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The Interaction between Dietary Electrolyte Balance and Microbial Phytase on Performance

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ABSTRACT

This experiment was carried out using 1200 Arian broiler chickens to evaluate the interaction effects of between different levels of dietary electrolyte balance and microbial phytase on performance. A 4×3 factorial arrangement of treatments was used with 4 levels of dietary electrolyte balance (200, 225, 250 and 275 mEq/kg of diet) and 3 levels of microbial phytase (0, 500 and 750 phytase units/kg of diets). Results showed that the main effect of the dietary electrolyte balance was significant ($P < 0.05$) for feed intake, feed conversion ratio and body weight in 42 d of age, whereas effect of the dietary electrolyte balance was not significant ($P > 0.05$) for other productive traits. Also, the main effect of phytase was significant ($P < 0.05$) for feed intake, weight gain, body weight, livability and production index. The dietary electrolyte balance and microbial phytase interaction was significant for all productive traits ($P < 0.05$). In this case, supplemental phytase improved the body weight, weight gains and production index at all dietary electrolyte balance levels. The overall results of the present study suggest that the microbial phytase is more likely to enhance the body weight and weight gain of broiler chickens in diets with low dietary electrolyte balance.

Key words: Dietary electrolyte balance, broiler, performance, microbial phytase.

INTRODUCTION

Sodium (Na^+), chlorine (Cl^-) and potassium (K^+) are minerals with important physiological functions. These monovalent minerals are essential for synthesis of tissue protein, maintenance of intracellular and extracellular homeostasis and electrical potential of cell membranes, enzymatic reactions, and osmotic pressure, and acid-base balance [1]. The birds have minimum requirements for the monovalent minerals Na, K, and Cl that provided by natural ingredients and electrolyte salts. Mongin and Sauveur [13] concluded that the dietary electrolyte balance (DEB) can be summarized by the equation $Na^+ + K^+ - Cl^-$, which value expresses the amount and the ratio among these ions. Optimum dietary electrolyte balance allows best live performance [13].

In the other hand, the inclusion of microbial phytase in poultry diets to enhance nutrient utilization and performance by counteracting the negative influence of targeted substrates has become commonplace within the last two decades [16]. Recently, Cowieson et al., [3] demonstrated that phytate and phytase alter secretion patterns of Na in the gastrointestinal tract of broiler chickens. In this pattern, phytate increase Na losses at the ileal level, whereas phytase reduced these losses. Similar pattern reported by Ravindran et al., [15].

Therefore, on the basis of these two recent studies, phytate and phytase influence the Na status of broiler chickens. It is possible, therefore, that phytate and phytase influence acid–base homeostasis and may also compromise Na-dependant co-transport mechanisms involved in the intestinal uptake of some nutrients in broilers [6, 5, 18]. It is therefore probable that added phytase modifies the effective dietary electrolyte balance of practical diets. Indeed, Na affects the dietary electrolyte balance level, and phytate induces the transfer of Na into the gut lumen implies that phytate is effectively influencing the dietary electrolyte balance of intestinal digesta. Consequently, it follows that phytate may compromise the efficiency of Na-dependent transport systems and the intestinal uptake of some nutrients by this depletion of Na, which is counteracted by phytase. Thus, it may be the possible interaction between dietary electrolyte balance and microbial phytase in broiler. The aim of the present study was to examine the effects of possible interaction between dietary electrolyte balance and microbial phytase on performance of broiler chickens.

MATERIALS AND METHODS

A total of 1200 one-day-old male Arian broiler chicks were selected and randomly allocated to 12 treatments, with each treatment having 4 replicates of 25 birds per replicate. Birds were maintained under continuous light. Temperature was maintained at 32°C for the first 5 d and then gradually reduced according to normal management practices until a temperature of 22°C was achieved at d 28. The treatment diets were offered for *ad libitum* consumption. Water was freely available throughout the trial period. The study was conducted as a completely randomized design with 4×3 factorial arrangement of treatments to evaluate the effects of 4 dietary electrolyte balance levels (200, 225, 250 and 275 mEq/kg of diet) on responses to 3 levels of microbial phytase (0, 500 and 750 phytase units (FUT)/kg of diet) [Phyzyme XP 5000 G, Finnfeed Company, USA] in corn-soybean meal based broiler diets. The composition of experimental diets is shown in Table 1.

