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Effect of Feeding Periods and Sodium Levels of Pre-starter Diet on Broiler Performance and Serum Electrolytes

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Abstract: The effect of feeding pre-starter diet during three periods (4, 7 and 10 days) with different sodium levels (0.15, 0.30 and 0.45%) on performance, carcass characteristics and serum electrolytes levels, in a completely randomized design and 42 days of study, 240 Ross (308) male broiler chickens were evaluated in a factorial arrangements of 3*3. By increasing sodium levels, dietary electrolyte balance increased (200, 250 and 300 mEq kg^{-1}). Treatments were compared with a control diet (starter diet with 0.20% sodium). Chickens were fed with starter diet to 21 days of age after feeding pre-starter diet. The results indicated that feeding pre-starter diet during 7 and 10 days increased feed intake and decreased feed conversion ratio at 42 days of age when compared with that of starter diet (control diet) ($p<0.05$). Feeding pre-starter diet during 7 and 10 days increased feed intake in starter period and weight gain in first 4 weeks of study ($p<0.05$). Feeding pre-starter diet with 0.30% sodium and 250 mEq kg^{-1} dietary electrolyte balance increased feed intake in first 2 weeks and weight gain in starter period ($p<0.05$). Feeding per-starter diet with 0.30% sodium and 250 mEq kg^{-1} dietary electrolyte balance during 10 days showed the lowest feed conversion ratio in second and fourth weeks of study ($p<0.05$). There was no significant difference among the treatments for mortality, serum electrolytes levels and carcass characteristics at the end of experiment. The results of the present study indicated that feeding pre-starter diet with 0.30% sodium and 250 mEq kg^{-1} dietary electrolyte balances for 7 days have positive effects on performance especially in first weeks of life.

Key words: Broilers, pre-starter diet, sodium, dietary electrolyte balance

INTRODUCTION

In the last 10 years, interest in early nutrition research has increased due to the high correlation between 7-d-old weight and final weight. Several investigations have shown that chicken weight in 6 and 7 weeks of age had the linear relationship with their weight in the first week of rearing (Pezeshkian, 2002). Broiler feeding in the first days of life is one of the priority factors that could affect on growth, feed efficiency, uniformity and finally economic benefits. 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, protein synthesis in tissues, maintain extra and intracellular homeostasis and electric potential of cell membrane (Nobakht, 2005). Electrolyte balance defines as Na+k-Cl (Mongin, 1980). Therefore, electrolytes concentration indirectly affect on feed intake and growth of chickens in first days of life. Electrolyte imbalance result in some metabolic disorders like tibial dyschondroplasia and respiratory alkalosis in laying hens (Leeson and Summers, 2001). Many studies in broilers indicated that sodium supplementation in the first week of life stimulated feed intake and modified weight gain and feed conversion ratio (Borges *et al*., 2002; Maiorka *et al*., 1998, 2004; Ribeiro *et al*., 2004). The purpose of this study, was to evaluate the effects of different levels of sodium and dietary electrolyte balance in pre-starter diets in 3 periods of 4, 7 and 10 days on performance, carcass characteristic and serum electrolytes levels.

MATERIALS AND METHODS

Total two hundred and forty, day-old Ross (308) male broilers chickens were used in this trial. In a completely randomized design, chickens were divided into 9 treatments of 3 replicates each according to a factorial arrangement of 3 periods of feeding pre-starter diet (4, 7

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Table 1: Composition of experimental diets

