Effect of Substitution of Groundnut with Soybean Meal at Varying Fish Meal and Protein Levels on Performance and Egg Quality of Layer Chickens

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ABSTRACT : Two hundred and sixteen single comb white egg layers of the White Leghorn hens of 24 weeks of age were randomly allocated to 12 groups with three replications of six hens in each. Hens were fed in a factorial arrangement 2×3×2, on diets containing either 16 or 18% crude protein with 0, 3 or 6% fish meal, replacing groundnut meal with soybean meal. Soybean meal incorporation improved ($p<0.05$) egg production, feed intake, feed conversion efficiency and egg weights. Egg quality traits of specific gravity, shape index, albumen index, yolk index and shell thickness remained unchanged. Laying performance was significantly ($p<0.05$) better at 18% than on 16% dietary protein level. Use of fish meal linearly improved egg production and feed conversion efficiency on diets supplemented with groundnut meal and fish meal incorporation showed quadratic improvement on feed conversion efficiency with SBM diets at 16% dietary protein level. Therefore, use of soybean meal as substitute of groundnut meal is recommended in layer diets, at 16% dietary protein level and fish meal incorporation could be beneficial for layers. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 11 : 1617-1621)***

Key Words : Groundnut Meal, Soybean Meal, Layer Performance, Egg Quality

INTRODUCTION

The oil seed meals are important sources of protein in the diet of chickens. At present, the requirement of protein sources in India is 4.72 million MT and it will increase to 19.83 million MT by 2015 (Chadda, 1998). Apart from animal protein sources, various oil meals prepared from groundnut, sunflower and rapeseed-mustard meals are available for animal and poultry feeding in South Asian countries including India. Only groundnut meal has been used as conventional vegetable protein supplement in the preparation of mixed feeds for various classes of poultry. Rapeseed-mustard meal contains glucosinolate (Tripathi et al. 2001), whereas sunflower meal contain more fiber (Gracia-Fernandez et al., 1999) and cause lipids peroxidation (Senkoylu and Dale, 1999), hence not used in poultry feeds. Groundnut meal, however, is not balanced in amino acids pattern desirable for poultry. It is deficient in methionine, tryptophan and tyrosine (Singh et al., 1981), Its keeping quality is poor as it may develop aflatoxins during storage (Mishra, 1993). The presence of aflatoxins in the feed leads to a deadly condition due to aflatoxicosis. In comparison to groundnut meal, the amino acid pattern of soybean meal approximates more to dietary requirement of poultry and methionine, which is a relatively deficient amino acid may be supplemented easily. Soybean meal availability in India has been increased markedly. It is also superior to groundnut meal. Soybean meal contains higher crude protein and methionine (Lesson and Summers, 1991) than groundnut meal and with less crude fiber and silica among all vegetable protein supplements (Uma, 2000).The occurrence (possibility) of aflatoxin contamination is also least in soybean.

Fish meal is an important animal protein supplement in poultry diets, which could be also contaminated with higher level of sand, silica, salt and contains gizzerosin (Okazaki et al., 1983) and another limiting factor is its high cost. The objective of this study was to assess the effect of replacing groundnut meal with soybean meal at varying levels of fish meal using two dietary protein levels on performance and egg quality of layer chickens.

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MATERIALS AND METHODS

Study site

The present experiment was conducted at Poultry Research Center of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India. The Research Center is located in the Tarai region at 29.3°N latitude, 79.3°E longitude and 243.84 meters above mean sea level. The climate of Pantnagar is humid and subtropical in nature. The temperature exceeds 40°C in summer and falls below 5°C in winter. The annual rainfall is approximately 125 cm. The experiment was conducted in 1999 from mid January to mid April and average ambient temperature was 22°C.

Experimental protocol

Birds and experimental design : Two hundred and sixteen single comb white egg layers of the White Leghorn strain were obtained at 24 weeks of age from Poultry Research Center and placed individually in cages (32×33 cm). They were obtained in January after being reared in an open sided house and thus may have been adapted to heat stress conditions. After the all birds entered in production (96% had laid), they were arranged accordingly to egg laid during a 2 week pre-experimental period prior to feeding with different diets. One hen was housed per cage and three replications of six hens each were fed on each experimental diet. The experiment was conducted in a completely randomized design.

