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Status of Dietary Electrolyte Balance in Commercial Poultry Diets in Pakistan

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Abstract: Dietary Electrolyte Balance (DEB) plays a vital role in body's homeostasis and optimum provision of DEB which is critical for maximum efficiency and stress coping in birds. A total of 68 poultry feed samples were collected from Multan, Rawalpindi and Sargodha districts of Punjab province of Pakistan. The study included 16 broiler, 16 breeder and 36 layer diets. Water samples (n = 51) alongwith feed samples were also collected wherever possible. These samples were examined for sodium (Na^+), potassium (K^+) and chloride (Cl^-) ions contents and DEB was calculated by subtracting anions from cations. The results showed variations and discrepancies in provision of individual ions as well as overall DEB. These results were compared with National Research Council (1994) recommendations for ionic contents and DEB level was compared by findings of other research studies. The mean of Na^+ contents were well within recommended range; Cl^- contents were slightly high while K^+ contents were 2 to 4 times higher than NRC (1994) recommendations. However the resulting DEB for broiler, breeder and layer flocks was 192.7, 168.1 and 198.2 mEq/kg, respectively. The water can play important role in supplementation of anions and cations thus effecting overall DEB. The 13, 23 and 15 water samples (total = 51) collected from Multan, Rawalpindi and Sargodha districts, respectively showed an area wise distribution pattern of these ions. The mean of Na^+ contents of water samples collected from Multan district was 229 ppm as compared to recommended level of 50 ppm for poultry consumption. Whereas analysis of water samples collected from Rawalpindi and Sargodha district showed much better ionic composition for poultry usage.

Key words: Chloride, dietary electrolyte balance, potassium, sodium, water

INTRODUCTION

Dietary Electrolyte Balance (DEB) is interplay of strong monovalent ions in the poultry diet. Of these ions, sodium (Na^+), potassium (K^+) and chloride (Cl^-) are of particular interest because of their high bioavailability and relatively higher proportion in the body (Hodge, 1995). These electrolytes are critical for intra and extracellular homeostasis and influence variety of biological parameters within the body ranging from acid base balance, osmotic pressure, impulse transmission, enzymatic activity and provide platform for optimum live bird performance (Ahmad and Sarwar, 2006; Borges *et al*., 2007).

The optimum level of these electrolytes is provided through feed formulation in the view of guidelines laid by National Research Council (NRC) and nutritional recommendations of management guide manuals provided with different varieties of birds. It is defined in terms of mEq of Na^+ and K^+ minus mEq of Cl^-/kg of the diet (Nutrition and Council, 1994). However it is equally important to provide optimum DEB according to productive and environmental conditions by manipulating these electrolytes in feed and water. Various studies have suggested varying optimum levels of DEB for high growth and productivity ranging between 150-300 mEq/kg for different classes of poultry. An earlier study (Mongin, 1981) suggested that 250 mEq/kg DEB for broilers while later on study (Johnson and Karunajeewa, 1985) recommended DEB between 180-300 mEq/kg for broilers. Other research studies indicated optimum DEB level was within the same range i.e., 246 to 315 mEq/kg for starter phase and 249 to 257 mEq/kg for growing phase (Murakami *et al*., 2001; Oviedo-Rondon *et al*., 2001). Maximum body weight gain and feed conversion ratio was reported at DEB levels of 236 and 207 mEq/kg, respectively (Borges *et al*., 2003a). However, minimum body weight gain and feed conversion ratio was reported at high DEB levels of 340 and 360 mEq/kg, respectively (Borges *et al*., 2003b; Borges *et al*., 2004). The DEB requirements for broilers depend on age of the birds. Szabo and coworkers found that 175 mEq/kg of DEB was appropriate upto 21 days of age, while DEB of 250 mEq/kg found better results from 22 to 42 days of age. The DEB variations did not affect macromineral composition of bones (Szabo *et al*., 2011). However, Ahmad and coworkers (Ahmad *et al*., 2009) suggested that no single DEB value can be recommended to improve broiler performance in hot and humid tropical conditions. They found that DEB values of 50, 150 and 250 mEq/kg showed quadratic effect on weight gain and flock maintained decreased mortality and better blood pH balance, whereas DEB of 0 and 350

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mEq/kg resulted in metabolic acidosis and alkalosis, respectively. The effect of DEB on layers was well studied by Gezen *et al.* (2005), who reported that the DEB level of 256 mEq/kg caused improvement in egg shell quality and also corrected metabolic acidosis resulting from egg lay.