	Sodium level in pre-starter diets (%)				
Ingredients (%)	0.15	0.30	0.45	Starter[1]	Grower
Corn	57.49	57.22	57.10	60.43	64.21
Soybean meal	31.77	31.83	31.87	30.53	30.05
Fish meal	5.00	5.00	5.00	5.00	-
Soybean oil	2.40	2.40	2.40	1.17	2.40
Limestone	1.23	1.23	1.22	1.21	1.22
Dicalcium phosphate	0.97	0.97	0.97	0.91	1.28
DL-Methionine	0.26	0.26	0.26	0.06	0.01
L-Lysine	0.13	0.13	0.13	-	-
Salt	0.25	0.46	0.55	0.18	0.33
$NaHCO_3$	-	0.27	0.70	0.30	0.42
NH_4Cl	0.10	-	-	-	-
Vitam-min premix[2]	0.50	0.50	0.50	0.50	0.50
Composition					
AME (Kcal kg^{-1})	3000	3000	3000	3000	3085
Crud protein, %	22.50	22.50	22.50	21.60	18.75
Calcium, %	0.96	0.96	0.96	0.94	0.84
Available P, %	0.48	0.48	0.48	0.47	0.42
Chloride, %	0.28	0.34	0.39	0.18	0.23
Potassium, %	0.84	0.84	0.84	0.82	0.79
Sodium, %	0.15	0.30	0.45	0.20	0.26
Arginine, %	1.43	1.43	1.43	1.40	1.21
Methionine+Cystine, %	1.05	1.05	1.05	0.84	0.67
Lysine, %	1.39	1.39	1.39	1.25	1.00
Threonine, %	0.91	0.91	0.91	0.90	0.76
Tryptophan, %	0.28	0.28	0.28	0.28	0.24
Na + K – Cl (mEq kg^{-1})	200	250	300	250	250

[1]Control treatment; National Research Council (1994) to reach dietary electrolyte balance of 250 mEq kg^{-1}, [2] Provides per Kg of diet: vitamin A (11000 IU); vitamin D_3 (2250 IU); vitamin E (9 IU); vitamin K_3 (1.8 mg); vitamin B_{12} (0.02 mg); thiamin (1.1mg); riboflavin (9 mg); pyridoxine (1.8 mg); biotin (0.1 mg); cholin (680 mg); pantothenic acid (9 mg); niacin (35 mg); folic acid (1 mg); selenium (0.18 mg); iodine (1.2 mg); iron (70 mg); copper (10 mg); zinc (60 mg); manganese (70 mg)

and 10 days) and 3 dietary sodium levels (0.15; 0.30 and 0.45%), in the pre-starter diets. By increasing sodium levels, dietary electrolyte balance increased (200, 250 and 300 mEq kg^{-1}). The experiment was conducted in batteries with 8 birds per cage and a total of 27 experimental units. In addition to these treatments, there was a control diet (starter diet with 0.20% sodium) to reach to a 200 mEq kg^{-1} diet. The calculated dietary electrolyte balance "Mongin Number" was obtained by addition of the NaCl, $NaHCo_3$ and NH_4Cl into the feed. Crude proteins of corn and soybean meal samples were determined by kjeldahl method and their sodium and potassium were determined by flame spectrophotometry (AOAC, 1990). Pre-starter diets compositions were similar, except for the sodium and chloride (Table 1). Starter (control diet) and grower diet met or exceeded broiler nutrient requirements as recommended by the National Research Council (1994). Chickens were fed with starter diet to 21 days of age after feeding pre-starter diet. Grower diet was fed from 22-42 days of age. All diets were given *ad labium*. During the experiment, feed intake, body weight gain and feed conversion ratio (adjusted for mortality) were measured weekly. At 42 days of age, 2 chickens from each experimental unit were selected and their wing vein blood samples were collected. Serum electrolytes (sodium, potassium and chloride) levels were measured by flame spectrophotometry and routine biochemical methods (AOAC, 1990). At 42 days of age, one chicken from each experimental unit was also selected and carcass characteristics (carcass weight, breast weight, leg weights and abdominal fat pad) were measured. Data were analyzed based on the general linear models procedures of SAS (1998). Significant differences among treatment means were analyzed by Duncan multiple range test at $p<0.05$, unless otherwise stated (Steel and Torrie, 1982). Control diet (starter) compared with treatments using t-tests (SAS, 1998).