Diets and feeding : Twelve experimental layer diets were prepared containing either 16 or 18% crude protein with 0, 3 and 6% fish meal, replacing groundnut with soybean meal on a crude protein basis. The composition of diets is given in Table 1. Diets were analysed for proximate principles and calcium content following the procedures of AOAC (1984). All birds were fed 2-3 weeks for a adaptation period. The birds were fed at 8:30 am daily and records of feed intake were maintained on a week basis for 90 days. Diet and water were provided *ad. libitum*. The birds were allowed 10% diet refusals. Mortality and egg production were recorded twice daily at 10:00 h and 17:00 h. Hens were weighed individually at 30 day intervals to assess the change in body weight.

Egg quality measurements : All eggs from each treatment were weighed for 4 consecutive days at 30 days intervals. Specific gravity was determined by the eggs flotation method using eight salt (NaCl) solutions varying in specific gravity by increment of 0.005 from 1.065 to 1.100. The shape index was measured by dividing the transverse diameter of egg by the length {Shape index= (width of egg/length)×100}. The eggs were then broken on a glass sheet (30×30 cm), albumen index (height of dense albumen/average width) and yolk index (height of yolk/ width of yolk) were determined. The shell thickness was measured with shell membranes intact using a micrometer at equatorial parts of the egg.

Statistical analysis

The data obtained on a cage basis for all parameters except feed intake which was on pen basis were statistically analyzed using a linear model (Harvey, 1975).

$$Y_{ijk}=\mu+P_i+F_j+S_k+e_{ijk}$$

where: μ=General mean
P_i=Effect of $_i$th protein level (i=1, 2)
F_j=Effect of $_j$th fish meal level (j=1, 3)
S_k=Effect of $_k$th vegetable protein source (k=1,2)
e_{ijk}=Random error

Regression analysis was also carried out using the level of fish meal as factor, separately with 16 or 18% protein level utilizing a polynomial design which tested linear and quadratic relationship (Snedecor and Cochran, 1982).

Table 1. Ingredient and chemical composition of experimental diets

Protein level (%)	16 % crude protein diet						18 % crude protein diet					
Fish meal level	0		3		6		0		3		6	
Vegetable protein source	GNM[a]	SBM[b]	GNM	SBM	GNM	SBM	GNM	SBM	GNM	SBM	GNM	SBM
Ingredients (g/100 g)												
Wheat	53.69	57.37	55.03	57.76	56.34	58.16	45.18	50.69	46.52	51.10	47.85	51.49
Soybean meal	-	13.27	-	9.88	-	6.48	-	19.95	-	16.54	-	13.15
Groundnut meal	16.95	-	12.61	-	8.30	-	25.46	-	21.12	-	16.79	-
Ricebran[c]	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Fishmeal	-	-	3.00	3.00	6.00	6.00	-	-	3.00	3.00	6.00	6.00
Premix[d]	9.36	9.36	9.36	9.36	9.36	9.36	9.36	9.369	9.36	9.36	9.36	9.36
Analysed chemical composition (% in DM)												
Dry matter	94.52	92.94	94.13	92.36	93.75	94.00	94.77	92.40	93.39	92.43	94.00	92.44
Crude protein	16.00	16.00	16.01	16.02	16.03	16.03	17.99	18.00	18.00	18.01	18.01	18.02
Ether extract	0.79	0.88	0.89	0.96	0.99	0.93	0.71	0.84	0.83	0.92	0.93	0.99
Crude fiber	5.67	3.68	4.92	3.45	4.20	5.69	7.16	4.18	4.53	3.95	5.69	3.72
Ash	12.99	12.88	13.74	14.49	14.98	13.47	13.33	14.23	14.33	14.10	14.98	14.87
Calcium	3.00	3.00	3.19	3.18	3.37	3.40	3.03	3.01	3.21	3.20	3.40	3.58

[a] GNM: Groundnut meal.
[b] SBM: Soybean meal.
[c] Ricebran: It was deoiled and contained 2 g oil per kg DM.
[d] Premix provides: 1. Mineral mixture 2 kg; contained (g/kg) calcium 315.8, phosphorus 60.5, copper 0.3, manganese 1.8, cobalt 0.5, zinc 2.4, potassium iodide 0.3 and fluoride <0.3. 2. Shell grit 7 kg. 3. Vitamin supplement 30 g, contained: Vitamin A 82,500 IU, Vitamin D_3 12,000 IU, Vitamin E 10 mg, Vitamin B_{12} 40 mg. 4. Niftin-200, 25 g [contained furazolidone 20% (W/W)]. 5. Dinitolmide 50 g. 6. NaCl 250 g.