Since DEB is the function of individual ions, it is equally important to provide effective level of each ion. The effects of extreme levels of Na^+, K^+ and Cl^- have been well studied by Borges and coworkers (Borges *et al.*, 1999) and they also defined the extreme levels of Na^+ (0.15-0.6%), K^+ (0.98-1.21%) and Cl^- (0.15-0.71%). However, NRC recommended levels for Na^+ (0.12-0.2%), K^+ (0.13-0.3%) and Cl^- (0.12-0.2%) for various classes of poultry are significantly lower (Borges *et al.*, 2007), whereas Oviedo-Rondon *et al.* (2001) recommended optimum Na^+ and Cl^- requirements for young broiler chicken as 0.28 and 0.25%, respectively.

Another study suggested that under heat stress conditions, relatively higher DEB level should be provided because of respiratory alkalosis resulting from evaporative cooling of the body and excessive loss of K^+ ion through kidneys (Fixter *et al.*, 1987). Under ambient temperature of 18-26°C, DEB level of 250 mEq/Kg was optimum but higher temperature (25-35°C) required an elevated DEB level of 350 mEq/Kg (Fixter *et al.*, 1987).

There are lacking information concerning an actual status of these ions in the available finished poultry feed and water in the country. Current study focuses on the field survey of DEB of poultry feed diets being used at farms of different regions of the Punjab province of Pakistan. To have an overall picture of availability of individual dietary electrolytes, water samples from the same farms were also collected and analyzed wherever possible.

MATERIALS AND METHODS

Feed samples collection: A total of 68 poultry feed and 51 water samples were collected from Rawalpindi, Sargodha and Multan districts of Punjab. These samples were analyzed for Na^+, K^+ and Cl^- contents to calculate overall DEB. Feed samples which routinely received for proximate analysis in the Feed Testing Laboratory, Poultry Research Institute, Rawalpindi were also included in this study.

Wet digestion: Feed samples were oven dried and grinded before wet digestion for Na^+ and K^+ analysis. Exactly 1 gram of feed sample was taken in digestion flask and incubated with 20 mL of conc. HNO_3 for overnight. Another 10 ml of conc. $HOCl_4$ was added in the mixture and heated at 300°C till the volume reduced to 4 to 5 mL and vapors color changed to white. Distilled water was added to make volume up to 100 mL and filtered through Whatman no. 1 filter paper.

Sodium (Na^+) and Potassium (K^+) ions analysis: The Na^+ and K^+ were determined according to the methods of AOAC by flame photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK) using standard curve (International and Horwitz, 2011). The concentration of Na^+ and K^+ in water samples was also determined through flame photometer.

Chloride ions (Cl^-) analysis: The Cl^- in feed samples was determined by dry ashing feed samples at 500 to 550°C in the presence of calcium oxide. The resulting ash was dissolved in hot distilled water and titrated against 0.05 M $AgNO_3$ solution, using K_2CrO_7 as indicator (Chapman and Pratt, 1961). For chloride contents in water samples, 10 ml of water sample was taken in a beaker and 2 drops of K_2CrO_7 were added into it. The resulting yellow color solution was titrated against 0.05 M $AgNO_3$ solution, till a stable red color appeared. Molarity of chloride ion was calculated by using $M_1V_1 = M_2V_2$ equation and converted to ppm concentration through following formula:

$$\text{Conc. } Cl^- \text{ ions in ppm} = \text{Molarity of } Cl^- \text{ ions} \times 35.5 \times 1000$$

Calculation of dietary electrolyte balance: The DEB was calculated by converting the concentration of these monovalent ions in mEq/kg by following formulas:

$$\text{Concentration of } Na^+ \text{ in mEq/kg} = \text{Concentration in ppm}/23$$
$$\text{Concentration of } K^+ \text{ in mEq/kg} = \text{Concentration in ppm}/39.1$$
$$\text{Concentration of } Cl^- \text{ in mEq/kg} = \text{Concentration in ppm}/35.5$$

The resulting values were put into the following formula to calculate dietary electrolyte balance. The concentration of these ions in water samples was also used in equation, wherever water samples were available.

DEB = (mEq/kg of Na^+ in feed+mEq/kg of Na^+ in water+mEq/kg of K^+ in feed+mEq/kg of K^+ in water)-(mEq/kg of Cl^- in feed+mEq/kg of Cl^- in water).

Statistical analysis: For statistical analysis SPSS version 17 was used to calculate mean, mode and standard error of mean (SEM).

RESULTS AND DISCUSSION

Broiler diets: The ionic concentration of different poultry diets is shown in Table 1. The results showed that in 16 broiler diet samples, the mean concentration of Na^+, K^+ and Cl^- was 1688, 7019 and 2215 ppm, respectively. Only 2 numbers of samples, out of 16 broiler diets samples had Na^+ concentration within range as recommended by NRC (Nutrition and Council, 1994). The concentration of Cl^- and K^+ was higher in 9 and 16 samples, respectively when compared with NRC recommendations; however, other studies have recommended higher level of K^+ in broiler diets (Borges *et al.*, 1999).

