

Full Length Research Paper

Effect of low protein diet supplemented with or without amino acids on the production of broiler

Shahzad Akbar Khan^{1*}, Nisar Ujjan², Gulzar Ahmed¹, Muhammad Ismail Rind³, Sarfaraz Ali Fazlani², Shahid Faraz², Shoaib Ahmed² and Muhammad Asif²

¹Department of Veterinary and Animal Sciences, University of Azad Jammu and Kashmir, Pakistan.

²Faculty of Veterinary and Animal Sciences, Lasbela University of Agriculture, Water and Marine Sciences, Uthal Balochistan, Pakistan.

³Department of Poultry Husbandry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam, Pakistan.

Accepted 10 June, 2011

Experiment was carried out to investigate the effect of low protein diet supplemented with or without amino acids on the performance of broiler. Hubbard 375 day-old broiler were purchased, initially weighed and randomly divided into five groups (75 broilers in each group). Group A was kept as control given commercial feed, group B further divided into two group B1 and B2 were fed low CP (15 and 16%) ratio supplemented with lysine (1.0%) and methionine (0.5%) , while group C also further divided into group C1 and C2 were fed with the same low CP(15 and 16%) ratio without lysine and methionine supplementation. The experimental ratios were start up from fourth week of the experiment. Feed intake of broiler in group A, B1, B2, C1 and C2 was 3.793, 3.781, 3.739, 3.837 and 3.852 kg/b,(P > 0.05) and water intake 11.113, 11.494, 11.850, 11.277 and 11.252 lit/b, (P > 0.05), respectively. Live body weight of broiler was higher in B1 (2.149), than A(2.091), B2(2.069), C1(1.952) and C2(1.929), kg/b (P < 0.05) and their FCR was better for B1(1.75) than B2(1.80), A(1.81), C1(1.85) and C2(1.99), respectively. Carcass weight of broiler for A (1.227), B1 (1.339), B2 (1.210), C1 (1.155) and C2 (1.200) kg/b, (P > 0.05) and their dressing percentage were A(60.46), B1 (62.41), B2(60.48), C1 (59.59) and C2(59.22) percent (P > 0.05), respectively. Mortality of broiler in group A (5.3), B1 (2.6), B2 (6.6), C1 (4.0) and C2 (1.3) percent (P > 0.05), respectively. The average weight of liver, heart, gizzard, spleen and intestine for various group of broiler were found non significant (P > 0.05). Net profit was better in group B1 (75.5), followed by B2 (68.3), A (62.5), C1 (51.8) and C2 (49.9) Rs/b, respectively. It was concluded that low protein diet supplemented with lysine plus methionine significantly improved live body weight of broiler.

Key words: Protein, amino acid, supplemented, broiler.

INTRODUCTION

Broiler meat is one of the principal sources to fill the genuine gaps of the animal protein and can play leading role in providing balanced diet (Alam and Khan, 2000). Poultry industry is producing meat and eggs under intensive husbandry, during the past half century, chicken meat production has changed from being a byproduct of the egg industry to an industry as an independent, with annual production of more than 7 billion broilers and

roasters (Khan, 2009). During the year 2008 to 2009, the country produced 448.55 million broilers, 7.99 million breeding stock and 468.51 million day old chicks, while broiler meat production was 550 thousand tons (Anonymous, 2009). The current poor nutritional status is due to lack of sufficient energy and protein in the feed. There are mainly two origins of proteins that is, animal and plant (Aftab, 2007).

Methionine and lysine are two important limiting amino acids obtained from poultry diet. The requirement of these two amino acids is substantial but variable for Changes in genetic, nutrition and management of broiler

*Corresponding author. E-mail: mughal_161@yahoo.com.

chicks. Feed consumption, growth rate and carcass composition are affected by individual amino acids that is receiving considerable attention for development of broiler industry. Methionine acts as lipotropic agent through its role as an amino acid in balancing crude protein (Hesabi et al., 2006). It is well known that crude protein and lysine interaction is considered to be an important factor which affects performance and carcass quality of growing chicks; so the dietary requirement of crude protein is actually a requirement for the lysine contained in the crude protein (Rezae et al., 2004). Poultry diets that are composed of natural feed stuffs can therefore be supplemented with small amounts of synthetic amino acids to meet the bird's requirements for the most limiting amino acids (Aftab, 2007a). Hussein et al. (2001) observed that the reduction of litter N and ammonia production may be accomplished by decreasing dietary crude protein to levels below the requirements.

