendations and metabolizable energy of 2700 kcal/kg; T5 (high energy , 10% extra methionine and lysine with 2% oil): dietary treatment with crude protein of 16 % supplemented with synthetic lysine and DL-methionine by 10 % higher than BIS recommendations and metabolizable energy of 2700 kcal/kg with 2 % addition of rice bran oil to meet this energy level. Ingredient and nutrient composition of the pre-lay rations are shown in Tables 1 and 2, respectively.

The body weights of the experimental birds were recorded at 15 weeks of age and at age of sexual maturity. Weight gain was calculated. All the experimental birds were provided pre-weighed *ad lib.* chick, grower and pre-layer pre weighed feed during the experimental period, the leftover feed was weighed at biweekly interval. The feed consumption was arrived at and feed efficiency for body weight at sexual maturity and for weight gain during transition period was calculated.

Statistical analysis: Statistical analysis of data was carried

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Table 1. Per cent ingredient composition of experimental rations

Ingredients (kg)	Chick feed (0-8 weeks)	Grower feed (9-14 weeks)	Pre-layer feed (15 weeks - 5% egg production)				
			T1 (BIS control)	T2	T3	T4	T5
Yellow maize	42.00	24.00	24.00	38.97	38.50	37.00	28.00
Broken rice	10.00	13.00	13.00	10.00	10.75	10.00	12.00
Cumbu/Bajra	-	22.00	22.00	17.00	12.75	20.00	20.25
Ragi	5.50	-	-	-	-	-	-
Deoiled rice bran	5.00	12.50	12.50	10.00	10.75	8.87	13.00
Wheat bran	-	8.00	8.00	2.00	1.00	2.00	3.50
Sunflower oilcake	5.00	4.80	4.80	4.00	1.00	4.00	2.50
Soybean oilcake	23.50	9.50	9.50	11.00	18.25	11.00	11.50
Dry fish	7.00	4.00	4.00	5.00	5.00	5.00	5.00
Rice bran oil	-	-	-	-	-	-	2.00
Mineral mixture*	2.00	1.55	1.55	1.55	1.55	1.55	1.55
Dicalcium phosphate	-	0.52	0.52	0.48	0.45	0.45	0.44
Shell grit	-	-	-	-	-	-	-
Lysine	-	-	-	-	-	0.05	0.02
DL-methionine	-	0.05	0.05	0.05	-	0.08	0.09
Salt	-	0.08	0.08	-	-	-	-
Total	100	100	100	100	100	100	100

*Mineral mixture (TANUVAS) composition : calcium, 23%; phosphours,12%; magnesium, 6.5 %; iron ,0.5 %; iodine ,0.026 % ; copper, 0.077 %; manganese, 0.12 %; cobalt ,0.012 % ; zinc ,0.38 % ; sulphur,0.5%; fluorine,0.07 (max) and selenium, 0.3 ppm. Composition of feed supplements: 100 g Ultra vit M contains vit A_3, 20000 IU; vit B_2, 0.1g; vit D_3, 69 000 IU; Vit B_{12}, 0.6mg; vit E, 30 IU; vit K, 0.04g; niacinamide, 0.4g; calcium pantothenate, 0.1 g; choline chloride, 12 g; calcium, 30.4 g; copper, 0.08g ; Iodine,0.08g; iron,0.8g; manganese, 2.2 g; zinc, 2.08 g and cobalt, 4 mg; 100 g ultra Sil, TCF contains sodium alumino silicate, 95.25 %; predigested protein , 20 ppm; cobalt and organic acid, 2 ppm; 100 g ultra phos–D_3 contains calcium, 21.6 g; phosphorus, 15.6 g; vit D_3, 12 000 IU; vit B_{12}, 80 Mcg; manganese, 1080 mg and zinc, 1040 mg; 100 g ultra B_{12}, FS contains vit B_{12}, 10 mg; elemental cobalt,10 mg; elemental calcium, 22.5 % and protein hydrolysate, 5 ppm.