The starter, grower and finisher diets were fed from 0 to 2 weeks, 2 to 4 weeks and 4 to 6 weeks of age, respectively. Feed ingredients and diets samples were analyzed for Na^+, K^+ and Cl^-. Analyses of the drinking water revealed very low quantities of sodium, potassium and chloride. Therefore, the intake of these elements via drinking water was not considered in the calculations. The different dietary electrolyte balance levels were manipulated by the use of ammonium chloride (NH_3Cl), sodium chloride (NaCl) and sodium bicarbonate ($NaHCO_3$).

Performance (live body weight, weight gain, feed intake and feed conversion ratio), percentage of livability and production index were assessed. Body weights and feed intake were recorded weekly. Mortality was recorded daily. The body weight gain was obtained by deduction of body weight of the previous week from the weight of the present week. Any bird that died was weighed and the weight was used to adjust the feed conversion ratio. Feed conversion ratios were calculated by dividing total feed intake by weight gain of live plus dead birds. Production index was measured by using the following formula:

$$\text{Production index} = \frac{\text{Final body weight}_{(g)} \times \text{livability}_{(\%)}}{\text{FCR} \times \text{length of period husbandry}_{(day)} \times 10}$$

Table 1. Ingredient composition and nutrient content of experimental diets[1]

	DEB level (mEq/kg of diet)											
	1-14 (Starter diet)				**15-28 (Grower diet)**				**29-42 (Finisher diet)**			
	200	225	250	275	200	225	250	275	200	225	250	275
Ingredient (%)												
Corn	53.5	53.5	53.5	53.5	57.5	57.5	57.5	57.5	63.7	63.7	63.7	63.7
Soybean meal	39.0	39.0	39.0	39.0	36.0	36.0	36.0	36.0	30.0	30.0	30.0	30.0
Fish meal	1.5	1.5	1.5	1.5	0.00	0.00	0.00	0.00	0.7	0.7	0.7	0.7
Dicalcium phosphate	1.7	1.7	1.7	1.7	1.63	1.63	1.63	1.63	1.6	1.6	1.6	1.6
Oyster shell	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.12	1.12	1.12	1.12
Soybean oil	1.7	1.7	1.7	1.7	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7
DL-Methionine	0.26	0.26	0.26	0.26	0.2	0.2	0.2	0.2	0.14	0.14	0.14	0.14
Sodium chloride	0.38	0.4	0.25	0.25	0.3	0.27	0.25	0.25	0.17	0.25	0.14	0.1
Sodium bicarbonate	0.00	0.00	0.05	0.27	0.16	0.00	0.21	0.42	0.21	0.25	0.4	0.24
Ammonium chloride	0.28	0.12	0.00	0.00	0.28	0.00	0.00	0.00	0.16	0.04	0.00	0.00
Vitamin premix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix[3]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Builder's sand	0.00	0.14	0.36	0.14	0.35	0.82	0.63	0.42	0.17	0.00	0.00	0.2
Total	100	100	100	100	100	100	100	100	100	100	100	100
Nutrient content												
AME, (kcal/kg)	2830	2830	2830	2830	2910	2910	2910	2910	2970	2970	2970	2970
Crude Protein (%)	22.0	22.0	22.0	22.0	20.0	20.0	20.0	20.0	19.0	19.0	19.0	19.0
Lysine (%)	1.15	1.15	1.15	1.15	1.01	1.01	1.01	1.01	0.89	0.89	0.89	0.89
Methionine (%)	0.48	0.48	0.48	0.48	0.44	0.44	0.44	0.44	0.39	0.39	0.39	0.39
Met + Cys (%)	0.94	0.94	0.94	0.94	0.85	0.85	0.85	0.85	0.77	0.77	0.77	0.77
Calcium (%)	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Available P (%)	0.5	0.5	0.5	0.5	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Sodium (%)	0.18	0.18	0.14	0.20	0.18	0.12	0.17	0.23	0.15	0.15	0.20	0.20
Potassium (%)	0.95	0.95	0.95	0.95	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.80
Chloride (%)	0.44	0.35	0.19	0.19	0.38	0.20	0.19	0.19	0.15	0.15	0.15	0.15