Some researchers have shown that reduced crude protein-amino acid supplemented diets support good growth and feed consumption of broilers (Aletor et al., 2000). Addition of methionine over and above the recommended requirement of broilers improves their performance in terms of body weight gain and food conversion efficiency (Simon et al., 1995). Therefore, the objective of this study was to evaluate the influence of low protein broiler diet supplemented with or without amino acids on the production of broiler.

MATERIALS AND METHODS

Study was carried out during the year 2009 to 2010, to evaluate the effects of low protein broiler diet supplemented with or without amino acids on the production of broiler.

A total of 375 day old chicks were purchased from Hyderabad and taken to Poultry Experimental Station, Department of Poultry Husbandry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam. Chicks were randomly divided into three groups that is, A, B and C. Group-A (control) consisted of 75 broiler, while groups B and C were further divided into group that is, B1, B2 and C1 and C2 having 75 chicks in each sub-groups.

During the initial period of brooding (1 to 3 weeks) normal commercial pre-starter and starter ratios were fed to all groups. In the later stage, from 4th to 6th week of experiment, the finisher ratio was offered. Group-A was fed commercial diet containing 18% crude protein (without supplement), while the remaining groups, B1, B2 and C1 and C2 were provided low crude protein feed as 16, 15 and 16, 15%, respectively. In addition to this, groups B1 and B2 were supplemented with lysine and methionine as to maintain, 1.0 and 0.5%, but groups C1 and C2 were fed the diet without amino acid supplementation. The feed and water was offered twice daily *ad libitum*. The feed and water refusal from each group were collected, weighed and measured daily at morning and recorded.

Slaughtering of broiler

At the end of the experiment, five birds randomly selected broilers from each group were slaughtered for carcass weight, dressing percentage and weight of edible parts.

Data analysis

Collected data was tabulated and transferred into Minitab of statistical package and analyzed by using general linear model (Minitab, 2000).

RESULTS

In order to investigate the effect of low protein diets supplemented with or without amino acids that is, lysine and methionine. The data on feed intake, water intake, live body weight, mortality and behavior are presented.

Feed intake

Average feed intake of broiler for A, B1, B2, C1 and C2 group were 3.793, 3.781, 3.739, 3.837 and 3.852 kg/broiler, ($P > 0.05$), respectively. The differences of feed intake between broiler groups was non significant. The interaction effect of groups with weeks on feed intake of broiler was also found non-significant ($P > 0.05$). The weekly feed intake of broiler in all the broiler groups was highly significant ($P < 0.01$) and feed intake was successively increased with the progression in age of the broiler (Table 1).

Feed intake results showed that it was comparatively more in group A during week 1 (0.118), group B2 during W2 (0.350), group A during W3 (0.528), group C2 during W4 (0.807), group C1 during W5 (0.969), group C2 during W6 (1.123), followed by over all for group C2 (3.852).

Water intake

Average water intake of broiler, in group A, B1, B2, C1 and C2 were 11.113, 11.494, 11.850, 11.277 and 11.252 liter/broiler, ($P > 0.05$), respectively. The interaction effect of groups with weeks on water intake of broiler was also found non-significant ($P > 0.05$). The weekly water intake of broiler in all the broiler groups was highly significant ($P < 0.01$) and water intake increased considerably with age development of broiler (Table 2).

Water intake results show that it was comparatively more in group B2 during W1 (0.351), group A during W2 (0.740), group C1 during W3 (1.507), group B2 during W4 (2.226), group B2 during W5 (3.117), group B2 during W6 (4.029), followed by over all for group B2 (11.850.) lit/broiler.

Live body weight

The results for live body weight of broiler, in group A, B1, B2, C1 and C2 were 2.091, 2.150, 2.069, 1.953 and 1.929 kg/broiler, ($P < 0.01$), respectively. The weekly live

Table 1. Average feed intake of broiler (kg/b/w).

Week	Group					Probability
	A	B1	B2	C1	C2	
W1	0.118	0.117	0.112	0.112	0.113	0.001
W2	0.341	0.349	0.350	0.332	0.348	
W3	0.528	0.522	0.495	0.499	0.500	
W4	0.759	0.789	0.766	0.803	0.807	
W5	0.935	0.920	0.905	0.969	0.963	
W6	1.113	1.085	1.112	1.122	1.123	
TOTAL	3.793	3.781	3.739	3.837	3.852	
Prob.	0.506					

Interaction between group and week for feed intake probability = 0.5.

