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Different Sodium Levels and Electrolyte Balances in Pre-Starter Diets for Broilers

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Broiler, chlorine, electrolyte balance, performance, potassium, sodium, water.

ABSTRACT

An experiment with 400 one-day-old male chicks (Ross) was conducted to evaluate the effects of different Na levels (0.10, 0.22, 0.34 and 0.46%) and different cation/anion balances (Na+K-Cl) (100, 150, 200, 250 and 300 meq/kg) in pre-starter diets on broiler performance. The corn and soybean-based diets had 22% crude protein and 2,900 kcal/kg metabolizable energy and were fed ad libitum. Performance data showed a positive quadratic effect of increasing Na levels on feed and water consumption, weight gain and feed conversion. Na+K-Cl also had a quadratic influence on feed intake and weight gain. None of the effects tested affected the amount of water measured in excreta. Derivatives of obtained regression equations pointed to optimal Na levels of 0.45% for water consumption, 0.40% for feed intake and weight gain and 0.38% for feed conversion. As to the effect of dietary Na+K-Cl balances on performance, regression equation values were 174 meq/kg for feed consumption and 163 meq/kg for weight gain. These results show that both Na level and Na+K-Cl balance interfere on broiler performance.

INTRODUCTION

Many researchers and nutritionists have recommended the use of a differential diet for broilers during the first week of life. The adoption of this specific diet is justified by the fact that chicks have very distinct nutritional needs during this stage, possibly due to differences of the digestive tract. Many studies emphasize that the digestive processes are not fully developed soon after hatching (Austic, 1985, Moran 1985).

Newly hatched chicks grow fast and require high environmental temperature during the first week of life (Penz & Vieira, 1997). Sodium (Na), as well as chlorine (Cl) and potassium (K), are essential elements in order to maintain the osmotic pressure and acid-base balance within normal values. It is suggested that the variation in the acid-base balance changes pH values, carbon dioxide concentration and base levels in the blood. Therefore, dietary concentrations of electrolytes have an important, despite indirect, effect on feed intake and growth of chicks during the first days of life. Information on adequate levels of Na and balance among the electrolytes (Na+K-Cl), as recommended by Mongin & Sauveur (1977) for diets during the first week of life, are still few or incomplete. The last edition of the National Research Council increased Na level from 0.15% (NRC, 1984) to 0.20% (NRC, 1994) for the first weeks of age.

This study was performed to identify the effects of different Na levels and different Na, K and Cl (Na+K-Cl) balances in broiler feeds during the first week of age.

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MATERIAL AND METHODS

The experiment was carried out with 400 one-day-old male Ross chicks. The birds were housed in an environmentally controlled room and distributed in 4 batteries divided into 10 compartments each, measuring 0.8 x 1.0 x 0.2 m. Each compartment was equipped with a feeder and a drinker. Feed and water were supplied *ad libitum*. Therefore, 40 experimental units with 10 birds each were used. Birds received 24 hours of daily light during the experimental period.

Experimental diets (fed from 1 to 7 days of age) were isocaloric and isoproteic (2,900 kcal ME/kg and 22% CP), as shown in Table 1. Treatments consisted of 4 Na levels and 5 Na+K-Cl balances, corresponding in 20 treatments with two replicates each, as presented in Table 2. In order to obtain different Na levels and different Na+K-Cl balances, the basal diet left a space of 1.9 % out of 100% to add different amounts of NaCl, CaCl, $NaHCO_3$ and $KHCO_3$.

Table 1 - Basal composition of the experimental diets.