Table 2. Per cent nutrient composition of experimental rations

Ingredients	Starter (0-8 weeks)	Grower (9-14 weeks)	Pre-layer (15 weeks - 5% egg production)				
			T1 (BIS control)	T2	T3	T4	T5
Crude protein (%)*	20.48	15.94	15.94	16.06	18.33	15.93	16.23
Metabolizable energy** (kcal/kg)	2835	2543	2543	2715	2705	2716	2729
Calcium (%)*	0.98	1.23	1.23	1.05	1.33	1.11	1.08
Total phophorus (%)*	0.60	0.60	0.60	0.59	0.57	0.60	0.59
Lysine (%)**	1.10	0.71	0.71	0.73	0.87	0.77	0.77
Methionine (%)**	0.39	0.35	0.35	0.35	0.37	0.39	0.39
Crude fibre (%)*	5.30	7.41	7.41	6.15	5.93	5.99	6.55
Salt**	0.47	0.48	0.48	0.48	0.47	0.48	0.48

*Mean of the analyzed values; **calculated values.

as per Snedecor and Cochran (1994) by using the SPSS 10.0 program package (SPSS, 2001). The significance of the difference among the groups was determined by Duncan's multiple range tests (Petrie and Watson 1991).

Body weight and pubertal growth spurt: Body weight at age of sexual maturity plays a very important role for the subsequent layer production performance. The mean body weight at sexual maturity and weight gain (pubertal growth spurt) during transition period of treatment groups were significantly ($P<0.05$) higher than the birds fed with control feed of BIS specification (Table 3). Between treatment groups fed high energy with high protein diets, 10 % extra lysine and methionine or 2 % oil addition, there was no significant difference in body weight and pubertal growth spurt. Among these comparable treatments, pullets provided with 2700 kcal energy with 18 % protein or 2 % oil group had numerically higher body weight and pubertal growth spurt at sexual maturity. This increase in body weight could be due to

Table 3. Mean (±SE) effect of varying pre-lay energy and protein diets on pullet body weight (g), weight gain (g) /pubertal growth spurt

Dietary ME/Crude protein	Control-2500/16	2700/16	2700/18	2700/16 (10% L&M**)	2700/16 (10% L&M +2% oil)
Body weight at 15weeks^{NS}	995.0 ± 12.6	982.6 ± 13.1	992.8± 16.0	1008.1±15.2	979.4 ± 13.7
Body weight at sexual maturity*	1181^{b} ± 28.3	1269^{a} ± 27.84	1294^{a} ±25.7	1260^{a} ± 26.8	1306^{a} ± 27.2
Pubertal growth spurt (g) during pre-lay period*	186.0^{b} ±25.7	287.1^{a} ± 21.2	301.0^{a}±22.2	252.4^{a}± 0.4	327.8^{a} ± 21.5

*Significant (P<0.05); NS, not significant; **L+M, Lysine and methionine; values bearing different superscript in a row differ significantly.

quantity of protein and energy consumed by these pullets through growing period. Various workers also reported higher body weight due to higher cumulative intake of protein and energy till sexual maturity (Hussein *et al.* 1996, Keshavarz 1998, Razvani *et al.* 2000, Kingori *et al.* 2003, Babiker and Abbas 2009, Anderson 2010 and Babiker *et al.* 2010). Leeson and Summers (1984) observed that although energy was provided at higher levels to heavy pullets at 8, 12 or 16 weeks of age, it was more profitable to give higher energy at 16 weeks alone, rather than during the earlier ages. As suggested by Leeson and Caston (1991), any treatment imposed at early growing period had little influence on body weight. So, it appears that within certain limits pullet weight just before sexual maturity influences the onset of production. It has also been contended that pre-lay diets were used to condition or correct growth problems, which have arisen during 14-18 weeks before sexual maturity when bird's nutrient requirement changes and so, pre-lay diet has been introduced to bring up target body weight at sexual maturity (Leeson and Summer 2000, Leeson 2001a and b). Hence, high energy diets in this experiment have conditioned and corrected the growth during this critical period (15 weeks to sexual maturity) making the bird ready for future performance. Scott and Balnave (1991) also observed that retention of crude protein (49% vs 41%) significantly increased at both high and low temperatures respectively as age advanced during rearing, reaching a plateau when the birds were approximately 24 weeks of age, just after sexual maturity. This demonstrates the need for high level of dietary crude protein towards age of sexual maturity by sexually maturing pullets. As per Leeson (2001b), at 18 weeks of age, it would be ideal for White Leghorn strain to reach body weight of 1250 to 1350g. The average body weights of all the pullets on high energy treatments were in the range of 1260 to 1300 g, falling well within the recommended target weight at age of sexual maturity. Further, the pubertal growth spurt between 15 weeks to sexual maturity (Kwakkel *et al.* 1995) was well accelerated and target body weight was obtained with high dense pre-lay diets as compared to BIS feed.