Table 2. Average water intake of broiler (lit/b/w).

Week	Group					Probability
	A	B1	B2	C1	C2	
W1	0.338	0.345	0.351	0.347	0.333	0.001
W2	0.740	0.737	0.665	0.719	0.734	
W3	1.346	1.468	1.463	1.507	1.457	
W4	2.081	2.197	2.226	2.174	2.207	
W5	2.791	2.897	3.117	2.759	2.785	
W6	3.818	3.849	4.029	3.770	3.736	
TOTAL	11.113	11.494	11.850	11.277	11.252	
Prob.	0.134					

Interaction between group and week for water intake probability = 0.238.

Table 3. Average live body weight of broiler (kg/b/w).

Week	Group					Probability
	A	B1	B2	C1	C2	
W0	0.37	0.38	0.37	0.37	0.38	0.001
W1	0.148	0.143	0.142	0.145	0.142	
W2	0.389	0.393	0.386	0.384	0.388	
W3	0.786	0.799	0.783	0.796	0.788	
W4	1.339	1.355	1.345	1.324	1.297	
W5	1.727	1.756	1.715	1.616	1.599	
W6	2.091	2.150	2.069	1.953	1.929	
Prob.	0.001					

Interaction between group and week for live body weight probability = 0.001.

body weight of broiler in all the groups were also highly significant ($P < 0.01$) and live body weight increased remarkably with the development of broiler age. The interaction effect of groups with weeks on live body weight of broiler was also highly significant ($P < 0.01$).

Live body results show that it was higher in group B1 and C2 during W0 (0.38), than group A during W1 (0.148), group B1 during W2 (0.393), group B1 during W3

(0.799), group B1 during W4 (1.355), group B1 during W5 (1.756) and final weight for group B1 during W6 (2.150), kg/broiler (Table 3).

Feed conversion ratio

The average feed conversion ratio of the broiler for group

Table 4. Feed conversion ratio.

Week	Group				
	A	B1	B2	C1	C2
W1	0.80	0.81	0.79	0.77	0.83
W2	1.17	1.18	1.19	1.10	1.17
W3	1.25	1.23	1.22	1.18	1.27
W4	1.29	1.31	1.27	1.31	1.39
W5	1.55	1.53	1.53	1.67	1.73
W6	1.81	1.75	1.80	1.85	1.99
Probability	0.012				

Table 5. Mortality of broiler.

Parameter	Group				
	A	B1	B2	C1	C2
Broiler #	4	2	5	3	1
Mortality (%)	5.3	2.6	6.6	4.0	1.3
Probability	0.563				

Table 6. Carcass weight of broiler (kg/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	1.210	1.384	1.242	1.038	0.982
2	1.255	1.284	1.158	1.141	1.228
3	1.270	1.643	1.145	1.159	1.305
4	1.281	1.134	1.340	1.274	1.347
5	1.120	1.250	1.165	1.172	1.142
Average	1.227	1.339	1.210	1.155	1.201
Probability	0.221				

A, B1, B2, C1 and C2 were 1.81, 1.75, 1.80, 1.85 and 1.99 ($P < 0.01$), respectively. There was a gradual improvement in the feed conversion ratio of broiler with the development of broiler age, it was noted that the feed conversion ratio of broiler for groups B1 was better as compared to the rest of the treatment groups (Table 4).

Mortality rate

The results showed that the mortality of broiler in group A, B1, B2, C1 and C2, were 5.3, 2.6, 6.6, 4.0 and 1.3% ($P > 0.05$), respectively. The over all 15 broilers died out of 375 during six week (Table 5).

Carcass weight

Average carcass weight of broiler in group A, B1, B2, C1 and C2 were 1.227, 1.339, 1.210, 1.156 and 1.201 kg/b ($P > 0.05$), respectively. The carcass weight was comparatively more in broiler of group B1 when compared with the rest of the groups (Table 6).

Dressing percentage

The data indicated that the average dressing percentage of broiler in group A, B1, B2, C1 and C2 were 60.46, 62.41, 60.48, 59.59 and 59.22%, respectively.

Table 7. Dressing percentage of broiler.