Ingredients	(%)
Corn	56.95
Soybean meal	36.53
Limestone	1.63
Dicalcium phosphate	1.28
Soybean oil	1.00
L-Lysine HCl	0.01
DL-Methionine	0.24
Vitamin mix[1]	0.10
Choline chloride	0.06
Mineral mix[2]	0.30
Free space	1.90
Calculated values	
Crude protein (%)	22.00
ME (kcal/kg)	2,900
Ca (%)	1.00
Available P (%)	0.45
Lysine (%)	1.10
Methionine + cystine (%)	0.90
Choline (mg/g)	1,500
Average Geometric Diameter (mm)	489

1 - Provides per kg of diet: vitamin A (11,000 IU); vitamin D3 (2,250 IU); vitamin E (9 IU); vitamin K3 (1.8 mg); vitamin B12 (0.02 mg); thiamin (1.1 mg); riboflavin (9 mg); pyridoxine (1.8 mg); biotin (0.1 mg); choline (680 mg); pantothenic acid (9 mg); niacin (35 mg); folic acid (1 mg). 2 - Provides per kg of diet: selenium (0.18 mg); iodine (1.2 mg); iron (70 mg); copper (10 mg); zinc (60 mg); manganese (70 mg).

From the 8th to the 21st day of age, all birds received the same basal diet, containing 3,000 kcal ME/kg, 21% CP and 0.20% Na (Table 3).

Feed intake (FI), weight gain (WG) and feed conversion (FC) were measured when birds were seven and 21 days old. Water consumption (WC) was also determined.

Table 2 - Sodium levels and percentages of substances added to the diet to obtain different electrolyte balances (Na+K-Cl).

Na levels (%)	Substances (%)	Na + K – Cl (meq/kg) 100	150	200	250	300
0.10	NaCl	0.145	0.145	0.060	-	-
	CaCl	0.475	0.197	-	0.210	-
	$NaHCO_3$	-	-	0.123	-	0.210
	$KHCO_3$	-	-	-	0.400	0.904
	Inert	1.280	1.558	1.717	1.290	0.786
Total		1.900	1.900	1.900	1.900	1.900
0.22	NaCl	0.452	0.453	0.367	0.073	-
	CaCl	0.475	0.197	-	-	-
	$NaHCO_3$	-	-	0.124	0.548	0.654
	$KHCO_3$	-	-	-	-	0.377
	Inert	0.973	1.250	1.409	1.279	0.869
Total		1.900	1.900	1.900	1.900	1.900
0.34	NaCl	0.760	0.760	0.674	0.381	0.087
	CaCl	0.474	0.196	-	-	-
	$NaHCO_3$	-	-	0.124	0.548	0.972
	$KHCO_3$	-	-	-	-	-
	Inert	0.666	0.944	1.102	0.971	0.841
Total		1.900	1.900	1.900	1.900	1.900
0.46	NaCl	1.067	1.068	0.982	0.688	0.394
	CaCl	0.474	0.196	-	-	-
	$NaHCO_3$	-	-	0.125	0.549	0.972
	$KHCO_3$	-	-	-	-	-
	Inert	0.359	0.636	0.793	0.663	0.534
Total		1.900	1.900	1.900	1.900	1.900

Table 3 - Nutritional composition of the diet fed from 8 to 21 days of age.

Crude protein (%)	21.00
Metabolizable energy (kcal/kg)	3,000
Ca (%)	1.00
Available P (%)	0.45
Lysine (%)	1.10
Methionine (%)	0.91
Na (%)	0.20
Choline (mg/g)	1,500

At seven days of age, excreta humidity was determined (excreta was collected twice a day, within a 12 h interval in order to avoid moisture loss due to evaporation). Excreta was frozen (-10°C), subsequently dried in an oven at 60°C for 72 hours and then dried in an oven at 105°C for 12h, in order to determine dry matter content.

A completely randomized experiment with response surface experimental design was used. Data were submitted to multiple regression analysis, and only the parameters which were significant at the F-test were maintained in the model. An analysis of correlation between WC and FI, FI and WG, and FI and FC was performed.

