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Performance of Broilers Fed Diets With Different Dietary Electrolyte Balance Under Summer Conditions

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■ Keywords

Broiler performance, chloride, electrolytes, potassium, sodium.

ABSTRACT

The aim of this study was to compare performance and carcass characteristics of broilers fed diets with different Dietary Electrolyte balances (DEB) during the summer season. A total of 1,280 one-day-old Ross sexed chicks were distributed in 32 experimental units according to a randomized block design in a 4x2 factorial arrangement (4 levels and 2 sexes) and 4 replicates per treatment (40 birds per replicate). Feed program consisted of 3 phases (1-21, 22-42, 43-49 days of age). Experimental diets were formulated based on corn and soybean meal and adjusted to 210, 250, 290 and 330 mEq/kg of Na + K - Cl through the addition of sodium carbonate, potassium carbonate and ammonium chloride. Weekly measurements of body weight gain and feed intake were done, and at 49 days, birds were slaughtered to evaluate the dressing percentage and parts yield. Weight gain during the starter phase increased linearly ($p<0.01$) as DEB increased. Different DEB levels did not affect feed intake or mortality. Carcass characteristics were not affected by treatments. Dietary electrolytic balance influenced weight gain and feed gain ratio from 1 to 21 days, and best results were observed when diets contained 290 and 330 mEq/kg.

INTRODUCTION

In the last decades, broiler chicken production has experienced a great development. Nevertheless, poultry has also incorporated higher sensibility to stress factors along with this development. Among such factors, heat stress is one of the most important. It is responsible for considerable economic losses such as reduction in body weight gain and high mortality rates, which occur mainly during the summer when environmental temperatures are higher than the comfort temperature for birds.

Several management procedures are performed as an attempt to minimize the deleterious effects of heat stress. Thus, the addition of salts in the feed or drink water can beneficially affect the acid-base equilibrium of animals.

The effect of acid-base balance on the different metabolic processes of animals is currently an issue discussed by researchers worldwide. The concept of Dietary Electrolyte Balance (DEB) has also been applied for different species.

Dietary Electrolyte Balance, according to Mongin (1981), refers to the difference between positive and negative ions present in the diet ($Na^+ + K^+ - Cl^-$) and it is commonly expressed as mEq/kg of dry matter (DM). Besides the minimum required level of each element, proportions among them must be considered and maintained. The established value that expresses the quantity and relation among them is called Mongin Number (MN) (Silva *et al.*, 1993):

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MN = mEq Na^+ + mEq K^+ - mEq Cl^-

This balance is related to the analysis of several factors and specific aspects such as the absorption, storage, utilization and excretion of minerals involved in animal nutrition.

Only a few specific studies in the literature assessed the influence of DEB on the performance and carcass yield of poultry, a fact that makes it difficult to put into practice the ideal balance concept for commercial diets. A previous study reported that values between 200 and 300 mEq/kg are the optimum DEB for maximum growth in poultry (Mongin & Sauveur, 1977). On the other hand, extreme values of DEB close to 0 and 600 mEq/kg resulted in growth depression. Data published by Johnson & Karunajeewa (1985) indicated that DEB levels between 250 and 300 mEq/kg are within the range for maximum growth of broilers.

The aim of this study was to assess different DEB effects on the live performance and carcass yield of broilers raised during the summer in the southeast of Brazil.

MATERIAL AND METHODS

The assay was carried out from 20/01 to 11/03/2000 at the Avian Experimental Laboratory (Animal Nutrition and Production Department) of Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo (USP).

A total of 1,280 one-day-old sexed Ross broiler chicks were randomly assigned to 32 floor pens, with 40 birds per pen (4.25 m^2). The 32 floor pens were grouped into four blocks of eight pens each. The eight treatments were assigned following a 4x2 factorial arrangement (4 DEB levels and 2 sexes) in a randomized block design. Internal compartments of the building were considered as blocks.

Standard broiler management practices were used. The maximum and minimum temperatures recorded inside the building were 30.6°C and 23.8°C, respectively.