Table 2. Effect of experimental diets on hen performance and egg quality

Protein level	16 % crude protein diet						18 % crude protein diet						SEM
Fish meal (%)	0		3		6		0		3		6		
Vegetable protein source	GNM[a]	SBM[b]	GNM	SBM	GNM	SBM	GNM	SBM	GNM	SBM	GNM	SBM	
Hen performance													
Rate of laying (%)	83.1[a]	92.4[bc]	86.0[ab]	93.0[bc]	87.2[ab]	93.9[bc]	91.7[bc]	91.0[bc]	91.2[bc]	93.4[bc]	93.0[bc]	96.7[c]	2.04
Feed consumption (g per hen day^{-1})	127[ab]	132[bc]	127[ab]	135[bc]	118[a]	130[b]	133[bc]	133[bc]	134[bc]	143[c]	132[bc]	134[bc]	3.78
Feed conversion ratio (g feed per egg)	142[b]	137[ab]	136[ab]	131[a]	133[ab]	131[a]	135[ab]	135[ab]	134[ab]	134[ab]	134[ab]	135[ab]	3.02
Egg quality measurments													
Egg weight (g)	50.3[ab]	52.2[b]	49.3[a]	54.6[b]	50.2[ab]	52.5[b]	51.6[ab]	51.9[ab]	50.7[ab]	52.8[b]	51.8[ab]	54.0[b]	0.62
Specific gravity	1.11	1.06	1.10	1.09	1.09	1.08	1.10	1.09	1.10	1.10	1.10	1.10	0.010
Shape index	77.40	76.22	77.28	75.63	76.83	76.83	77.67	77.58	75.86	75.36	78.05	76.50	0.68
Yolk index	0.463	0.473	0.463	0.470	0.480	0.473	0.460	0.457	0.470	0.480	0.467	0.473	0.065
Albumen index	0.104	0.099	0.101	0.097	0.107	0.113	0.099	0.107	0.099	0.099	0.114	0.103	0.056
Shell thickness (×0.1mm)	3.3	3.4	3.5	3.5	3.6	3.4	3.5	3.5	3.5	3.5	3.6	3.6	0.65

[a] GNM: Groundnut meal.
[b] SBM: Soybean meal.
Values having different letters in a row differ significantly p<0.05.

Table 3. Regression effects of protein level, source of protein and fish meal levels on hen performance

	Protein levels	Protein Source	Fish meal levels							
			16 % protein				18 % protein			
			GNM[a]		SBM[b]		GNM		SBM	
			Lin[c]	Quad[d]	Lin	Quad	Lin	Quad	Lin	Quad
Rate of lay	*	*	*	NS[e]	NS	NS	NS	NS	NS	*
Feed intake	*	*	NS	*	NS	NS	NS	NS	NS	NS
Feed conversion ratio	NS	*	*	NS	NS	*	NS	NS	NS	NS
Egg weight	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

[a] GNM: Groundnut meal.
[b] SBM: Soybean meal.
[c] Lin: Linear effects of dietary protein and fish meal levels or vegetable protein source on performance.
[d] Quad: Quadratic effects of dietary protein and fish meal levels or vegetable protein source on performance.
[e] NS: Not significant.
* p<0.05.

RESULTS

Chemical composition

The diets of two protein groups were isonitrogenous and contained 16 to 16.03% protein in 16% group, whereas 18 % diets contained 17.99 to 18.02% protein. Ether extract ranged from 0.71 to 0.99 %, crude fiber varied from 3.45 to 7.16 % and calcium 3.0 to 3.58% either of 16 or 18 % diets (Table 1).

Hen performance

Rate of laying was constantly better (p<0.05) on SBM diets to that of GNM diets. Fish meal level linearly increased rate of lay in GNM diet at 16% protein level, however, egg production remained unaffected in SBM diets. Fish meal level quadraticly increased egg production at 18% protein diets containing SBM. The highest (p<0.05) egg production was recorded at 18% protein level with 6% fishmeal in SBM diet, which was (p<0.05) higher to the diets containing GNM at 16% dietary protein with either of 0, 3 or 6 % fish meal.

Feed intake of layers was higher (p<0.05) on diets containing 18% protein with SBM and 3 or 6% fish meal to that on 16% protein diet contained GNM and 3 or 6% fish meal, respectively. Feed intake was significantly (p<0.05) lower on diets containing GNM to that of SBM at 16% protein with 6% fish meal level. Dietary protein levels and vegetable protein sources showed significant effect on feed intake, which was better at 18% protein with SBM diets. The quadratic depression on feed intake was observed with GNM diet at 16% protein with 6% fish meal level.