Table 1: Surveillance of Sodium (Na^+), Potassium (K^+) and Chloride (Cl^-) ions concentration in poultry diets used for different flock types

			Ionic concentration (ppm)					
Flock type	No. samples	Type of ions	Min.	Max.	Mean	Mode	SEM	Recommended Level*
Broiler	16	Na^+	1000	3200	1688	1800	129	1200-2000
		K^+	3900	9500	7019	7500	376	3000
		Cl^-	1500.0	3900.0	2215.6	1700.0	157.9	1200-2000
Breeder	16	Na^+	600	2100	1250	600	208	1500**
		K^+	4400	8800	6600	4400	687	1500**
		Cl^-	1100.0	3000.0	1983.3	1100.0	311.4	1300**
Layer	36	Na^+	1000	5200	1978	1700	150	1500**
		K^+	4000	11000	6681	7000	253	1500**
		Cl^-	1200.0	3540.0	2163.6	2300.0	107.1	1300**

*(Nutrition and Council, 1994). **Based on 100 gm of feed intake per hen daily at 90% production

Table 2: Comparison of Dietary Electrolyte Balance (DEB) level of poultry diets of different flock types

		DEB (mEq/kg)					
Flock type	No. samples	Min.	Max.	Mean	Mode	SEM	Recommended Level
Broiler	16	134.0	254.2	192.7	134	8.3	240*
Breeder	16	107.6	206.8	168.1	107.6	16.3	-
Layer	36	124.5	316.8	198.2	124.5	8.1	256**

*(Borges *et al*., 2003a); **(Gezen *et al*., 2005)

Table 3: Area wise distribution of Sodium (Na^+), Potassium (K^+) and Chloride (Cl^-) ions in water samples

			Ionic concentration (ppm)					
Region		Type of ion	Min.	Max.	Mean	Mode	SEM	Maximum acceptable level*
Multan	13	Na^+	60	531	229	246	40	50
		K^+	3	21	11	5	2	500
		Cl^-	17.0	181	75.7	71.0	12.3	250
Rawalpindi	23	Na^+	25	110	51	32	11	50
		K^+	1	4	2	2	0	500
		Cl^-	52.0	70	70.0	7.1	70.0	250
Sargodha	15	Na^+	6	44	24	12	3	50
		K^+	4	25	9	4	2	500
		Cl^-	17.0	246	75.2	48.0	15.7	250

(Carter and Sneed, 1987)

Breeder diets: A total of 16 breeder diets had a lower level of Na^+ (mean = 1250 ppm), K^+ (mean = 6600 ppm) and Cl^- (mean = 1983 ppm) concentration as compared to broiler's diets. The range of the values showed inconsistency with NRC recommendation. Out of 16 samples, 14 samples had less Na^+ level than NRC recommendation, whereas K^+ level were higher than NRC recommended level in all samples.

Layer diets: The 36 diet samples used for layer flocks showed a slightly higher level of Na^+ (mean = 1978 ppm) as compared to breeder diets as well as NRC recommendation. The level of K^+ in a layer diet was as high as 11000 ppm (1.1%), but the mean value (6681 ppm) was in approximation with the recommendations (5000 ppm) of commercial management guide for layer production. The level of Cl^- was higher than NRC recommended level in 32 out of 36 samples analyzed (Anonymous, 2007-08; Borges *et al*., 2003a,b; Nutrition and Council, 1994).

Table 2 showed the overall DEB in poultry diets of different flock types. The results showed the mean of DEB was 192.7, 168.1 and 192 mEq/kg in broiler, breeder and layer flocks, respectively. The mean of DEB level in broiler and layer diets was considerably low as per recommendation of Borges *et al*. (2003a) in moderately high ambient temperature and humidity (Oviedo-Rondon *et al*., 2001). The DEB level was as low as 134, 107.6 and 124.5 mEq/kg in broiler, breeder and layer flock's diets, respectively.

Water samples: Water samples were collected alongwith feed samples to investigate overall DEB. The water samples showed an area wise distribution pattern of Na^+, K^+ and Cl^- concentration (Table 3). Water samples (n = 13) collected from Multan area had a mean of Na^+ concentration of 229 ppm which is good and above the recommended level for poultry. However, the mean of K^+ and Cl^- level was found within the recommended level for poultry consumption (Carter and Sneed, 1987). The 23 samples collected from Rawalpindi district had mean of Na^+, K^+ and Cl^- concentration of 51, 2 and 70 ppm, which were more suitable for poultry use. Samples (n = 15) collected from Sargodha district had also very appropriate mineral composition for poultry usage, having mean of Na^+, K^+ and Cl^- levels of 24, 9 and 75.2 ppm, respectively.

