THE INFLUENCE OF DIETARY PROTEIN AND ENERGY LEVELS ON EGG QUALITY IN STARCROSS LAYERS

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Summary

The interaction of 4 dietary crude protein (13, 16, 19 or 22 %) and 4 metabolizable energy (2600, 2800, 3000 or 3100 kcal ME/kg) levels on egg quality performances of Starcross layers were assessed between 245 and 275 days of age.

The egg weight increased significantly with the increasing dietary protein and energy levels. But egg shape index, albumen index, yolk index, yolk dry matter, yolk protein, yolk fat, albumen protein and shell tickness were similar at all dietary protein and/or energy levels. The egg specific gravity and albumen weight increased but the yolk, weight, Haugh unit and albumen drymatter decreased with the increase of dietary protein levels and showed irregular trend with energy levels. The albumen dry matter and egg shell weight, however, were not affected by energy and protein levels. Simultaneous increase of protein and energy increased specific gravity, albumen index and shell thickness at a greater rate than that increased by the increase of protein or energy alone
(Key Words : Layers, Energy, Protein, Egg Quality)

Introduction

The egg weight was found to improve with the increasing dietary protein (15.1 to 17.2%) and energy (770 to 3 and 10 kcal ME/kg) levels (Doran et al., 1980). Aitken et al. (1973) reported an increase in Haugh unit score at the decreased dietary protein levels. The results of Aitken et al. (1973) and Ross and Herrick (1976) indicated that egg shell thickness and specific gravity are not affected by dietary protein levels. However, there are limited findings on the effects of varying dietary protein and/or energy levels on some other quality characteristics of eggs. The present study, therefore, investigated the effects of 4 crude protein (CP) and 4 metabolizable energy (ME) levels and their interaction on egg quality of Starcross layers.

Materials and Methods

Five hundred and twelve Starcross pullets, 160 days of age were distributed randomly into 16 dietary treatment groups, with two replications in each treatment. The birds were vaccinated against Newcastle Disease, Fowl Pox, and Fowl Cholera and Dewormed prior to the commencement of the experiment. Sixteen diets were computed (table 1) to contain 4 different crude protein (CP) levels (13, 16, 19 or 22%) and 4 different metabolizable energy (ME) levels (2600, 2800, 3000 or 3100 kcal/kg. The birds, housed in a sand littered open-sided tinshed building, were offered feed and fresh water *ad libitum*.

At approximately 40 to 45% egg production (between 245 and 275 days of age), a total of 384 fresh eggs (taking 12 eggs from each replication) were collected in 3 batches with an interval of 10 days. Following collection, the eggs were identified replication wise and weighed individually. Following the methods, the shape index (Reddy et al., 1979), specific gravity (Hamilton, 1982), albumen and yolk index (Heiman and Carver, 1936) and Haugh units (Haugh, 1987) were measured. The weight of the yolk, albumen and shell were measured and calculated according to Chowdhury (1987) and the Shell thickness was measured following the methods described by Sadagopan et al. (1972). The proximate components (dry matter, crude protein and crude fat) were determined by the A.O.A.C.

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TABLE 1. COMPOSITION OF THE EXPERIMENTAL RATIONS (EXPERIMENT 1 & 2).

Ingredients (%)	Treatments															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Wheat crushed	4.00	5.00	17.00	29.00	29.00	40.00	53.00	53.00	75.00	75.00	75.00	70.00	90.00	84.00	78.00	71.00
Wheat bran	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00	1.00	1.00	1.00	1.00	1.00	1.00
Rice polish	85.00	70.00	46.00	21.00	60.00	36.00	10.00	1.00	14.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fish meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	6.00	1.00	3.00	13.00	23.00	2.00	9.00	15.00	22.00
Sesame oil cake	5.00	19.00	31.00	44.00	5.00	18.00	31.00	35.00	5.00	13.00	6.00	1.00	2.00	1.00	1.00	1.00
Bone meal (Steamed)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Nutrient content :																
Dry matter (%)	86.91	88.42	89.71	87.50	90.00	87.50	90.08	89.27	90.74	88.73	90.69	86.95	86.84	85.76	88.00	88.16
Crude protein (%)	13.12	16.16	19.19	21.98	13.18	16.07	19.01	22.11	13.17	16.20	18.93	22.17	13.02	15.96	19.25	21.87
Crude fiber (%)	3.49	5.01	4.76	4.42	3.53	4.30	4.48	5.00	3.68	4.37	3.55	2.76	3.62	3.21	3.08	2.74
Ether extract (%)	13.02	12.07	9.84	7.56	9.87	7.71	5.30	4.89	4.06	3.21	3.59	4.18	2.31	2.81	3.44	4.09
Ash (%)	10.71	10.66	10.88	10.22	9.81	9.59	9.09	9.72	7.34	7.70	7.97	8.98	7.15	7.12	8.57	9.81
Nitrogen free extract (%)	46.57	44.52	44.02	43.32	53.61	49.83	52.20	47.55	62.49	57.25	56.65	48.86	60.74	56.66	53.66	49.65
Estimated :																
Metabolizable energy (kcal/kg):	2600	2600	2600	2600	2800	2800	2800	2800	3000	3000	3000	3000	3100	3100	3100	3100
Methionine	0.29	0.46	0.59	0.62	0.72	0.42	0.56	0.70	0.25	0.37	0.46	0.58	0.22	0.33	0.44	0.56
Lysine	0.71	0.65	0.71	0.73	0.64	0.55	0.58	0.83	0.92	0.57	1.17	1.68	0.51	0.90	1.23	1.65
Cystine	0.35	0.39	0.40	0.41	0.32	0.34	0.35	0.40	0.26	0.28	0.36	0.44	0.23	0.30	0.36	0.43