Feed consumption and feed efficiency: The mean feed consumption and feed efficiency of Bovans' white pullets fed with various pre-lay feeding strategies is presented in Table 4. The mean cumulative feed consumption was best (1930 and 5460 g) from 15 weeks to 5% egg production and 0 week to 5% egg production respectively for the high dense pre-lay dietary group of 2700/18 and this was comparable to the other groups of 2700/16, 2700/16+ lysine and methionine. Birds provided control feed and 2700/16 with 2% addition of oil recorded significantly (P<0.05) highest feed consumption during transition period and from 0 week to 5% egg production. The feed efficiency for pubertal growth spurt during transition period was significantly (P<0.05) better for all treatment groups other than control group; whereas, the control (BIS) group recorded significantly (P<0.05) a poor feed efficiency of 5.05±0.07 at sexual maturity and 13.12±0.18 during transition period. Higher protein and energy levels could have contributed to lower feed intake. This has been acknowledged by many studies

Table 4. Mean (±SE) Effect of varying pre-lay energy and protein diets on feed consumption and feed efficiency of pullets

Dietary ME/crude protein	Control-2500/16	2700/16	2700/18	2700/16 (10% L&M**)	2700/16 (10% L&M +2% oil)
Feed consumption (g)					
Transition period* (15 weeks to 5% egg production)	2440^{b} ± 1.56	2040^{a} ± 1.66	1930^{a} ± 1.08	2050^{a} ± 2.87	2480^{c} ±1.71
0 weeks to 5% egg production	5940^{b} ± 1.32	5580^{a} ± 1.19	5460^{a} ± 1.25	5540^{a} ± 1.38	6060^{b}±1.45
Feed efficiency					
Transition period* (15 weeks to 5% egg production)	13.12^{c} ±0.18	7.10^{a} ± 0.11	6.41^{a} ± 0.14	8.12^{a} ± 0.11	7.56^{a} ± 0.10
0 weeks to 5% egg production	5.05^{c} ± 0.07	4.39^{a} ± 0.03	4.31^{a} ± 0.06	4.40^{a} ± 0.06	4.64^{b}± 0.04

*Significant (P<0.05); NS, not significant; **L+M-lysine and methionine; values bearing different superscript in a row differ significantly.

(Carrijo *et al.* 1994, Hussein *et al.* 1996 and Oke *et al.* 2003). On the contrary, Mohammad and Hassan (2008), Babiker and Abbas (2009) and Anderson (2010) have found no significant difference in feed consumption due to increased rearing dietary protein or energy levels, this difference may be attributed to the wide range of varying energy and protein levels provided, that ranged from 12 to 18% with regard to dietary protein and from 2400 to 3200 kcal with regards to energy levels. The instinct of tastiness towards oil would have increased feed intake significantly ($P<0.05$) high feed intake with oil added group; but feed conversion efficiency for body weight was significantly ($P<0.05$) better for 2700 kcal of energy when compared to 2500 kcal of energy irrespective of protein levels and other factors. Significantly better feed efficiency on body weight was observed by Keshavarz (1998) and Oke *et al.* (2003). This variation in feed efficiency could be attributed to the higher bodyweight and weight gain with lower feed consumption seen in pullets fed 2700 kcal of energy when compared to the pullets fed BIS standard of 2500 kcal energy.

It is concluded that an effective pre-lay diet is necessary in the existing traditional method of feeding layer pullets (Bureau of Indian Standards). Under a humid tropical climate, both the dietary energy and crude protein levels need to be increased at least 3 to 4 weeks before sexual maturity (transition period) so as to provide her with a required body weight and to reach maximum pubertal growth spurt.

SUMMARY

The present study was carried out to review Bureau of Indian Standards recommendations for layer pullet feed under a hot and humid tropical climate. Commercial layer chicks were fed from 0 to 14 weeks of age as per BIS. At 15 weeks, pullets were randomly assigned to each of 5 pre-lay diets namely, T1 (BIS control), T2–16/2700, T3–18/2700 (%CP / kcal ME/kg); T4–same as T2+lysine and methionine by 10% higher than BIS, and T5 – same as T4 with 2 % oil. Pullets fed on high energy and protein pre-lay diets of 2700 kcal and 18% CP gave significantly better body weight at sexual maturity, pubertal growth spurt during transition period (2 to 3 weeks before sexual maturity), with better feed efficiency. It was concluded that, pre-lay diet is needed to accelerate pubertal growth spurt during transition period and to achieve target body weight at sexual maturity.

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