Bird	Group				
	A	B1	B2	C1	C2
1	65.76	65.01	60.97	57.44	60.99
2	60.13	65.69	62.09	60.72	57.11
3	59.06	59.38	59.35	59.86	59.31
4	58.25	60.69	60.25	61.33	60.13
5	59.10	61.30	59.73	58.6	58.56
Average	60.46	62.46	60.48	59.59	59.22
Probability			0.165		

Table 8. Liver weight of broiler (g/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	41.76	42.69	51.76	37.5	34.25
2	47.25	43.45	53.07	41.24	47.41
3	39.45	66.23	43.07	43.2	49.6
4	51.26	48.65	51.79	52.86	50.25
5	43.20	52.31	41.64	43.33	49.63
Average	44.58	50.66	48.26	43.62	46.22
Probability			0.436		

Comparatively, minimum dressing percentage was recorded in group C2 and maximum from group B1 respectively ($P > 0.05$), (Table 7).

Liver weight

The data indicated that the average liver weight in groups A, B1, B2, C1 and C2 was 44.58, 50.66, 48.26, 43.62 and 46.22 g/b, ($P > 0.05$), respectively. The liver weight was comparatively more in broiler of group B1 when compared with the rest of the groups (Table 8).

Heart weight

The data showed that the average heart weight of broiler in group A, B1, B2, C1 and C2 were 9.38, 10.35, 9.38, 8.63 and 8.91 g/b ($P > 0.05$), respectively. The heart weight was relatively more in broiler of group B1 when compared with the rest of the groups (Table 9).

Gizzard weight

The experimental results suggest that the gizzard weight of broiler in group A, B1, B2, C1 and C2 were 33.11, 33.38, 32.00, 33.04 and 32.78 g/b ($P > 0.05$), respectively. The gizzard weight was comparatively more

in group B1 when compared with the rest of the groups (Table 10).

Spleen weight

The results indicated that the differences in spleen weight of broiler in group A, B1, B2, C1 and C2 were 1.90, 1.98, 1.91, 1.51 and 1.97 g/b ($P > 0.05$), respectively. The spleen weight was slightly more in broiler group B1 when compared with the rest of the groups (Table 11).

Intestine weight

It is evident from the data that the intestinal weight of broiler in group A, B1, B2, C1 and C2 were 128.80, 127.60, 115.00, 109.40 and 105.80 g/broiler, non-significant ($P > 0.05$), respectively (Table 12).

Economics

The results indicated that the economics of the flock was markedly affected by feeding broiler with amino acids supplemented with low protein ratio. The total cost of production of broiler in group A, B1, B2, C1 and C2 were Rs. 188.5, 183.1, 181.3, 182.2 and 180.2/broiler, with resultant live body weight of 2.091, 2.149, 2.069, 1.952

Table 9. Heart weight of broiler (g/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	8.23	11.20	8.92	8.11	7.31
2	10.85	9.40	7.57	8.52	10.20
3	9.53	11.74	9.84	7.79	8.91
4	9.39	8.84	11.25	10.15	9.42
5	8.91	10.61	10.64	8.62	8.72
Average	9.38	10.35	9.38	8.63	8.91
Probability	0.228				

Table 10. Gizzard weight of broiler (g/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	30.59	34.26	32.19	29.46	28.41
2	35.46	32.34	27.59	34.9	32.61
3	33.76	38.60	30.85	35.09	30.92
4	36.01	29.36	37.13	32.29	44.52
5	29.75	32.36	32.25	33.5	27.44
Average	33.11	33.38	32.00	33.04	32.78
Probability	0.985				

Table 11. Spleen weight of broiler (g/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	2.21	2.20	2.26	1.20	1.20
2	1.69	1.90	1.41	2.10	1.91
3	2.15	2.30	2.16	1.60	2.31
4	2.23	1.30	2.41	1.52	2.20
5	1.20	2.21	1.35	1.13	2.22
Average	1.90	1.98	1.91	1.51	1.97
Probability	0.465				

Table 12. Intestine weight of broiler (g/broiler).

Bird	Group				
	A	B1	B2	C1	C2
1	115	137	105	98	63
2	148	84	142	122	135
3	139	181	104	112	116
4	130	117	115	119	105
5	112	119	109	78	128
Average	128.80	127.60	115.00	109.40	105.80
Probability	0.447				

Table 13. Economics of broiler.