Treatments consisted of different levels of DEB (210, 250, 290 and 330 mEq/kg DM). The levels were obtained by adding different proportions of salts (sodium carbonate, potassium carbonate and ammonium chloride), which were calculated using the following equation:

DEB = Na^+ + K^+ - Cl^- mEq/kg DM of diet

Diet formulation was performed according to the breed management guide. Experimental corn-soybean based diets were isocaloric and isoproteic, and DEB was adjusted in the different growing phases: starter (1-21 days), grower (22-42 days) and finisher (43-49 days). Diet composition is presented in Table 1 and sodium, chloride and potassium contents of each diet are presented in Table 2.

Table 1 - Composition of experimental diets.

Ingredients (%)	Phases		
	Starter	Grower	Finisher
Grounded corn	55.79	61.54	66.58
Soybean meal 46	34.00	29.00	23.70
DL- Methionine	0.22	0.19	—
L-Lysine	0.20	0.15	0.16
Soybean oil	2.80	3.00	3.29
Dicalcium phosphate	1.80	1.68	1.50
Limestone	1.08	1.20	1.12
Vitamin supplement[1]	5.00	5.00	3.00
Mineral supplement[1]	0.50	0.50	0.50
Copper sulphate[2]	0.10	0.10	0.07
Salt supplement[3]	3.00	3.00	3.00
Calculated analysis			
ME (kcal/kg)	3,080	3,150	3,220
CP (%)	21.00	19.00	17.00
Ca (%)	1.000	1.000	0.900
Total P (%)	0.673	0.636	0.589
Available P (%)	0.450	0.420	0.380

1 - Supplied per kilogram of diet - starter: vitamin A 120,000 IU, vitamin D3 40,000 IU, vitamin E 190 mg, menadione 32.5 mg, choline 4,000 mg, niacin 400 mg, pantothenic acid 125 mg, riboflavin 80 mg, thiamin 17.5 mg, folic acid 15 mg, biotin 2.5 mg, vitamin B12 200 mcg, virginiamycin 1,250 mg, growth promoter 437.5 mg, methionine 18,000 mg, antioxidant 300 mg, selenium 4.0 mg, iron 2,500 mg, copper 1,000 mg, manganese 10,000 mg, zinc 7.0 mg, iodine 0.13 mg; growing: vitamin A 100,000 IU, vitamin D3 30,000 IU, vitamin E 150 mg, menadione 25 mg, choline 4,000 mg, niacin 300 mg, pantothenic acid 90 mg, riboflavin 50 mg, pyridoxine 17.5 mg, thiamin 10 mg, folic acid 10 mg, biotin 2.0 mg, vitamin B12 150 mcg, virginiamycin 600 mg, growth promoter 200 mg, methionine 15,000 mg, antioxidant 300 mg, selenium 4.0 mg, iron 2,500 mg, copper 1,000 mg, manganese 10,000 mg, zinc 7.0 mg, iodine 0.13 mg; finishing: vitamin A 100,000 IU, vitamin D3 20,000 IU, vitamin E 130 mg, menadione 17 mg, choline 4,650 mg, niacin 325 mg, pantothenic acid 130 mg, riboflavin 65 mg, pyridoxine 15 mg, thiamin 8.0 mg, folic acid 0.7 mg, biotin 3.5 mg, vitamin B12,200 mcg, growth promoter 100 mg, methionine 13,000 mg, antioxidant 1,200 mg, selenium 3.5 mg, iron 2,500 mg, copper 1,000 mg, manganese 10,000 mg, zinc 7.0 mg, iodine 0.13 mg. 2 - Copper sulphate was included only in 210 mEq/kg diets. 3 - Salt supplement contains variable amounts of potassium carbonate, sodium carbonate, sodium chloride and ammonium chloride in order to obtain 210, 250, 290 and 330 mEq/kg.

At 49 days of age, all birds were weighed and killed following technical recommendations and 10% of the housed birds (four birds/replicate) were used to determine dressing percentage and parts yield.

Abdominal fat content was calculated according to Cabel *et al.* (1987), including the gizzard surrounding fat. Carcass yield, innards and retail cuts were assessed according to Souza *et al.* (1994).

