PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 8 (10): 1613-1616, 2009
ISSN: 1680-5194

Dietary Electrolyte Requirement of Broiler Chicks as Affected by Dietary Protein Content

A.A. Adekunmisi[1] and K.R. Robbins[2]
[1]Department of Animal Production, College of Agricultural Sciences,
Olabisi Onabanjo University, Yewa Campus, Ayetoro, Nigeria
[2]Department of Animal Science, University of Tennessee, Knoxville, TN 37901-1071, USA

Abstract: A soy protein based semi-purified diet was used to estimate the optimum electrolyte balance (meq Na^+, K^+, Cl^-/kg diet) at 3 levels of dietary crude protein. Results indicated that in diets containing 14.3% Crude Protein (CP), the optimum electrolyte balance was approximately 250 meq/kg; at 21.4% CP the optimum was about 325 meq/kg and at 28.6% CP it was about 400 meq/kg. A conventional 21% CP corn-soy broiler diet which, by calculation, contained 228 meq Na^+, K^+, Cl^-/kg was used in two subsequent experiments. In both experiments, it was found that feed intake, gain and feed efficiency were significantly improved ($p<0.05$) by the addition of 100 meq Na^+, K^+/kg diet in diets containing 56.4 meq Cl/kg, thus, confirming an optimum electrolyte balance of about 325 meq/kg in diets containing 21% CP. It was concluded that the optimum dietary electrolyte balance of broiler chicks is dependent on diet crude protein content. Further, within the range of 14-28% CP, the optimum electrolyte balance is increased by about 11 meq/kg per 1 percentage unit increase in diet crude protein content.

Key words: Crude protein, optimum electrolyte balance, animal diet

INTRODUCTION

Acid-base balance in birds is influenced by some factors which include the environmental condition, diet and metabolism. All these factors alter the regulation of pH in the blood and tissues (Olanrewaju *et al*., 2007).

Experiments have shown that addition of salt in the diet or water can affect the acid-base balance of animal (Borges *et al*., 2004). Derjant-Li *et al*. (2002) have also reported the essential role that dietary electrolytes exert on the acid base balance. Adekunmisi and Robbins (1985, 1987a and b) in their series of experiments showed that there is a marked interaction between dietary crude protein level and dietary electrolyte balance (Meq Na^+, K^+, Cl^-/kg diet). Namely, increasing the electrolyte balance from 200-350 meq/kg or more, improved gain and feed consumption of birds fed high protein diets, but depressed growth of birds fed low protein diets. It was found that although, dietary electrolyte balance did affect kidney asparaginase activity, plasma uric acid concentration and metabolic acid-base status, these observed effects were not statistically correlated with the growth response. The nature and the magnitude of the electrolyte balance x protein interaction observed in these experiments were apparently the result of a specific effect on feed consumption.

Interest has been centered on these monovalent electrolytes (Na, K, Cl) largely because of their prominent effect on metabolic acid-base balance and because they are among the minerals most likely to be varied in diet formulation (Mongin and Sauveur, 1977; Leach, 1979). Mongin and Sauveur (1977) indicated that an electrolyte balance of 250 meq (Na^+, K^+, Cl^-/kg diet) was optimum for growth of young chicks. Johnson and Karunajeewa (1985) observed that the optimum electrolyte balance lies between 250 and 300 meq/kg diet. However, in neither of these reports was the effect of protein level evaluated. The electrolyte balance x crude protein interaction observed in preceding studies (Adekunmisi and Robbins 1985, 1987a and b) strongly suggested that the electrolyte balance required to maximize growth is proportional to the level of dietary protein.

The present study was undertaken to quantify the optimum dietary electrolyte balance at three protein levels utilizing semi-purified diets and to evaluate the applicability of such estimates to a conventional corn-soy diet.