Conclusion: The DEB affects the bird's performance and the optimal ratio was considered around 250 mEq/kg. The very high (340 and 360 mEq) and very low (0 mEq/kg) DEB can result in metabolic alkalosis and acidosis, respectively. That is why such DEB should be avoided while formulating diets. Similarly, excess or deficiency of any particular mineral must be avoided while maintaining the DEB. The bird's survivability during heat stress depends on the water consumption, which depends directly on bird's age and on DEB (Na+K-Cl) of the diet. In the current study, the resulting DEB was slightly lower than recommended level for all three flock types. The highest Na contents in water were observed in Multan district, while two districts (Sargodha and Rawalpindi) had much suitable ionic contents in water for poultry consumption.

REFERENCES

Ahmad, T., T. Mushtaq, M.A. Khan, M.E. Babar, M. Yousaf, Z.U. Hasan and Z. Kamran, 2009. Influence of varying dietary electrolyte balance on broiler performance under tropical summer conditions. J. Anim. Physiol. Anim. Nutr., 93: 613-621.

Ahmad, T. and M. Sarwar, 2006. Dietary electrolyte balance: implications in heat stressed broilers. World's Poult. Sci. J., 62: 638-653.

Anonymous, 2007-08. Commercail management guide for Hy-line^R variety W-36.

Borges, S., J. Ariki, E. Santin, A. Fischer da Silva and A. Maiorka, 1999. Balanco eletrolítico em dieta pre-inicial de frangos de corte durante o verao. Revista Brasileira de Ciencia Avico, 1: 175-179.

Borges, S., A. Fischer da Silva, J. Ariki, D. Hooge and K. Cummings, 2003a. Dietary electrolyte balance for broiler chickens under moderately high ambient temperatures and relative humidities. Poult. Sci., 82: 301-308.

Borges, S.A., A.V. Fischer da Silva, J. Ariki, D.M. Hooge and K.R. Cummings, 2003b. Dietary electrolyte balance for broiler chickens exposed to thermoneutral or heat-stress environments. Poult. Sci., 82: 428-435.

Borges, S., A. Fischer da Silva, A. Majorka, D. Hooge and K. Cummings, 2004. Physiological responses of broiler chickens to heat stress and dietary electrolyte balance (sodium plus potassium minus chloride, milliequivalents per kilogram). Poult. Sci., 83: 1551-1558.

Borges, S.A., A.V. Fischer Da Silva and A. Maiorka, 2007. Acid-base balance in broilers. World's Poult. Sci. J., 63: 73-81.

Carter, T.A. and R.E. Sneed, 1987. Drinking water quality for poultry. PS and T Guide No. 42, Extension Poultry Science, North Carolina State University, Raleigh, N.C.

Chapman, H.D. and P.F. Pratt, 1961. Methods of Analysis for Soils, Plants and Water: University of California.

Fixter, M., D. Balnave and R.J. Johnson, 1987. The influence of dietary electrolyte balance broiler growth at high temperatures. Proc. Foundation Symp., Uni. Sydney Aust., 34-48.

Gezen, S.S., M. Eren and G. Deniz, 2005. The effect of different dietary electrolyte balances on eggshell quality in laying hens. Rev. Med. Vet., 156: 491-497.

Hodge, D.M., 1995. Dietary electrolytes influence metabolic processes in poultry. Feed Stuffs, 67: 14-15.

International, A. and W. Horwitz, 2011. Official Methods of Analysis of AOAC International: AOAC International.

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.

Mongin, P., 1981. Recent advances in dietary anion-cation balance: applications in poultry. Proc. Nutr. Soc., 40: 285-294.

Murakami, A., E. Oviedo-Rondon, E. Martins, M. Pereira and C. Scapinello, 2001. Sodium and chloride requirements of growing broiler chickens (twenty-one to forty-two days of age) fed corn-soybean diets. Poult. Sci., 80: 289-294.

Nutrition, S.O.P. and N.R. Council, 1994. Nutrient Requirements of Poultry: Ninth Revised Edition, 1994: The National Academies Press.

Oviedo-Rondon, E., A. Murakami, A. Furlan, I. Moreira and M. Macari, 2001. Sodium and chloride requirements of young broiler chickens fed corn-soybean diets (one to twenty-one days of age). Poult. Sci., 80: 592-598.

Szabo, J., A.V. Vucskits, E. Andrasofszky, E. Berta, A. Bersenyi, L. Borzsonyi and I. Hullar, 2011. Effect of dietary electrolyte balance on production, immune response and mineral concentrations of the femur in broilers. Acta. Vet. Hung., 59: 295-310.