Table 2 - Calculated contents of sodium, chloride and potassium in each DEB level of experimental diets.

Period (days)	Nutrients	Treatments (mEq/kg)			
		210	250	290	330
Starter	Sodium (%)	0.18	0.18	0.18	0.18
	Chloride (%)	0.39	0.32	0.27	0.22
	Potassium (%)	0.95	1.02	1.12	1.22
Grower	Sodium (%)	0.18	0.18	0.18	0.18
	Chloride (%)	0.39	0.32	0.27	0.22
	Potassium (%)	0.95	1.02	1.12	1.22
Finisher	Sodium (%)	0.18	0.18	0.18	0.18
	Chloride (%)	0.39	0.32	0.27	0.22
	Potassium (%)	0.95	1.02	1.12	1.22

Performance data were evaluated in the starter, grower and finisher phases and the analyzed characteristics were average body weight gain (BWG, g/d), average feed intake (FI, g/d), feed to gain ratio (F:G, g feed/g body weight gain) and mortality (%).

Performance, carcass composition, and mortality data were analyzed by ANOVA as described by Snedecor & Cochran (1967) using the SAS®* General Linear Model procedure.

RESULTS AND DISCUSSION

Body weight gain (BWG) increased linearly ($p<0.01$) with DEB from 1 to 21 days of age for both sexes (Table 3). The following linear equations were derived $y = 29.146938 + 0.019794x$ for females and $y = 33.081938 + 0.019794x$ for males ($R^2 = 0.83$). The best BWG was observed at 330 mEq/kg, although the rate of gain decreased with age. Such value is higher than the value considered as ideal (250 mEq/kg) by Mongin (1981), but is within the range of 250-350 mEq/kg suggested by Johnson & Karunajeewa (1985). Better performance was also seen in birds from 1 to 21 days old fed with diets containing DEB between 246 and 315 mEq/kg, levels that did not cause tibial dyschondroplasia or acid-base disturbance (Murakami *et al.*, 2000). Borges *et al.* (1999) reported growing rate depression in chicks between 1 and 7 days old as a result of high values of DEB in the diet (354-360 mEq/kg) by supplementing K^+ or Na^+. On the other hand, growing rate depression was not seen in the present study in the group fed the highest DEB level (330 mEq/kg) by addition of K^+ (1.21%). On the other experimental phases (22 to 42, 43 to 49 and 1 to 49 days of age), no differences were observed among treatments for BWG. Results for the period from 1 to 49 days differed from those observed by Borges *et al.* (1999), who reported better BWG by using diets with 240 mEq/kg, a level similar to the ideal DEB indicated by Mongin (1981).

Table 3 - Daily average weight gain (g/bird/day) for male and female broilers fed with different DEB levels in the starter, grower and finisher phases.

Treatment		Phase			Total
Sex	DEB	Starter	Grower	Finisher	
		Interactions			
M	210	37.05	75.14	72.90	58.50
	250	38.35	75.76	54.61	56.71
	290	38.85	76.17	69.50	59.23
	330	39.45	77.14	65.89	59.38
F	210	32.83	62.95	54.79	48.88
	250	34.58	63.58	46.18	48.67
	290	35.23	63.26	59.89	50.77
	330	35.32	63.06	53.93	49.90
		Main effects			
	210	34.94	69.05	63.84	53.69
	250	36.46	69.67	50.39	52.69
	290	37.04	69.71	64.70	55.00
	330	37.39	70.10	59.91	54.62
M		38.43	76.05	65.72	58.45
F		34.49	63.21	53.70	49.54
		Average			
Average		36.46	69.63	59.71	54.00
CV (%)		6.61	9.98	17.58	8.92
		Statistical probability			
DEB					
Linear		0.0001	NS	NS	0.0442
Quadratic		NS	NS	NS	NS
Deviation		NS	NS	0.0002	0.0202
Sex		0.0001	0.0001	0.0001	0.0001
Interactions		NS	NS	NS	NS

CV – coefficient of variation. NS – non significant.

As shown in Table 4, no significant ($p>0.05$) differences were observed among treatments for feed intake. However, Oviedo-Rondon *et al.* (2001) observed feed intake reduction in response to dietary increase of the Mongin number obtained by chloride addition.