RESULTS AND DISCUSSION

In first, second and third weeks and from 1-21 days of study, chickens fed pre-starter diet for 7 and 10 days had more feed intake than those of chickens fed pre-starter diets for 4 days ($p<0.05$, Table 2). In first and second weeks of study, feed intake was greater for chickens fed pre-starter diet with 0.30% sodium and 250 mEq kg^{-1} dietary electrolyte balance than those of chickens in other treatments ($p<0.05$). No significant differences in intake were observed in next weeks. It seems feeding pre-starter diet in a period of 7 or 10 days improves body weight gain in first weeks of life, so the feed intake increases. The probable reason of improvement in chicken growth rate might be a better index of broiler requirements and feeding this diet for 4 days is not sufficient. Because the first 10 days of age are critical for broiler performance at slaughtering weight and the chicken undergoes several physiological developments. This result is in agreement with the result of Mongin (1981) who estimated 250 mEq kg^{-1} dietary electrolyte balances increases feed intake. Borges *et al.* (2002) indicated that sodium supplementation in the first week of life stimulated feed intake. This study showed that feed intake increases when sodium in pre-starter diet increased up to 0.30%. Borgest *et al.* (2002) observed the highest feed intake in chickens at 202 mEq kg^{-1}. Riberiro *et al.* (2004) got the similar results. Feed intake increased when sodium in pre-starter diet increased up to 0.36% and decreased with 0.48%. In the present study, feed intake decreased with 0.45% sodium into the diet. Borges *et al.* (2003) observed maximum feed intake with 0.35% sodium and 240 mEq kg^{-1} dietary electrolyte balance for starter diet. Results obtained by Barros *et al.* (1998), Johnson and Karunajeewa (1985), Murakami *et al.* (1997) and Oviedo-Rondon *et al.* (2001) are in agreement with the result of this study regarding feed intake.

Table 2: Effect of periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45 %) on feed intake at different ages

	Feed intake (g)			
Treatment/week	1	2	3	Starter period
4 days	111.01[b]	256.89[b]	514.40[b]	881.51[b]
7 days	121.58[a]	287.97[a]	536.56[ab]	946.11[a]
10 days	121.96[a]	294.98[a]	550.73[a]	970.38[a]
± SEM	3.22	7.06	10.18	14.85
Sodium level in diet (%)				
0.15[1]	113.76[b]	268.37[b]	527.19	908.59
0.30[2]	124.70[a]	292.08[a]	541.07	957.85
0.45[3]	115.70[ab]	277.44[ab]	533.43	924.34
± SEM	3.22	7.06	10.18	14.85

[a, b] Means in each column with different superscripts are significantly different ($p<0.05$), [1]200 mEq kg^{-1} dietaryelectrolyte balance. [2]250 mEq kg^{-1} dietary electrolyte balance, [3]300 mEq kg^{-1} dietaryelectrolyte balance

Table 3: Effect of periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45 %) on weight gain at different ages

	Weight gain (g)				
Treatment/week	1	2	3	4	Starter period
4 days	74.34[b]	185.85[b]	273.11[b]	359.22[b]	533.30[b]
7 days	87.81[a]	192.05[ab]	294.81[a]	373.57[ab]	575.23[a]
10 days	89.55[a]	201.68[a]	303.15[a]	390.20[a]	594.38[a]
± SEM	2.92	4.28	6.49	8.58	11.65
Sodium level in diet (%)					
0.15[1]	82.54[ab]	194.51[ab]	293.59[ab]	371.02	570.38[ab]
0.30[2]	89.93[a]	203.76[a]	301.53[a]	384.23	595.22[a]
0.45[3]	79.24[b]	181.59[b]	275.95[b]	367.74	536.77[b]
± SEM	2.92	4.28	6.49	8.58	11.65

[a, b] Means in each column with different superscripts are significantly different ($p<0.05$), [1]200 mEq kg^{-1} dietary electrolyte balance, [2]250 mEq kg^{-1} dietary electrolyte balance, [3]300 mEq kg^{-1} dietary electrolyte balance

Table 4: Interactions among periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45) on weight gain at different ages

	Weight gain (g)					
Treatments/week	1	2	3	4	1-21 d	1-42 d
4 days, 0.15% sodium	73.34[b]	190.28[b]	277.15[ab]	331.25[d]	540.77[bc]	1739.31[b]
4 days, 0.30% sodium	77.7[b]	190.10[b]	285.66[ab]	356.37[bdc]	553.47[bc]	1799.29[ab]
4 days, 0.45% sodium	71.98[b]	177.16[b]	256.52[b]	390.05[abc]	505.66[c]	1784.90[ab]
7 days, 0.15% sodium	85.46[ab]	200[b]	290.82[ab]	380.4[abcd]	575.31[ab]	1895.98[a]
7 days, 0.30% sodium	94.69[a]	197.78[b]	314.63[a]	371.48[bcd]	607.10[ab]	1856.38[ab]
7 days, 0.45% sodium	83.30[ab]	181.03[b]	278.99[ab]	368.81[bcd]	543.32[bc]	1784.40[ab]
10 days, 0.15% sodium	88.82[ab]	195.07[b]	312.82[a]	401.39[ab]	596.71[ab]	1875.48[ab]
10 days, 0.30% sodium	97.40[a]	223.39[a]	304.31[a]	424.84[a]	625.10[a]	1912.86[a]
10 days, 0.45% sodium	82.4[ab]	186.58[b]	292.33[ab]	344.37[dc]	561.35[abc]	1777.19[ab]
± SEM	5.16	7.41	11.24	14.85	20.18	42.23