RESULTS AND DISCUSSION

From 1 to 7 days of age, quadratic effects of Na levels and Na+K-Cl balances were observed for FI and WG, whereas for WC and FC a quadratic effect was observed only for Na levels (Tables 4 and 5). No significant effect of the tested treatments on excreta humidity was found (Table 6). The obtained regression equations suggested for maximum responses dietary Na levels of 0.45% for WC, 0.40% for FI and WG, and 0.38% for FC. The values calculated by regression analysis (Table 5) showed that the Na levels that promoted the best results during the period of 1 to 7 days of age were higher than the ones recommended by the NRC (1984 and 1994), and similar to the level suggested by Britton (1992). Sklan & Noy (2000) demonstrated that Na has a very important role in feed intake just after hatching, and also in secretion and activity of some digestive enzymes. A high correlation between WC and FI (R=0.77) was observed. FI was also correlated to WG (R=0.82), as well as to FC (R= 0.90). The highest Na level resulted in the highest WC. The increase in WC is often associated to high excreta humidity, which may affect broiler performance. However, results showed (Table 6) that Na levels did not interfere in water excretion up to seven days of age.

Table 4 - Means and regression equations for feed intake (FI) and water consumption (WC) during the period from 1 to 7 days of age.

meq/kg	FI (g) Na (%)				WC (ml) Na (%)			
	0.10	0.22	0.34	0.46	0.10	0.22	0.34	0.46
100	125	130	149	163	229	289	324	334
150	125	151	152	134	222	282	317	327
200	130	154	164	147	215	275	310	320
250	124	135	150	149	208	268	303	313
300	115	122	132	142	201	261	296	306

$Y_{(FI)}$= 77.8620 + 0.37148 x meq/kg + 222.287 x Na + (-0.00107) x meq/kg^2 + (-279.344) x Na^{2}Point of maximum response (2nd derivate) (R^2 = 0.49) - 0.40% Na and 173.6 meq/kg. $Y_{(WC)}$ = 165.77 + 776. 721 x Na + (-868.022) x Na^2 Point of maximum response (2nd derivate) (R^2 = 0.80) - 0.45% Na.

As to the effect of dietary Na+K-Cl balance on performance, the values obtained in the regression equations were 174 meq/kg for FI and 163 meq/kg for WG (Tables 4 and 5). These values are different from those suggested by Mongin & Sauveur (1977), who recommended the value of 250 meq/kg as the most adequate for broilers. However, it must be noted that these authors did not mention differences among ages. Therefore, this variation may be explained by the large differences in the processes of digestion and absorption seen in broilers during the first week of age, as compared to older broilers. Na and K are involved in the process of absorption of some nutrients, such as glucose (Larbier & Leclercq, 1992), and this may affect maintenance requirement. Moreover, taking into consideration the definition of treatments, it is possible that Cl levels in treatments with high Na+K-Cl were marginally deficient, interfering with performance. The application of specific balances between ions (Na and Cl) in poultry diet formulation may benefit broiler performance as compare to the use of a single NaCl level in the diet (Murakami *et al.,* 1997). Thus, further studies are needed to determine the influence of different balances between these ions in the diet of broilers during the first stage of development.

Table 5 - Means and regression equations for weight gain (WG) and feed conversion (FC) during the period from 1 to 7 days of age.

meq/kg	WG (g) Na (%)				FC (g/g) Na (%)			
	0.10	0.22	0.34	0.46	0.10	0.22	0.34	0.46
100	67	113	119	123	1.876	1.155	1.256	1.316
150	67	116	118	115	1.898	1.299	1.244	1.157
200	71	116	127	119	1.837	1.329	1.289	1.232
250	67	99	120	119	1.848	1.327	1.248	1.254
300	63	79	94	117	1.820	1.561	1.397	1.223

$Y_{(WG)}$ = 6.33105 + 0.32513 x meq/kg + 474.958 x Na + (-0.000999) x meq/kg^2 + (-600.381) x Na^2 Point of maximum response (2nd derivate) (R^2 =0.85) - 0.40% Na and 162.7 meq/kg. $Y_{(FC)}$ = 2.39825 + (-6.09183) x Na + 8.02900 x Na^2 Point of maximum response (2nd derivate) (R^2 = 0.83) - 0.38% Na

Table 6 - Effect of dietary Na level on excreta humidity during the period from 1 to 7 days of age.