[1] 1 kg of vitamin-mineral premix contained: Vitamin-A-480000 IU; Vitamin-D-1000000 IU; Vitamin-E-8000 IU; Vitamin-K 1.60 g; Vitamin B_1 0.60g; Vitamin-B_2-2.00g; Vitamin-B_6-1.60g; Nicotinic Acid-12.00g; Pantothenic acid-4.00g; Vitamin-B_{12}-4.00mg; Folic acid-0.20g; Cobalt-0.12g; Copper-6.4g; Iron-9.6g; Iodine-0.24g; Manganase 19.20g; Zinc-1.60g; Selenium-0.048g; DL-methionine-20.00g; Choline-chloride-100.00g; BHT-20.00g; Cereal base-100% (2.5 kg) ed.

(1980) methods.

The experiment was 4 × 4 (Crude protein × metabolizable energy) factorial in a Completely Randomized Design. Analysis of Variance and correlation and regression were performed to compare between the treatments.

Results

The effects of crude protein and/or metabolizable energy levels on egg quality parameters are presented in table 2 and their regressions on dietary protein or energy levels are presented in

TABLE 2. EGG WEIGHT, EGG SHAPE INDEX, EGG SPECIFIC GRAVITY, ALBUMEN INDEX, YOLK INDEX, ALBUMEN WEIGHT, YOLK WEIGHT, HAUGH UNITS, YOLK DRY MATTER, YOLK PROTEIN, YOLK FAT, ALBUMEN DRY MATTER, ALBUMEN PROTEIN, SHELL WEIGHT AND SHELL THICKNESS OF STAR-CROSS LAYERS AT THE AGE BETWEEN 245 AND 275 DAYS

Parameters	Percent crude protein in feed	Metabolizable Energy (kcal ME/kg feed)				Mean	SED and level of significance		
		2600	2800	3000	3100		CP	ME	CP×ME
Egg weight (g)	13	50.02	51.00	50.83	52.40	51.06	1.008	1.008	NS
	16	50.32	54.74	53.85	54.89	53.45	**	**	
	19	52.00	55.25	56.46	58.01	55.43			
	22	54.50	56.50	57.95	64.15	58.27			
	Mean	51.71	54.37	54.77	57.36	54.55			
Egg shape index	13	77.31	77.09	76.62	76.27	76.82	NS	NS	NS
	16	77.12	76.71	76.92	76.42	76.79			
	19	76.84	76.55	76.21	76.34	76.48			
	22	76.83	76.51	75.99	76.16	76.37			
	Mean	77.02	76.71	76.43	76.29	76.61			
Egg specific gravity	13	1.0685	1.0740	1.0690	1.0635	1.0687	0.0006	0.0006	0.0012
	16	0.0700	1.0755	1.0720	1.0745	1.0730	**	**	**
	19	1.0705	1.0755	1.0705	1.0830	1.0748			
	22	1.0705	1.0825	1.0790	1.0865	1.0796			
	Mean	1.0698	1.0768	1.0726	1.0769	1.0740			
Albumen index	13	0.0843	0.0870	0.0843	0.0870	0.0856			
	16	0.0839	0.0826	0.0879	0.0880	0.0856	NS	NS	*
	19	0.0864	0.0865	0.0842	0.0837	0.0854			
	22	0.0854	0.0855	0.0852	0.0837	0.0849			
	Mean	0.0850	0.0854	0.0854	0.0856	0.0853			
Yolk index	13	0.430	0.420	0.429	0.423	0.425	NS	NS	NS
	16	0.428	0.420	0.435	0.432	0.428			
	19	0.429	0.420	0.433	0.430	0.428			
	22	0.423	0.424	0.423	0.424	0.423			
	Mean	0.427	0.421	0.430	0.427	0.426			
Albumen weight (%)	13	57.21	57.47	56.70	57.82	57.30	0.561	0.561	NS
	16	56.70	59.05	58.55	59.20	58.37	**	*	
	19	57.81	60.13	58.33	59.96	59.05			
	22	60.51	58.74	58.91	61.81	59.99			
	Mean	58.05	58.84	58.12	59.69	58.67			
Yolk weight (%)	13	34.86	34.60	34.85	33.93	34.56	0.555	0.555	NS
	16	35.2	32.86	33.15	32.53	33.43	**	*	
	19	31.15	32.08	33.14	31.52	32.72			
	22	30.98	33.02	32.79	29.76	31.63			
	Mean	33.80	33.14	33.48	31.93	33.08			