Figure 1 shows the quadratic effect of DEB on the F:G ratio of females ($p<0.05$) in the starting phase, whereas a linear effect was seen for male birds. The estimated optimum F:G ratio is obtained using 266 mEq/kg. According to Hullan *et al.* (1987), FG is not

* SAS Institute Inc., Cary, NC 27511.

altered when DEB is within the range of 155-330 mEq/kg, but nevertheless Borges *et al.* (1999) observed the same quadratic effect of K^+ addition that resulted in DEB levels between 119 and 127 mEq/kg in pre-initial diets.

Table 4 - Daily average feed intake (g/day) for male and female broilers fed with different DEB levels in the starter, grower and finisher phases.

Treatment		Phase			
Sex	DEB	Starter	Grower	Finisher	Total
		Interactions			
M	210	51.48	141.64	176.93	108.04
	250	51.15	142.12	164.08	106.27
	290	51.89	145.84	173.14	109.48
	330	51.61	146.21	169.35	108.97
F	210	48.66	124.50	145.02	94.93
	250	47.76	125.35	143.99	94.76
	290	47.38	125.83	152.98	96.09
	330	47.69	126.13	149.66	95.88
		Main effects			
	210	50.07	133.07	160.97	101.48
	250	49.46	133.74	154.04	100.51
	290	46.64	135.84	163.06	102.78
	330	49.65	136.17	159.51	102.42
M		51.54	143.95	170.88	108.19
F		47.87	125.46	147.91	95.41
		Average			
Average		49.70	134.70	159.39	101.80
CV (%)		4.16	7.52	8.83	6.88
		Statistical probability			
DEB					
Linear		NS	NS	NS	NS
Quadratic		NS	NS	NS	NS
Deviation		NS	NS	0.0245	NS
Sex		0.0001	0.0001	0.0001	0.0001
Interactions		NS	NS	NS	NS

CV – coefficient of variation.NS – non significant.

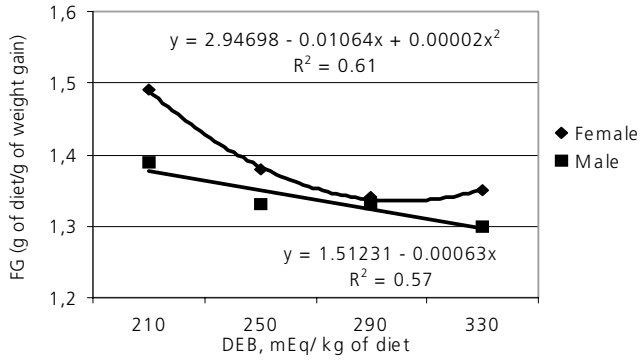

Figure 1 - Effect of different DEB on the feed:gain ratio of male and female broiler chickens from 1 to 21 days old.

The different Na + K - Cl ratios had no effects ($p>0.05$) on carcass yield, abdominal fat, heart, liver, gizzard, feet, blood and non-edible innards corroborating results reported by Borges *et al.* (1999). However, DEB levels in the diets affected some parts yields. A quadratic effect of DEB on wing ($p<0.05$) is observed in Figure 2 and the best average was obtained by using 210 mEq/kg. The estimated optimum wing yield was seen when levels of 291 and 278 mEq/kg of diet were used for females and males, respectively. Breast yield increased linearly as demonstrated in the equations y = 0.290070+ 0.000063x for females and y = 0.268945 + 0.000063x for males (R^2=0.71), and the best result was observed when 330 mEq/kg were used. A quadratic effect was observed on leg and thigh yield for males (Figure 3). The estimated optimum leg and thigh yield is achieved by using 286 mEq/kg of diet.