MATERIALS AND METHODS

In each experiment, female Peterson crossbred broiler chicks were used. Chicks were randomly distributed to four replicate groups of 6 chicks each per treatment in Experiment 1 and to three replicate groups of 6 chicks each per treatment in experiments 2 and 3. The chicks were housed in electrically-heated battery brooders in an environmentally-controlled room which was kept at 25°C. Chicks were fed the experimental diets from day 4-32 posthatching in Experiment 1; from day 5-26 posthatching in Experiment 2 and from day 1-29 posthatching in Experiment 3. A corn-soy broiler starter diet was fed to the chicks for the day preceding the

Table 1: Percentage Composition of the Basal Diets (Experiment 1)[a]

	Protein level[b]		
Ingredient	14.3%	21.4%	28.6%
Dextrose	25.00	25.000	25.00
Cornstarch	30.99	23.000	15.02
Isolated soy protein (85% CP[b])	16.65	24.970	33.30
Corn oil	7.50	7.500	7.50
Mineral premix[c]	4.65	4.650	4.65
Vitamin premix[d]	0.20	0.200	0.20
Chorine chloride	0.40	0.400	0.40
DL – Methionine	0.25	0.375	0.50
Cellulose to	100.00	100.000	100.00

[a]Contained by calculation 3200 kcal ME/kg. [b]As analysed. [c]Provided per kg diet: calcium chloride dihydrate, 4.14 g; calcium carbonate, 2.47 g; dibasic calcium phosphate, 25.2 g; monobasic calcium phosphate, 8.14 g; magnesium oxide, .568 g; manganous sulfate monoghydrate, cupric sulfate pentahydrate, 20 mg; boric acid, 9 mg; sodium molybdate, 9 mg, ethylene diaminedihydroiodide, 40 mg, cobalt sulfate septahydrate, 1 mg; sodium selenite, 0.21 mg; silica, 4.65 g. [d]Baker *et al.* (1979)

Table 2: Elemental Composition of the Experimental Diets (Experiment 1)[a]

Diets	1	2	3	4	5	6	7	8	9
Sodium, meq/kg	94	174	254	139	221	304	183	268	352
Potassium, meq/kg	82	152	222	112	180	247	153	208	274
Chloride, meq/kg	76	76	76	76	76	76	76	76	76
Electrolyte balance, meq/kg[b]	100	250	400	175	325	475	250	400	550

[a]Calculations based on mineral analyses of all raw ingredients of the diet.
[b]Calculated as meq (Na^+, K^+, Cl^-)/kg diet at the expense of cellulose

Table 3: Composition of the basal diet (Experiments 2 and 3)

Ingredient	(%)	Calculated analysis	
Corn	61.36	CP, %	21.000
Fish meal	3.55	ME, Kcal/kg	3200.000
Rock phosphate	1.49	Ca, %	1.000
Limestone	0.63	P (avail.), %	0.500
Salt	0.23	Na, %	0.200
Soybean meal	27.71	K, %	0.773
Soy oil	4.18	Cl, %	0.200
Vitamin premix[a]	0.60	Met + Cys, %	0.940
DL – methionine	0.25	Lys, %	1.200
Total	100.00	Na^+, K^+, Cl^-, meq/kg 228	

[a]Provided per kg diet: vitamin D_3, 750 ICU; vitamin A, 4,175 IU; riboflavin, 4.74 mg; vitamin B_{12}, .011 mg; Choline, 468 mg; niacin, 41.7 mg; D-Ca-pantothenate, 7.34 mg

initiation of the experiments. Feed and water were provided *ad libitum* throughout the experimental periods. The composition of the semi-purified basal diets and the elemental composition of all experimental diets utilized in Experiment 1 are presented in Table 1 and 2, respectively. All diets were formulated to meet or exceed the nutrient requirements for growing chicks (NRC, 1994). The experimental treatments consisted of 3 levels of dietary electrolyte balance (meq Na^+, K^+, Cl^-/kg diet) at each of the three protein levels. The choice of the various electrolyte balances used was based on preceding experiments (Adekunmisi and Robbins, 1987a and b) and governed by the Na and K content of the basal diets. The concentrations of these elements increase as the protein level increases. These electrolyte balances were achieved by the addition of Na and K-citrate.