TABLE 2. (CONTD.)

Parameters	Percent crude protein in feed	Metabolizable Energy (kcal ME/kg feed) 2600	2800	3000	3100	Mean	SED and level of significance CP	ME	CP×ME
Haugh units	13	80.50	81.24	80.43	80.84	80.75	0.9250	NS	NS
	16	79.00	79.76	79.45	78.22	79.10	**		
	19	78.05	78.71	78.06	77.42	78.06			
	22	77.35	77.21	77.88	76.61	77.26			
	Mean	78.72	79.23	78.95	78.27	78.29			
Yolk dry matter on fresh basis (%)	13	51.92	50.18	51.52	50.34	50.99	NS	NS	NS
	16	51.96	50.08	51.58	51.60	51.30			
	19	51.80	50.85	51.76	51.54	51.48			
	22	50.90	51.75	52.74	52.43	51.95			
	Mean	51.64	50.71	51.90	51.54	51.43			
Yolk crude protein content (%) on dry matter basis	13	15.97	15.93	14.65	15.94	16.62	NS	NS	NS
	16	15.86	15.85	16.30	16.50	16.12			
	19	16.02	16.16	16.28	16.57	16.25			
	22	16.13	16.15	16.72	16.62	16.40			
	Mean	15.99	16.02	15.98	16.40	16.09			
Yolk fat content (%) on dry matter basis	13	33.05	31.75	32.65	31.75	32.30	NS	NS	NS
	16	32.25	32.27	32.45	32.37	32.33			
	19	32.91	32.04	32.48	32.39	32.39			
	22	32.25	32.90	33.25	32.92	32.83			
	Mean	32.61	32.26	32.59	32.48	32.46			
Albumen dry matter on fresh basis (%)	13	12.58	12.42	12.16	12.06	12.30	0.157	NS	NS
	16	12.68	12.36	12.03	12.01	12.27	*		
	19	12.23	11.87	11.81	11.83	11.93			
	22	11.71	11.87	11.96	12.01	11.89			
	Mean	12.36	12.13	11.99	11.97	12.09			
Albumen crude protein content (%) on dry matter basis	13	10.76	10.59	10.66	10.90	10.72	NS	NS	NS
	16	10.96	10.65	10.83	10.63	10.76			
	19	11.06	10.67	10.59	10.75	10.76			
	22	10.97	10.90	11.04	11.21	11.03			
	Mean	10.93	10.70	10.78	10.87	10.82			
Shell weight (%)	13	7.91	7.92	8.43	8.43	8.17		0.0806	NS
	16	8.06	8.10	8.28	8.24	8.17	NS	**	
	19	8.00	7.77	8.50	8.54	8.20			
	22	8.39	8.22	8.28	8.41	8.32			
	Mean	8.09	8.00	8.37	8.40	8.21			
Shell thickness (mm)	13	0.355	0.346	0.345	0.330	0.344	NS	NS	0.0046
	16	0.349	0.346	0.336	0.351	0.345			**
	19	0.338	0.352	0.351	0.359	0.348			
	22	0.344	0.343	0.354	0.354	0.348			
	Mean	0.346	0.346	0.346	0.347	0.346			

[1] All SEDs are against 16 df, NS ($p > 0.05$), * ($p < 0.05$), ** ($p < 0.01$).

