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Electrolytic Balance in Broiler Chicks During the First Week of Age

Balanço Eletrolítico Para Frangos de Corte na Primeira Semana de Idade

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ABSTRACT

Two experiments were carried out using 712 day-old chicks to evaluate the electrolytic balance (Na+K-Cl) in pre-starter (1-7 days) broiler diets. The feed, based on corn and soybean meal with 21.5 % protein and 2,900 kcal ME/kg, was offered ad libitum. In experiment I, K level was fixed, and Na and Cl levels were changed, using four treatments and eight replicates of 16 birds. In experiment II, increasing levels of Na and K were used, with a total of four treatments and five repetitions of 10 birds. In both experiments, the dietary electrolytic balance was 40; 140; 240 and 340 mEq/kg. Electrolytic balance caused a quadratic effect on weight gain and feed:gain ratio, and a linear increase in feed intake when the electrolytic balance was increased by the single supplementation of Na, indicating that this ion stimulates feed intake of birds at this stage. However, feed intake was maximum for 202 mEq/kg, when K and Na levels were concurrently increased in the diet, indicating that there is a limit over which feed intake is depressed as a function of excessive K. The ideal electrolytic dietary balance was between 246 and 277 mEq/kg, obtained by the manipulation of Na and Cl levels.

RESUMO

Foram conduzidos dois experimentos, utilizando-se 712 pintos de corte para avaliar o efeito do balanço eletrolítico (Na+K-Cl) em rações pré-iniciais (1-7 dias) de frangos de corte. As rações à base de milho e farelo de soja, com 21,5 % de proteína e 2.900 kcal EM/kg, foram oferecidas à vontade. No experimento I, o nível de K foi fixado e os níveis de Na e Cl foram manipulados, em 4 tratamentos com 8 repetições de 16 aves cada. No experimento II, níveis mais elevados de Na e K foram usados, com 4 tratamentos e 5 repetições de 10 aves cada. Em ambos os experimentos, os balanços eletrolíticos foram de 40; 140; 240 e 340 mEq/kg de ração. O balanço eletrolítico causou um efeito quadrático no ganho de peso e na conversão alimentar e um aumento linear no consumo de alimento quando o balanço eletrolítico foi aumentado pela suplementação de Na, indicando que esse íon estimula o consumo de alimento das aves nesse período. Porém, o consumo de alimento foi máximo em 202 mEq/kg, quando os níveis de K e Na foram simultaneamente aumentados na dieta, indicando que o limite superior de consumo de alimento é deprimido em função do K em excesso. O balanço eletrolítico ideal foi entre 246 e 277 mEq/kg obtidos pela manipulação dos níveis de Na e Cl.

INTRODUCTION

Nutritional programs using pre-starter diets have been extensively discussed in the last decade. The adoption of this practice is justified as the bird has distinctive nutritional needs at this stage. On the other hand, it is hard to find information in literature on the electrolytic balance of broilers up to 7 days of age. The essential electrolytes for the maintenance of the osmotic pressure and acid-base balance are sodium (Na^+), potassium (K^+) and chlorine (Cl^-). Besides their need in minimum amounts in the feed to satisfy the nutritional requirements, it is important to maintain the proper balance among them. The availability of theses ions may be influenced by the intestinal and kidney homeostasis regulation, as a result of increased absorption or excretion. Mongin & Sauveur (1977) concluded that the electrolytic balance of the diet can be summarized by the equation $Na^+ + K^+ - Cl^-$, which value expresses the amount and the ratio among these ions. These authors proposed the ideal value of 250 mEq/kg or 25 mEq /100g in broiler diets. Maiorka et al. (1998) found a value of 160 mEq/kg; however, Borges et al. (1999) suggested the balance of 251 mEq/kg in pre-starter diets, Rondón et al. (2000), evaluating the performance of broiler up to 7 days of age, found values which varied between 250 and 319 mEq/kg for weight gain and feed:gain ratio, respectively. The experiments of the present study aimed to determine the best electrolytic ratio (Na+K-Cl) in pre-starter diets for chicks up to seven days of age.