The Na and K concentrations of all dietary ingredients were determined by atomic absorption spectrophotometry and Cl was measured using a Dionex ion chromatograph.

Experiments 2 and 3 were conducted to evaluate the applicability of the determined optimum electrolyte balance (325 meq/kg at 21.4% crude protein) estimated in Experiment 1 to a conventional corn-soy based diet containing 21% crude protein. The experimental diets were formulated based on ingredient compositions of NRC (1994). The electrolyte balance of the basal (control) diet was calculated to be 228 meq/kg (Table 3). The experimental diet was prepared by the addition of 100 meq Na^+, K^+ (1:2.27 molar ratio) to the basal diet at the expense of corn, thus, achieving an electrolyte balance of 328 meq/kg.

RESULTS AND DISCUSSION

The results of Experiment 1 are presented in Table 4. The quadratic effect of electrolyte balance on gain was significant ($p<0.05$) at each level of crude protein. There were no significant effect of electrolyte balance on feed intake of chicks fed diets containing either 21.4% or 28.6% dietary crude protein, however, there was a significant ($p<0.006$) quadratic effect in chicks fed diets containing 14.3% crude protein. The quadratic effect of electrolyte balance on feed efficiency was significant ($p<0.005$) when diets containing either 14.3 or 21.4% crude protein were fed. The linear effect of electrolyte balance on feed efficiency was significant ($p<0.005$) for chicks fed 28.6% CP diets.

Within each level of crude protein, feed efficiency and gain were highest when diets contained the middle level of electrolyte balance, thus, indicating optimum electrolyte balances of near 250 meq/kg in diets

Table 4: Effect of dietary electrolyte balance on performance of chicks at different protein levels (Experiment 1)[a]

	Treatment				
Diet no.	Electrolyte balance[b] (meq/kg)	Crude protein (%)	Gain[c] (g)	Feed cons.[d] (g)	Gain/feed[e] (g/kg)
1	100	14.3	620	1256	494
2	250	14.3	667	1316	507
3	400	14.3	602	1230	489
4	175	21.4	725	1253	579
5	325	21.4	755	1274	593
6	475	21.4	720	1229	586
7	250	28.6	702	1179	596
8	400	28.6	733	1200	611
9	550	28.6	714	1171	609
		pSEM[f]	13	25	5

[a]Data are means of quadruplicate groups of 6 female chicks each. Chicks were fed the experimental diets from day 4 to day 32 posthatching. Average initial weight was 71 g. [b]See Table 2 for complete description. [c]Quadratic effect of electrolyte balance was significant ($p<0.005$) at both 14.3 and 21.4% CP levels and was significant ($p<0.05$) at 28.6% CP. [d]Quadratic effect of electrolyte balance was significant ($p<0.005$) at 14.3%. [e]Quadratic effect of electrolyte balance was significant ($p<0.005$) at both 14.30 and 21.4% CP levels. Linear effect of electrolyte balance was significant ($p<0.005$) at 28.6% CP diets. [f]Pooled standard error of the mean

Table 5: Effect of electrolyte balance on growth of chicks fed a practical-type diet (Experiment 2 and 3)

	Electrolyte balance, meq Na^+, K^+, Cl^-/kg diet					
	Experiment 2[a]			Experiment 3[b]		
Variable	228	328	(pSEM)[c]	228	328	(pSEM)[c]
Gain (g)	532	580	(9)	695	761	(13)
Feed consumed (g)	870	929	(14)	1104	1188	(20)
Gain/feed (g/kg)	611	629	(2.9)	629	641	(3.5)