TABLE 3. REGRESSIONS OF EGG QUALITY PARAMETERS (Y) ON PROTEIN OR ENERGY LEVELS (X) IN THE FEED

Paramenters (Y)	Percent crude protein in the diet (X)			Metabolizable energy (kcal ME/kg feed) (X)		
	a	b	r	a	b	r
Egg weight (g)	40.774	0.787	0.692**[1]	46.536	0.0028	0.403*
Egg shape index	77.587	−0.055	−0.106 ns	80.789	−0.0014	−0.159 ns
Egg specific gravity	1.053	0.0011	0.558**	1.046	0.000009	0.262 ns
Albumen index	0.0868	−0.000054	−0.162 ns	0.0822	0.000001	0.118 ns
Yolk index	0.428	−0.00010	−0.050	0.418	0.0000027	0.069 ns
Albumen weight (%)	53.575	0.291	0.615**	52.490	0.0021	0.259 ns
Yolk weight (%)	38.621	−0.316	−0.637**	41.074	−0.0027	−0.320 ns
Haugh units	85.513	−0.383	−0.675**	80.953	0.00074	−0.075 ns
Yolk dry matter (%)	49.464	0.109	0.377**	48.758	0.00091	0.180 ns
Yolk crude protein (%)	14.663	0.082	0.461**	11.142	0.00156	0.113 ns
Yolk fat (%)	31.504	0.055	0.298 ns	33.011	−0.0001	−0.058 ns
Albumen dry matter (%)	13.012	−0.051	−0.494**	11.634	−0.00067	0.366*
Albumen crude protein (%)	10.300	0.029	0.377*	9.475	0.00046	0.338 ns
Shell weight (%)	8.066	0.0092	0.165 ns	6.011	0.00076	0.578**
Shell thickness (mm)	0.337	0.00054	0.242 ns	0.350	−1.419	−0.036 ns

[1] NS ($p > 0.05$), * ($p < 0.05$), ** ($p < 0.01$).

table 3. The egg weight increased ($p < 0.01$) with the increasing dietary protein and energy levels. Egg specific gravity and albumen weight improved, but the yolk weight and Haugh unit decreased significantly at the increasing protein levels and all these parameters did not show any trend with energy levels. The egg shape index, albumen index, yolk index, yolk dry matter, yolk protein and fat, albumen protein, and shell energy levels. The albumen dry matter content decreased ($p < 0.05$) at the increasing energy levels. Similarly, the egg shell weight tended to be increased at the increasing protein levels but significantly differed with an irregular trend across the energy levels. The egg shape index tended to be decreased at the increasing protein and energy levels.

There was a slight decreasing tendency in albumen index at increasing protein levels and increased ($p > 0.05$) at the increasing energy levels. An irregular trend ($p > 0.05$) in yolk index was observed at the increasing protein and energy levels. The yolk dry matter, protein and fat, and albumen protein tended to be increased at increasing protein levels and showed irrgular tendency at increasing energy levels. There were significant protein × energy interaction on egg specific gravity, albumen index and shell thickness. The dietary protein levels showed significant positive correlation with egg weight, egg specific gravity, albumen weight, yolk dry matter, yolk protein and albumen protein and negative correlation with yolk weight, Haugh units and albumen dry matter. The energy levels showed significant positive correlation with egg weight, shell weight and negative correlation with albumen dry matter.

Discussion

The results of increased egg weight at the increasing dietary protein and/or energy levels confirm the findings of Doran et al. (1980), Pearson and Herron (1982) and Spratt and Leson (1987). A decreased egg shape index can simply be explained by increase in egg weight (Reddy et al., 1979; Sharma and Vohra, 1980). The lack of effect of dietary protein and energy levels on albumen and yolk index is supported by the observations of Sadagopan et al. (1972).

The findings on higher percentage of egg yolk of smaller eggs at lower protein levels partially supports the results of Washburn (1979). The higher percentage of albumen at higher protein levels might possibly be due to lower percentages of yolk. The increased Haugh unit at the decreased protein levels is supported by Harms et al. (1962) and Sladagopan et al. (1972). The insignificant effect of energy levels on Haugh unit is supported by Saxens et al. (1986). The higher protein content of egg components (albumen and yolk) at higher protein levels is supported by Elwinger et al. (1981), Babatunde and Fetuga (1976) and Andersson et al. (1978). The slight increased fat percentage in yolk at the increased protein levels might be due to increased fat levels in the diet (Elwinger et al., 1981; ell et al., 1987). The insignificant effect of protein levels on percent shell is supported by Reddy et al. (1989).

Considering the findings of egg weight, egg protein and fat contents, it could be concluded that dietary protein and energy levels of Starcross layers may lie between 19 and 22% and 3000 and 3100 kcal/kg. To confirm these findings, further studies may be conducted.

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