Feed conversion ratio was not different between GNM or SBM diet at various fish meal levels but fish meal inclusion improved feed conversion ratio. The FCR showed quadratic improvement upto 3% fish meal with SBM diet, whereas GNM diet showed linear improvement upto 6% fish meal levels on 16% protein diets. The effect of vegetable protein source and fish meal levels was not evident on 18% protein diets.

Egg quality

Egg quality traits of specific gravity, shape index, yolk index, albumen index and shell thickness remained unaffected due to source of vegetable protein, fish meal level or dietary protein levels. Egg weight was higher ($p<0.05$) on SBM diets to that of GNM diets.

DISCUSSION

The methionine, tryptophan and lysine are deficient in groundnut meal (Singh et al., 1981; Singh and Zombade, 1986) for poultry, whereas amino acid pattern of soybean meal approximates more to dietary requirement of poultry (Lesson and Summers, 1991). The SBM contain higher crude protein, better amino acid pattern and bioavailability (Park et al., 2002). Dry extruded soybean meal was used in the present experiment, which contained minute trypsin inhibitor (Baier et al., 1989). Substitution of soybean meal improved hen performance which agreed favorably with previous reports (Ekpenyong and Agkwunobi, 1988; Rybina, 1979; Vodolazhchenko and Vedyakina, 1987 and Mandlekar and Thatte, 1993), who reported increased egg production and improved feed conversion ratio on soybean meal incorporated diets in comparison to other vegetable protein supplements such as groundnut, sunflower and rapeseed meal etc. Improved supply of lysine and methionine on soybean meal could have increased hen performance on SBM incorporated diets. Lysine is generally deficient in poultry diets and higher arginine content of groundnut meal create lysine- arginine antagonism and excess arginine promotes biosynthesis of creatinine which require methyl group thus increased requirement of methionine (Singh and Panda, 1998). Methionine and lysine levels in poultry diets have positive correlation with egg production (Uma, 2000).

The increase in egg weight due to soybean meal incorporation is in agreement with Svezhentsov and Gavrish (1994). Scholtyssek et al. (1991) reported that increasing soybean meal in diet increased egg weight and also reduced the cholesterol content. Danicke et al. (2000) reported that a simultaneous increase in the proportion of albumen and a decrease in yolk and shell percentage accompanied the increase in egg weight on soybean meal addition. In the present study, higher dietary protein level (18%) increased egg production and feed intake, whereas source of vegetable protein (SBM) significantly improved hen performance and egg weight. Linear effect was observed on GNM diets at 16% protein level for all fish meal levels, whereas quadratic effects of fish meal were noticed on SBM diets at 18%protein level for rate of egg laying. The linear improvement in feed conversion was observed with GNM diets, however, quadratic with SBM diet at 16% protein with increase in fish meal levels.

The amino acid pattern of SBM is more adequate for poultry in comparison with groundnut meal (Rao et al., 1998) and bio-availability of amino acids (Park et al., 2002) as well as, energy is higher (Gruhn and Hennig, 1989; Gruhn and Zander, 1989). Incorporation of SBM in layers diet improved egg production, egg weight and feed efficiency (Svezhentsov and Gavrish, 1994; Zhang and Parsons, 1991). Biological value of fish meal is higher than that of vegetable protein sources. Hence, fish meal inclusion improved hen performance and the effect of fish meal was more pronounced with SBM diet. Werner (1991) reported that fish meal improved hen performance, decreased nitrogen and phosphorus excretion and increased quality of product. Fish meal increased egg production on groundnut meal diets, whereas response of fish meal with SBM diets was lower (Mandlekar, 1992). Soybean oil meal could replace fish meal upto some extent in poultry diet (Vodolazhchenko and Vedyakina, 1987). Results of the reported experiment are in agreement with previous reports (Thakur et al., 1987; Skorupinska, 1985; Yin and Han, 1995; Kulikov and Sarda, 1987) who reported that regardless of energy concentration, the dietary protein levels have a positive relation with laying performance.

CONCLUSION

It is concluded that vegetable protein source and level of dietary protein have significant effect on layer performance. Soybean meal incorporation improved rate of laying, feed consumption, feed conversion ratio and egg weight. Use of fish meal with GNM diets improves rate of laying and feed conversion. Hence, substitution of groundnut meal with soybean meal is recommended in layer diets. It is concluded that the dietary level of 16% CP may be adequate for laying hens and an increase over this level (up to 18%) lead to a waste of protein.

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