S/N	Economic parameter	Group				
		A	B1	B2	C1	C2
1	Cost of day old chick (Rs/broiler)	65	65	65	65	65
2	Total feed intake (kg/broiler)	3.79	3.78	3.73	3.83	3.85
3	Total cost of feed (Rs/broiler)	98.5	90.4	87.7	92.2	90.2
4	Miscellaneous expenditure (Rs/broiler)	25	25	25	25	25
5	Cost of lysine + methionine	0	2.73	3.62	0	0
6	Final live body weight (Rs/broiler)	2.091	2.149	2.069	1.952	1.929
7	Total cost of production (Rs/broiler)	188.5	183.1	181.3	182.2	180.2
8	Broiler sale rate (Rs/kg)	120	120	120	120	120
9	Total income (Rs/broiler)	250.9	258.6	249.6	234.0	230.2
10	Net profit (Rs/broiler)	62.5	75.5	68.3	51.8	49.9
11	Profit increase (%)	-	+20.9	+9.4	-16.9	-20.00

Shed, water, light and labour charges are not included.

and 1.929 kg/broiler, respectively. After fetching the market price Rs. 120/kg live weight, the total income received was Rs. 250.92, 258.60, 249.6, 234.00 and 230.16/bird, which after deduction of production costs, earned a net profit of Rs. 62.5, 75.5, 68.3, 51.8 and 49.9/bird, respectively. The broiler fed lysine plus methionine supplemented low CP ratio proved to be more profitable when compared with the broiler under low CP ratio without essential amino acids and control (Table 13).

DISCUSSION

The results from this study showed that there was significant improve in live body weight of broiler when fed ratio with 16% CP plus 1% lysine and 0.5% methionine; in the case of 15 and 16% CP ratio plus 1% lysine and 0.5% methionine, water intake increased and FCR was also better, broiler feed consumption comparatively reduced. Mortality reduced in broiler fed low CP ratio with essential amino acids. Durrani et al. (2006) reported that the decrease in crude protein level up to 16% with adequate methionine and lysine supplementation had no deleterious effect on body weight gain. Similar results have also been determined to know the effect of dietary lysine on dietary responses of broilers and broilers had a greater response to supplemental lysine when 17% CP was fed, but less response to supplemental lysine when 23% CP was fed for both BWG and FCR (Sterling et al., 2006). Corzo et al. (2005) found that lysine supplementation significantly improved the live body weight and feed conversion efficiency. Aftab (2007a) reported significantly better ($P < 0.05$) feed efficiency at diet having the highest CP, compared with two intermediate levels that in turn resulted in an improved feed efficiency over the diet having the lowest level of CP. Similar study by Holsheimer and Veerkamp (1992) reported that the

broiler ratio with equal CP content and high-Lys gave significantly more gain ($P < 0.05$) than the normal-lysine diets. Simon et al. (1995) concluded that under reducing dietary protein by 10% could have no inappropriate effect on broiler performance; while in addition, increase in methionine level by 20% could improve broiler performance, similar result was also observed by Torki (2007).

Considerable research has been found published in different research journals on this aspect. Hussein et al. (2001) reported that broiler feed supplementation with essential amino acids or low CP diets (17.3 or 17.7% CP) could improve growth of broilers during weeks 2 and 3; while Si et al. (2001) evaluated the relationship of dietary lysine in diets for broilers and increase the level of essential amino acids resulted in significant improvements in feed conversion. Si et al. (2001) also observed that dietary lysine levels had no significant effects on dressing percentage, breast meat yield or abdominal fat content and carcass yield. Supporting the present findings, Bregendahl et al. (2002) concluded that low-protein diets failed to support equal growth performance to that of high-protein control diets. Zarate et al. (2003) reported that reducing CP elicited the most dominant effects on body weight gain and providing additional amounts of lysine and threonine enhanced early live performance and likely occurred because all other essential amino acids were more than satisfactory to realize additional benefits. Jianlin et al. (2004) indicated that reducing dietary protein by 10% had no significant effect on chicks' body weight ($P > 0.05$). Increasing dietary met levels increased body weight in 42 days of age ($P < 0.05$), but had no significant effect on body weight in 21 and 49 days of age ($P > 0.05$).

In this study, carcass weight, dressing percentage, weight of liver, heart, gizzard, spleen and intestine was relatively higher in group B1 (15 CP+1 lysine and 0.5% methionine), when compared with the rest of the groups. Broiler fed lysine+methionine supplemented low CP

ratios proved to be more profitable when compared with the broiler under low CP ratio without essential amino acids or control. These results are further in concurrence with those of Kamran and Mirza (2004) who studied the effect of decreasing dietary crude protein (CP) level on the performance of broilers and concluded that dietary protein level of broilers could be reduced from 23 to 20%, with beneficial effects on growth performance and carcass characteristics and increased economic returns. Hesabi et al. (2008) evaluated the effects of different levels of lysine and methionine suggested that additional methionine and lysine may improve performance and carcass traits in broiler chicks.