MATERIALS AND METHODS

Seven hundred and twelve male day-old chicks was used in two experiments. The birds received diets based on corn and soybean meal ad libitum with 21.5 % protein and 2,900 kcal EM/kg, and the levels of the other nutrients were added according to the National Research Council - NRC (1994). Feedstuffs samples were taken to be analyzed for Na, K and Cl content. Water samples were also analyzed for the same minerals. Sodium and potassium were determined by flame spectrophotometer (AOAC, 1990) and chlorine by $AgNO_3$ titration (Lacroix et al., 1970) and Labtest™ kit in the water. In Experiment I, the birds (Cobb strain) were distributed in boxes with 16 birds per experimental unit in a completely random experimental design of four treatments (40, 140, 240 and 340 mEq/kg of feed) and eight replicates. The K level remained constant (Table 1), whereas Na and Cl levels were altered to obtain the desired electrolytic balance. In Experiment II, the birds (Ross strain) were distributed in batteries with 10 birds per experimental unit in a completely random experimental design with four treatments (40, 140, 240 and 340 mEq/kg of feed) and five replicates. Na and K were added at increasing levels (Table 1), and the calculated electrolytic balance "Mongin Number" were obtained by the addition of de NaCl, $NaHCO_3$, $KHCO_3$ and NH_4Cl in the feed. Maximum and minimum temperatures, and relative humidity were monitored daily. Water temperature and pH were recorded twice a day, at the lowest and highest temperature hours. Weight gain (WG), feed intake (FI) and feed:gain ratio (F:G) were evaluated. The results were submitted to analysis of regression and, when necessary, the means were compared by the test of Tukey.

RESULTS AND DISCUSSION

From 1 to 7 days of age, a quadratic effect ($p<0,05$) was observed for weight gain and feed:gain ratio, and to feed intake and weight gain in Experiments I and II, respectively (Figures 1 and 2), and the results were dependent on the electrolytes used to alter the electrolytic balance. The ideal Na+K-Cl ratio for weight gain and feed:gain was between 277 and 246 mEq/kg, when K was fixed. When K and Na were increased, the ratio was 227 mEq for weight gain.

The comparison of means of the treatments (Table 2) allows us to infer that special attention must be paid to high Cl levels in the feed (0.77%), as well to low electrolytic balance (40 mEq), which should not be recommended to birds at this stage. This is explained by the fact that excessive amounts of Cl and low or negative electrolytic balance in the feed may reduce the pH, promoting metabolic acidosis (Johnson & Karunajeewa, 1985; Ruiz-Lopez & Austic, 1993), showing the direct or indirect negative effect of the excess of Cl.

The broiler response to electrolytic balance was more evident when Na levels between 0.30% and 0.40% were used. Feed intake was maximum for 202 mEq/kg, when K and Na levels were concurrently increased in the diet. However, the response was linear ($Y= 173.9675 – 0.0380X$, $R^2 = 0.91$) when the electrolytic balance was increased by the single supplementation of Na, indicating that this ion stimulates feed intake of birds at this stage, and that there is a limit over which feed intake is depressed as a function of excessive K. This reduces

weight gain, corroborating the results of Johnson & Karunajeewa (1985) and Borges et al. (1999). It is possible that K levels (0.95 e 1.05%) may have exceeded the birds tolerance, as the estimated requirement of this ion is 0.30% (NRC, 1994). The results obtained with increasing Na supplementation, specially the linear response in feed intake, suggest that Na requirements are underestimated, and the performance obtained with low electrolytic balance, due to the addition of high Cl levels, shows that high levels of Cl should be avoided.

When the electrolytic balance (Na + K - Cl) was higher or lower than 240 mEq, bird performance was impaired, corroborating the hypothesis that when acid-base balance is deviated from homeostasis to alkalosis or acidosis, metabolic pathways may be altered, and are more involved in regulation of homeostasis than in animal growth (Mongin, 1981).

The average environmental temperature and relative humidity fluctuated between 28 - 32ºC and 51%, 23 - 34ºC and 74%, and water temperature was between 19 to 29ºC with pH of 7.15 and 21 to 25ºC with pH of 7.00, in Experiments I and II, respectively. Analysis of the tap water indicated that it contained 0.7 ppm Na and traces of K and Cl. Although water intake was not evaluated, previous studies showed a linear increase in water intake as the electrolytic ratio increased in the diet (Borges et al.*, 1999). Diets with higher levels of electrolytes can increase blood osmolarity, specially in the presence of Na. This is important because an increase in water intake may stimulate feed intake. Despite previous studies had shown that KCl, $NaHCO_3$ and NaCl significantly increase water intake (Borges, 1997; Borges* et al.*, 1998) in growing and finishing stages, Borges* et al*. (1999) found that diets with high levels of Cl and/or K did not stimulate water intake during the first seven days of age.*

The consequence of a higher water intake promoted by diets with high electrolytic balance is higher litter humidity. However, Maiorka et al. (1998) did not find any effect of the electrolytic balance (100, 150, 200, 250 e 300 mEq) on the humidity of the excreta up to 7-days of age. Borges et al. *(1999) showed that diets containing 0.30 and 0.45% Na caused litter humidity similar to those obtained with the use of commercial diets at this age. Although not quantified, diets with an electrolytic balance between 246 and 277 mEq, with Na levels lower than 0.45%, apparently did not affect litter humidity up to 7 days of age of the chicks.*

In conclusion the data of this study suggest that, the electrolytic balance of the feed (Na+K-Cl) interfere in the performance of the chicks, and the ideal electrolytic balance, obtained by Na and Cl levels manipulation, was 246 and 277 mEq/kg for feed:gain ratio and weight gain, respectively. When formulating pre-starter diets which take into account the concept of electrolytic balance, extreme levels of Cl (0.77%) and K (1.05%) must be avoided.