[a, b, c] Means in each column with different superscripts are significantly different ($p<0.05$)

From first to fourth weeks and in starter period, chickens received pre-starter diet for 4 days had lower weight gain than those of chickens fed pre-starter diet for 7 or 10 days ($p<0.05$, Table3). No significant differences in weight gain were observed later on. In first 3 weeks and starter period chickens fed diet with 0.30% sodium and 250 mEq g^{-1} dietary electrolyte balance had the highest weight gain and the lowest weight gain was for treatments with 0.45% sodium and 300 mEq kg^{-1} dietary electrolyte balance. Similar results have been reported by Mongin (1981) and Maiorka *et al.* (1998). The results of present work is not in accordance with those of Oviedo-Rondon *et al.* (2001) and Britton (1991, 1992) and recommended sodium levels (0.15 and 0.20%) by National Research Council (1994). Sodium levels and dietary electrolyte balances were suggested for starter period and were not for pre-starter diet and it might be the reason of this discordance. A significant interaction effect ($p<0.05$) between feeding pre-starter diet and sodium levels for four first weeks, starter (1-21 days) and total period of experiment (1-42 days) were observed (Table 4). From 1-42 days of study the highest weight gain was observed in chickens fed pre-starter diet with 0.30% sodium and 250 mEq kg^{-1} dietary electrolyte balance during 10 days. Borges *et al.* (2003) verified that 240 mEq kg^{-1} dietary electrolyte balance and 0.35% sodium in starter diet resulted the highest weight gain. These results were nearly similar the results of present experiment and results obtained by Jhonson and Karunajeewa (1985). Murakami *et al.* (1997) estimated the

Table 5: Interactions among periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45 %) on feed conversion ratio at different ages

	Feed conversion ratio				
Treatments/week	2	4	1-21 d	21-42 d	1-42 d
4 days, 0.15% sodium	1.29 [b]	2.39 [ab]	1.57	2.55	2.21
4 days, 0.30% sodium	1.46 [ab]	2.21 [abc]	1.68	2.43	2.07
4 days, 0.45% sodium	1.41 [ab]	2.12 [abc]	1.62	2.44	2.17
7 days, 0.15% sodium	1.39 [ab]	2.00 [bc]	1.63	2.33	2.07
7 days, 0.30% sodium	1.54 [ab]	2.26 [abc]	1.58	2.51	2.20
7 days, 0.45% sodium	1.63 [a]	2.14 [abc]	1.75	2.49	2.27
10 days, 0.15% sodium	1.52 [ab]	2.02 [abc]	1.60	2.39	2.13
10 days, 0.30% sodium	1.32 [b]	1.96 [c]	1.58	2.40	2.13
10 days, 0.45% sodium	1.65 [a]	2.41 [a]	1.72	2.50	2.19
± SEM	0.083	0.118	0.081	0.097	0.055

[a, b, c] Means in each column with different superscripts are significantly different ($p<0.05$)

Table 6: Effect of periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45 %) on serum electrolytes in broilers at 42 days of age

	Serum electrolytes (mmol L^{-1})		
Treatments	Sodium	Potassium	Chloride
4 days	153.71	4.08	108.67
7 days	152.89	4.19	110.00
10 days	158.29	4.33	108.29
± SEM	2.51	0.14	1.31
Sodium level in diet (%)			
0.15 [1]	156.86	4.33	108.22
0.30 [2]	153.78	4.25	110.67
0.45 [3]	154.00	4.03	108.00
± SEM	2.51	0.14	1.31

Means in each column with no superscripts are not significantly different ($p>0.05$), [1]200 mEq kg^{-1} dietary electrolyte balance, [2]250 mEq kg^{-1} dietary electrolyte balance, [3]300 mEq kg^{-1} dietary electrolyte balance

Table 7: Effect of periods of feeding pre-starter diet (4, 7 and 10 days) and sodium levels (0.15, 0.30 and 0.45 %) on relative carcass characteristics