The comparative analysis of the results on low protein broiler diets obtained from this study and reported from different parts of the world suggested that serious efforts are needed to motivate the farming communities to adopt the technological innovation for broiler feed for low CP ratio and with inclusion of essential amino acids for reducing the cost of broiler production and improving further the weight gain.

REFERENCES

- Aftab U (2007). Study the extent to which dietary CP could be reduced at the expense of supplemental lysine, methionine, and threonine in broiler feed. Findings of Experiment 1 and 2: Ph.D Thesis submitted to Quid-a-Azam University, Islamabad, Pakistan.
- Alam SM, Khan MA (2000). Poultry farming in Pakistan. Industry and Economy Magazine. 7th August, 2000.
- Aletor VA, Hamid I, Neib E, Pfeffer E (2000). Low-protein amino acid supplemented diets in broiler chickens: effects on performance, carcass characteristics, whole body composition and efficiency of nutrient utilization. J. Sci. Food Agric. 80: 547-554.
- Anonymous (2009). Economic Survey of Pakistan 2007-2008, Ministry of Food, Agriculture and Livestock, Economic Wing, Government of Pakistan, Islamabad.
- Bregendahl K, Sell JL, Zimmerman DR (2002). Effect of low-protein diets on growth performance and body composition of broiler chicks. Poultry Sci., 81: 1156-1167.
- Corzo A, William D, Kidd D (2005). Dietary Lysine Needs of Late-Developing Heavy Broilers. Arch. Anim. Nutr. Poultry Sci. 85: 457-461.
- Durrani FR, Khan Q, Mian MA, Durrani Z (2006). Effect of feeding low protein broiler finisher diets supplemented with methionine and lysine on the overall performance of broiler chicks. Int. J. Bio. Biot. pp. 22-25.
- Hesabi A, Nasiri H, Birjandi M (2008). Effect of supplemental methionine and lysine on performance and carcass yield characteristics in broiler chicks. Animal Science Iran: alireza_hessabi@yahoo.com.
- Holsheimer JP, Veerkamp CH (1992). Effect of dietary energy, protein, and lysine content on performance and yields of two strains of male broiler chicks. Poultry Sci. USA., 71(5): 872-879.
- Hussein AS, Cantor AH, Pescatore AJ (2001). Effect of Low Protein Diets with Amino Acid Supplementation on Broiler Growth J. Appl. Poultry Res. 18(10): 354-362.
- Jianlin SI, Fritts CA, Burnham DJ, Waldroup PW (2004). Extent to which crude protein may be reduced in corn-soybean meal broiler diets through amino acid supplementation. Int. J. Poultry Sci. 3(1): 46-50.
- Kamran Z, Mirza MA, Haq A, Mahmood S (2004). Effect of decreasing dietary protein levels with optimal amino acids profile on the performance of broilers. Pak. Vet. J. 24(4).
- Khan MA (2009). Commercial poultry industry production. AgriPakistan: Agriculture News Portal of Pakistan. Daily Dawn Decembner 12.
- MTB (2000). A statistical packaging of Minitab., USA.
- Rezaei M, Moghaddam HN, Reza JP, Kermanshahi H (2004). The Effects of Dietary Protein and Lysine Levels on Broiler Performance, Carcass Characteristics and N Excretion. Int. J. Poultry Sci. 3(2): 148-152.
- Si J, Fritts CA, Burnham DJ, Waldroup WP (2001). Relationship of dietary lysine level to the concentration of all essential amino acids in broiler diets. Poultry Sci. 80(10): 1472-1479.
- Simon A, Bergner H, Buivan D (1995). Methodological investigation on the metabolism oriented determination of methionine requirement of broiler chickens. 3. degradation of 14C-(CH3)-and 35-Smethionine after feeding of synthetic diets. Arch. Anim. Nutr., 47: 229-244.
- Sterling KG, Pesti G, Bakalli MRI (2006). Performance of different broiler genotypes fed diets with varying levels of dietary crude protein and lysine. Poultry Sci., 85(6): 1045-1054.
- Torki M (2007). Performance of Broilers Fed on Low Protein Diets Fortified with Graded Levels of Methionine. Anim. Feed Sci. Technol., 117: 281-293.
- Zarate AJ, Moran ET, Burnham DJ (2003). Reducing Crude Protein and Increasing Limiting Essential Amino Acid Levels with Summer-Reared, Slow- and Fast-Feathering Broilers. J. Appl. Poultry Res., 12:160-168.