***Table 1 –** Electrolyte composition of the experimental diets (%).*

Mongin Number (mEq/kg)	Experiments					
	I			II		
	Na	K	Cl	Na	K	Cl
40	0.15	0.75	0.77	0.15	0.75	0.77
140	0.25	0.75	0.57	0.20	0.85	0.58
240	0.35	0.75	0.37	0.25	0.95	0.40
340	0.45	0.85	0.26	0.30	1.05	0.21

Table 2 *– Performance of chicks receiving different (Na+K-Cl) electrolytic balance in the diet up to 7 days of age (Experiment I and II).*

mEq/kg	Weight gain (g)	Feed intake (g)	Feed:gain
	Experiment I		
40	117c[2]	175	1.508a
140	124bc	178	1.445ab
240	138a	185	1.350b
340	131ab	186	1.418ab
CV [1] (%)	5.14	4.93	4.89
	Experiment II		
40	120	151	1.262
140	125	155	1.244
240	128	161	1.255
340	125	151	1.213
CV [1] (%)	5.34	4.60	3.33

1 - Coefficient of variation.
2 - Means with different letters in the columns are different (p<0,05).

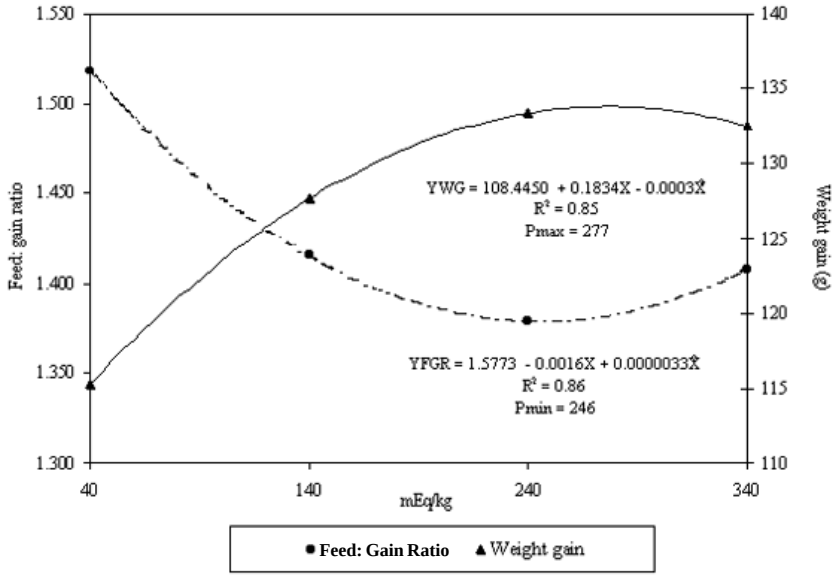

Figure 1 *– Effects of the Na+K-Cl electrolytic balance of feed on weight gain and feed:gain ratio up to 7 days of age in broiler (Experiment I).*

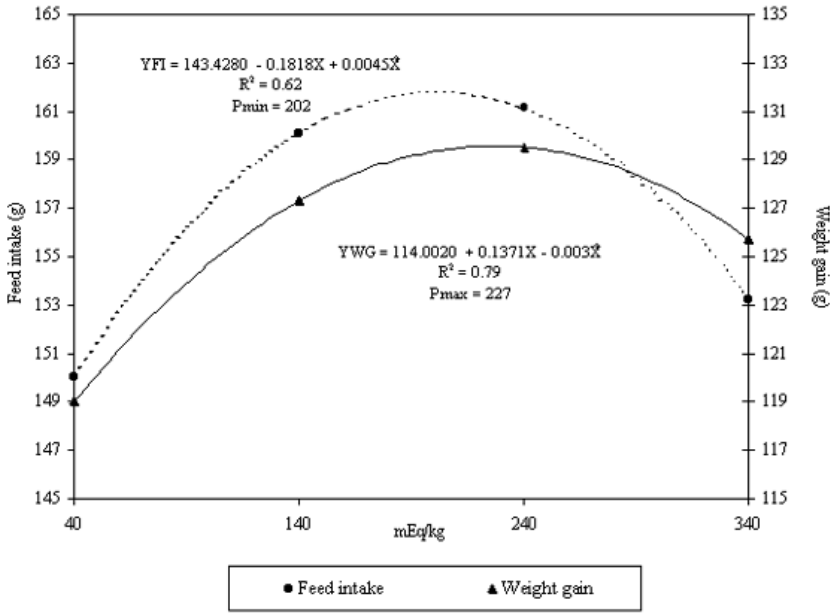

Figure 2 *– Effects of the Na+K-Cl electrolytic balance of feed on weight gain and feed intake up to 7 days of age in broiler (Experiment II).*

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