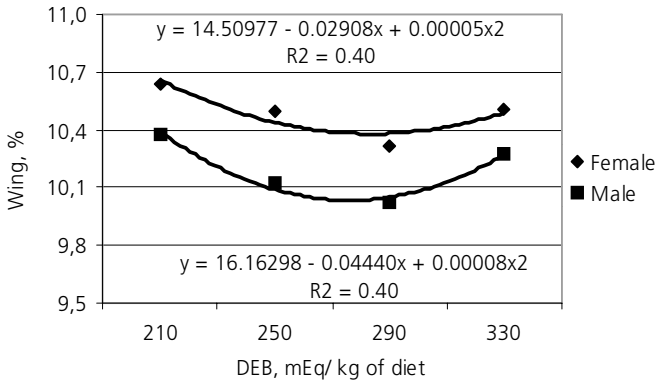

Figure 2 - Effect of different DEB on the wing yield of male and female broiler chickens.

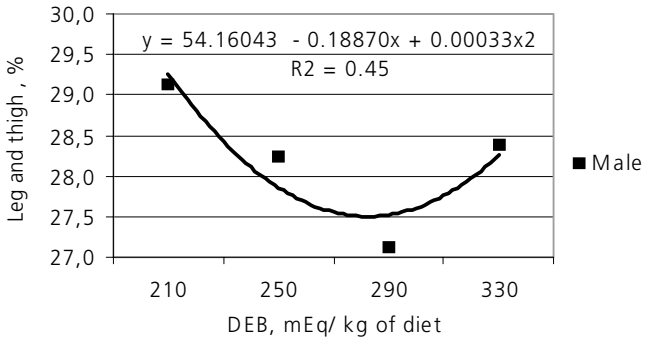

Figure 3 - Effect of different DEB on the leg and thigh yield of male broiler chickens.

Treatment and sex interaction ($p<0.05$) was observed for back and feather measurements, but there were no quadratic or linear associations ($p>0.05$) between treatments and the studied characteristics.

These results are in agreement to Borges *et al.* (1999) and Johnson & Karunajeewa (1985), who observed no effects of different DEB on the carcass yield and retail cuts.

The observed percentage of mortality during the entire period was considered low, with an average of 1.86% and no treatment effect ($p<0.01$) was observed in any of the evaluated phases, fact that is in accordance to Hullan *et al.* (1987) and Borges *et al.* (2000).

Table 5 - Feed:gain ratio for male and female broilers fed with different DEB levels in the starter, grower and finisher phases.

Treatment		Phase			
Sex	DEB	Starter	Grower	Finisher	Total
		Interactions			
M	210	1.39	1.88	2.43	1.85
	250	1.37	1.87	3.04	1.87
	290	1.33	1.91	2.52	1.85
	330	1.31	1.90	2.58	1.83
F	210	1.49	1.98	2.64	1.94
	250	1.38	1.97	3.24	1.95
	290	1.34	1.99	2.59	1.89
	330	1.35	2.00	2.78	1.92
		Main effects			
	210	1.44	1.93	2.54	1.89
	250	1.36	1.92	3.14	1.91
	290	1.34	1.95	2.56	1.87
	330	1.33	1.95	2.68	1.88
M		1.34	1.89	2.64	1.85
F		1.39	1.99	2.81	1.92
		Average			
Average		1.37	1.94	2.73	1.89
CV (%)		4.73	3.45	15.56	2.87
		Statistical probability			
DEB					
Linear		0.0001	NS	NS	NS
Quadratic		0.0278	NS	NS	NS
Deviation		NS	NS	0.0002	NS
Sex		0.002	0.0001	0.0001	0.0001
Interactions		NS	NS	NS	NS

CV – coefficient of variation.NS – non significant. 1 - Graduate student, CENA/ESALQ/USP. 2 - Professor at Faculdade de Medicina Veterinária e Zootecnia (FMVZ), Universidade de São Paulo. 3 - Animal Scientist, MSc Animal Nutrition. 4 - Graduate student, VRA/FMVZ/USP. 5 - Professor at Faculdade de Medicina Veterinária e Zootecnia (FMVZ), Universidade de São Paulo.

CONCLUSIONS

The observed results suggest that DEB for broilers under summer conditions affects bird performance in the starting phase (1-21 days of age) with the best results for BWG and FG obtained at 330 mEq/kg. However, the influence of DEB on performance and carcass yield parameters must be better examined because available data are divergent in the establishment of the ideal electrolytic balance.

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