meq/kg	Excreta humidity (%) Na (%)			
	0.10	0.22	0.34	0.46
100	67.4	73.3	70.7	70.1
150	67.8	68.6	71.9	71.5
200	67.7	65.8	69.7	71.0
250	69.5	70.2	69.0	70.6
300	71.1	70.6	70.6	70.6

From 8 to 21 days of age, all broilers were fed the same basal diet to verify if the effects observed during the pre-starter period (1 to 7 days of age) were maintained. For Na levels, the results found from 1 to 7 days of age maintained the same trend at 21 days of

Table 7 - Means and regression equations for feed intake (FI), weight gain (WG) and feed conversion (FC) during the period from 1 to 21 days of age.

meq/kg	FI (g) Na (%)				WG (g) Na (%)				FC (g/g) Na (%)			
	0.10	0.22	0.34	0.46	0.10	0.22	0.34	0.46	0.10	0.22	0.34	0.46
100	1,075	1,113	1,235	1,247	836	999	1,024	1,040	1.295	1.134	1.209	1.200
150	1,032	1,139	1,191	1,247	819	975	1,039	981	1.263	1.168	1.146	1.275
200	1,119	1,104	1,219	1,150	879	962	1,025	963	1.278	1.147	1.190	1.194
250	1,173	1,138	1,136	1,229	853	995	969	1,024	1.331	1.143	1.173	1.200
300	1,103	1,125	1,134	1,162	812	899	950	1,033	1.361	1.257	1.193	1.129

$Y_{(WG)}$ = 708.520 + 1611.14 x Na (-2071.18) x Na^2. R^2 = 0.92Point of maximum response (2^{nd} derivate): 0.39% Na. $Y_{(FC)}$ = 1.48286 + (-1.73403) x Na + 2.64387 x Na^2. R^2 = 0.86Point of maximum response (2^{nd} derivate): 0.33% Na from the same individual and by different routes. Blood samples were.

age. This shows the importance of the correct nutrient balance in poultry diets during the first week of life, particularly for broilers, as this period represent a large proportion of their lifespan. For the period of 1 to 21 days of age, a quadratic effect of Na levels on WG and FC was observed, as shown in Table 7.

CONCLUSIONS

The results indicate that approximate values of 0.40% total Na in pre-starter feeds (1 to 7 days of age) increase FI, WC, WG, and improve FC.

Na+K-Cl balance influence broiler performance. However, further studies on this balance and its correlation with the absorption of some nutrients are needed.

Until 7 days of age, neither Na level nor electrolyte balance influence excreta humidity.

The results obtained at the first week of life tend to continue for the next 14 days of age.

REFERENCES

Austic RE. Development and adaptation of protein digestion. Journal of Nutrition 1985; 115:686-697.

Britton WM. Effect of dietary salt intake on water and feed consumption. In: Nutrition Conference for Feed Industry; 1992; Atlanta, Georgia. United States of America. p. 48-53.

Larbier M, Leclercq B. Nutrition and Feeding of poultry. Loughborough (UK): University of Nottingham; 1992. 305 p.

Mongin P, Sauveur B. Interrelationships between mineral nutrition, acid-base balance, growth and cartilage abnormalities. Proceedings Poultry Science; 1977; Edinburg, Scotland. p.235-247.

Moran ET. Digestion and absorption of carbohydrates in fowl and events through perinatal development. Journal of Nutrition 1985; 115:665-674.

Murakami AE, Watkins SE, Saleh EA, England JA, Waldroup PW. Estimation of the sodium and chloride requirements for the young broiler chick. Journal of Applied Poultry Research 1997; 6:155-162.

National Research Council. Nutrient requirements of poultry. 8 ed. Washington (DC): National Academy Press; 1984. 71p.

National Research Council. Nutrient requirements of poultry. 9 ed. Washington (DC): National Academy Press; 1994. 155 p.

Penz Jr AM, Vieira SL. Nutrição de frangos de corte na primeira semana de idade. In: Jornada Internacional de Avicultura de Carne; 1997; Madri. Espanha. p. 12-19.

Sklan D, Noy Y. Hydrolysis and absorption in the small intestines of posthatch chicks. Poultry Science 2000; 79:1306-1310.