[a]Data are means of 3 groups of 6 chicks each fed the diets from 5-26 day posthatching. Average initial weight was 59 g. The effect of electrolyte balance was significant ($p<0.04$) for each variable. [b]Data are means of 6 groups of 6 chicks each fed the diets from 1-29 day posthatching. Average initial weight was 40 g. The effect of electrolyte balance was significant ($p<0.01$) for each variable.
[c]Pooled standard error of the mean

containing 14.3% CP, near 325 meq/kg in diets containing 21.4% CP and near 400 meq/kg in diets containing 28.6% CP. The optimal electrolyte balance of 325 meq/kg for diets containing 21% CP is close to the range (250-300 meq/kg) reported by Johnson and Karunajeewa (1985). Mongin and Sauveur (1977) reported an optimum electrolyte balance of 250 meq/kg, but it is not clear what levels of dietary crude protein were used in their experiments. The results of Experiments 2 and 3 were presented in Table 5. Addition of Na and K - citrate to the conventional corn-soy diet to achieve an electrolyte balance of 328 meq/kg resulted in a significant ($p<0.05$) increase in feed intake, body weight gain and feed efficiency in both Experiments 1 and 2.

The present studies demonstrated that an electrolyte balance of about 325 meq/kg is required to support maximum gain and feed efficiency of broilers fed typical corn-soy-based commercial broiler diets containing 21% CP. Moreover, the data indicated that within the range of 14-28% dietary crude protein, the optimum electrolyte balance is increased by approximately 11 meq (Na^+, K^+, Cl^-/kg) per 1 percentage unit increase in diet protein content.

REFERENCES

Adekunmisi, A.A. and K.R. Robbins, 1985. Effect of dietary protein and dietary mineral acid-base balance on growth and development of broiler chicks. Poult. Sci., 64: 1-3.

Adekunmisi, A.A. and K.R. Robbins, 1987a. Effects of dietary electrolyte balance on growth and metabolic acid-base status of chicks. Nutr. Res., 7: 519-528.

Adekunmisi, A.A. and K.R. Robins, 1987b. Effect of dietary crude protein, electrolyte balance and photoperiod on growth of broiler chicks. Poult. Sci., 66: 299-305.

Baker, D.H., K.R. Robbins and J.S. Buck, 1979. Modification of the level of histidine and sodium bicarbonate in the Illinois crystalline amino acid diet. Poult. Sci., 58: 749-750.

Borges, S.A., A.V. Fischer Da Silva, A. Majorka, D.M. Hooge and K.R. Cummings, 2004. Physiological responses of broiler chicken to heat stress and dietary electrolyte balance (Sodium plus potassium minus Chlorine, milli equivalents per kilogram). Poult. Sci., 83: 1551-1558.

Derjant-Li Verstegen, M.W.A., A. Jansman, J.W. Schrama and Verreth, 2002. Changes in oxygen content and acid base balance in arterial and portal blood in response to the dietary electrolyte balance in pigs during a 9 h period after a meal. J. Anim. Sci., 80: 1233-1239.

Johnson, R.J. and H. Karunajeewa, 1985. The effects of dietary minerals and electrolytes on the growth and physiology of the young chick. J. Nutr., 115: 1680-1690.

Leach, R.M., 1979. Dietary electrolytes: story with many facets. Feedstuffs., 18: 27-28.

Mongin, P. and B. Sauveur, 1977. Interrelationship between mineral nutrition, acid-base balance, growth and cartilage abnormalities. In: Boorman, K.N. and B. Wilson (Eds.). Growth and Poultry Meat Production. Br. Poultry. Science. Ltd. London, U.K. pp: 235-247.

National Research Council (NRC), 1994. Nutrient requirement of poultry. Natl. Acad. Sci., Washington, D.C.

Olanrewaju, H.A., J.P. Thaxton, W.A. Dozier and S.L. Branton, 2007. Electrolyte diet, stress and acid base balance in broiler chicks. Poult. Sci., 896: 1363-1371.