Treatments	Carcass (%)	Abdominal fat (%)	Breast (%)	Thighs (%)
4 days	74.86	2.65	18.62	16.79
7 days	74.57	2.72	17.61	17.35
10 days	74.76	3.12	17.89	17.19
± SEM	0.415	0.175	0.493	0.281
Sodium level in diet (%)				
0.15 [1]	74.69	2.92	17.89	16.76
0.30 [2]	74.14	2.73	18.22	16.97
0.45 [3]	75.36	2.84	18.01	17.59
± SEM	0.415	0.175	0.493	0.281

Means in each column with no superscripts are not significantly different ($p>0.05$), [1]200 mEq kg^{-1} dietary electrolyte balance, [2]250 mEq kg^{-1} dietary electrolyte balance, [3]300 mEq kg^{-1} dietary electrolyte balance

Table 8: Overall t-test comparison of individual treatments with control diet from 1-42 days of age

Treatments	Weight gain (g)	Feed conversion ratio
Control treatment	1605.08	2.42
4 days, 0.15% sodium	1739.31	2.30
4 days, 0.30% sodium	1799.29	2.20
4 days, 0.45% sodium	1784.96 *	2.23 *
7 days, 0.15% sodium	1895.98 *	2.06 *
7 days, 0.30% sodium	1856.38 *	2.20 *
7 days, 0.45% sodium	1784.04 *	2.27
10 days, 0.15% sodium	1875.48 *	2.13 *
10 days, 0.30% sodium	1912.86 *	2.13 *
10 days, 0.45% sodium	1777.19 *	2.42 *

Means in each column with *superscript are significantly different from control treatment ($p<0.05$)

best body weight gain can be obtained by 0.25% of sodium. This sodium level was close to the levels obtained by this experiment and suggested by Oviedo-Rondon *et al.* (2001). Different periods of feeding pre-starter diet and different levels of sodium and dietary electrolyte balance had no significant effect on Feed Conversion Ratio (FCR) but interaction between these factors was significant in second and fourth weeks ($p<0.05$) (Table 5). At these periods, chickens fed pre-starter diet with 0.30% sodium during 10 days had the lowest FCR. Stringhini *et al.* (2003) observed no significant effect of different periods of feeding pre-starter diet on FCR. Results of this study are in agreement with those of Silva *et al.* (1994), Junqueira *et al.* (2003), Silva and Flemming (1990) and Ali and Latshawe (1994). Different periods of feeding pre-starter diet and different levels of sodium and dietary electrolyte balance had no significant effect on serum electrolytes level, carcass, breast, leg and abdominal fat percentage (Table 6 and 7). There were no significant interactions ($p<0.05$) among the studied factors on serum electrolytes level and carcass characteristics. Rezaei *et al.* (2003) showed that by increasing dietary electrolyte balance, serum potassium level significantly decreases ($p<0.05$). These results might be due to a time lag between feeding pre-starter diets for 4, 7 and 10 days and the time of blood sampling at 42 days of study. Therefore, if different dietary electrolyte balances changes the serum electrolytes levels, this effect might remain for a short period after feeding these diets. Body systems that have important roles in acid-base balance and homeostasis, act immediately and return serum electrolyte levels to the normal values. Broilers excrete excess of sodium by increasing water intake (Leeson and Summers, 2001). So this was rational that the effect of dietary electrolyte balance didn't show any significant effect at 42 days of age. Chickens fed pre-starter diet compared to those didn't fed it and were given starter diet (control diet) from 1-21 days of study by t-test procedure (Table 8). Feed

intake and carcass characteristics of experimental treatments did not show any significant differences with control diet. Under the conditions of this study it was concluded that body weight gain and FCR in chickens fed pre-starter diet during 7 and 10 days of life with 0.3% sodium improve and might be recommended to broiler producers.

REFERENCES

Ali, Z. and D. Latshaw, 1994. Decreasing the effect of high temperature on broiler chicks by increasing dietary energy. Poult. Sci., 73: 111-118.

Association of Official Analytical Chemists, 1990. Official Methods of Analysis. (15th Edn.), Arlington (VA): Willian Horwitz, pp: 1018.

Barros, J.M.S., P.C. Gomes, L.F.T. Albino and A.H. Nascimento, 1998. Sodium levels over performance parameters of broiler chickens from 1-21 days of age. In: Anais da Conferencia APINCO 98 de Ciencia e Tecnologia Avicolas. FACTA, Campinas, SP, Brazil, pp: 14.

Borges, S.A., A. Maiorka, A. Carlos de Laurentiz, A.V. Fischer da Silva, E. Santin and J. Ariki, 2002. Electrolytic balance in broiler chicks during the first week of age. Brazilian J. Poult. Sci., 4: 149-153.

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

Britton, W.M., 1991. NaCl for broiler chick growth. Poult. Sci., 70: 1-18.

Britton, W.M., 1992. Dietary sodium and chloride for maximum broiler growth. Zootec. Int., 1: 52-57.

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.

Junqueira, O.M., L.E.C. Fonseca, L.F. Araujo, K.F. Duarte, Cs da S. Arauja and E.A.P. Rodrigues, 2003. Feed restriction on performance and blood parameters of broilers fed diets with different sodium levels. Brazilian J. Poult. Sci., 5: 47-56.

Leeson, S. and J.D. Summers, 2001. Scott's Nutrition of the Chicken. (4th Edn.), Guelph, Ontario: Chemistry of books.

Maiorka, A., N. Magro, H.A. Bartels and A.M. Penz, 1998. Effect of sodium level and different relations between sodium, potassium and chloride in pre-initial diets on broiler chicken performance. In: reniao annual da sociedade brasileira de zootecnia. Botucatu. Brazil, pp: 478-480.

Maiorka, A., N. Magro, H.A. Bartels, A.M. Kessler and A.M. Penz, 2004. Different sodium levels and electrolyte balances in pre-starter diets for broilers. Brazilian J. Poult. Sci., 6: 143-146.

Mongin, P., 1980. Electrolytes in nutrition. 3rd Int. Minerals Conf. Orlando, Florida, pp: 1-16.

Mongin, P., 1981. Recent advances in dietary cation-anion balance: Applications in poultry. Proc. Nutr. Soc., 40: 258-294.

Murakami, A.E., S.E. Saleh, J.A. England and P.W. Waldroup, 1997. Estimation of the sodium and chloride requirements for the young broiler chick. J. Applied Poult. Res., 6:155-162.

National Research Council, 1994. Nutrient Requirements of Poultry. (9th Rev. Edn.), National Academy Press, Washington, DC.

Nobakht, A., 2005. Electrolyte balance in broiler chick diet. Domestic and Poult. Sci., 18: 25-27.

Oviedo-Rondon, E.O., A.E. Murakami, A.C. 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.

Pezeshkian, S., 2002. Utilization of standard pre-starter feed formulation flour corn, calcium propionate in primary nutrition of chicken. Jahan Poult., 9: 13-15.

Rezaei, M., H. Nassiri Moghaddam, J. Pour Reza and H.A. Classen, 2003. Effect of different levels of crude protein and dietary electrolyte balance on performance and body composition of broiler chicks. Agric. Sci. Indus., 18: 69-78.

Ribeiro, A.M.L., E.L. Krabbe, A.M. Penz, S.V. Renz and H.V. Gomes, 2004. Effect of chick weight, geometric mean diameter and sodium level in pre-starter diets (1-7 days) on broiler perfomance up to 21 days of age. Brazilian J. Poult. Sci., 6: 225-230.

SAS Institute, 1998. SAS® User's Guide: Statistics. Version (6.12 Edn.), SAS Institute Inc., Cary, NC.

Silva, A.V.F. and J.S. Flemming, 1990. Interferencia da temperature no equilibrio acid-base em frangos de corte e sua resposta frente a suplementacao com bicarbonate de sodio, cloreto de ammonia e stacidem. Revista do Setor de Ciencias Agrarias, 11: 23-30.

Silva, A.V.F., J.S. Flemming and S.G. Franco, 1994. Utilizaco de diferentes sais na prevencao do estresse calorico de frangos criados em clima quente. Revista do Setor de Ciencias Agrarias 13: 287-292.

Steel, R.G.D. and J.H. Torrie, 1982. Principles and procedures of statistics Mc Grow-Hill, New York.

Stringhini, J.H., A. Resende, M.B. Cafe, N.M. Leandro and M.A. Andrade, 2003. Effect of one-day chicks weight and pre-starter diets on broiler performance. R. Bras. Zootec., 32: 234-242.