[1] *0, 500 and 750 phytase units of microbial phytase/kg of diet was applied to each level of dietary electrolyte balance.*
[2]*Vitamin supplements contributed per ton of complete feed: vitamin A, 2,300,000 IU; vitamin D3, 400,000 IU; vitamin E, 1,800 mg; menadione, 300 mg; thiamine, 150 mg; riboflavin, 1,400 mg; vitamin* B_{12}*, 3,500 mg; pantothenic acid, 2,000 mg; nicotinic acid, 7,000 mg; pyridoxine, 250 mg; folic acid, 150 mg; biotin,20 mg; choline, 125 g; monensin, 125 g; bacitracin-MD, 30 g; exthoxyquin, 20 g; DL-methionine, 275 g; and carrier, 1,000 g.*
[3]*mineral supplement provided per ton of complete feed: iron, 35,000 mg; copper, 50,000 mg; manganese, 35,000 mg; zinc, 30,000 mg; iodine, 600 mg; selenium, 90 mg; and diluent, 1,000 g.*

Two-way ANOVA was used to determine the main effects (dietary electrolyte balance and phytase) and their interaction by using the GLM procedure of SAS [15]. Comparison of means was made by Duncan's Multiple Range Test. The level of significance was $P < 0.05$.

RESULTS AND DISCUSSION

The data relating to effects of the dietary electrolyte balance and microbial phytase on performance (live body weight, feed intake, weight gain and feed conversion ratio), percentage of livability and production index are showed in Table 2.

Table 2. The effects of dietary electrolyte balance and phytase on the productive traits of broiler chickens

Item	Phytase (FUT/kg)	Body weight (g)	Feed intake (g/d)	Weight gain (g/bird/d)	Feed conversion ratio (g/g)	Livability %	Production index
DEB(mEq/kg of diet)							
200	0	2144.45^{c}	100.00^{a}	51.50^{f}	1.942^{ab}	97.50^{b}	264.41^{c}
200	500	2346.38^{a}	120.64^{ab}	61.99^{bc}	1.946^{ab}	98.00^{ab}	288.82^{bc}
200	750	2527.31^{a}	122.18^{a}	67.02^{a}	1.823^{b}	97.50^{b}	332.11^{a}
225	0	2251.78^{ab}	102.24^{c}	52.88^{e}	1.933^{ab}	97.33^{b}	276.66^{bc}
225	500	2260.53^{b}	111.58^{b}	58.56^{ed}	1.901^{ab}	98.00^{ab}	286.09^{bc}
225	750	2454.47^{a}	125.18^{a}	64.47^{ab}	1.942^{ab}	98.75^{a}	304.91^{b}
250	0	2244.05^{bc}	104.54^{bc}	55.25^{e}	1.892^{ab}	95.75^{c}	278.04^{bc}
250	500	2315.56^{a}	122.00^{a}	60.99^{cd}	2.000^{a}	98.50^{a}	280.21^{bc}
250	750	2400.44^{a}	126.53^{a}	64.33^{ab}	1.967^{a}	99.00^{a}	295.35^{b}
275	0	2185.19^{bc}	107.50^{bc}	55.86^{e}	1.925^{ab}	96.75^{bc}	267.96^{c}
275	500	2280.53^{bc}	104.45^{bc}	60.46^{cd}	1.728^{c}	97.00^{b}	313.16^{ab}
275	750	2414.59^{a}	123.27^{a}	64.58^{ab}	1.909^{ab}	98.00^{ab}	304.08^{b}
Pooled SEM		159.53	10.96	4.36	0.110	13.91	41.22
Main effect							
DEB(mEq/kg of diet)							
200		2363.74^{a}	116.06^{ab}	61.26	1.894^{ab}	98.50	299.69
225		2329.26^{ab}	113.00^{b}	59.62	1.895^{ab}	98.00	293.78
250		2322.51^{ab}	119.33^{a}	60.81	1.962^{a}	99.00	288.98
275		2293.44^{b}	111.74^{b}	60.30	1.854^{b}	97.76	295.88
Phytase (FUT/kg)							
0		2208.79^{c}	103.83^{c}	54.86^{c}	1.893	96.33^{b}	276.01^{b}
500		2300.75^{b}	114.67^{b}	60.50^{b}	1.895	99.00^{a}	294.68^{a}
750		2449.20^{a}	124.29^{a}	65.10^{a}	1.910	98.58^{a}	308.86^{a}
Probability, $P \leq$							
DEB		*	*	NS	*	NS	NS
Phytase		*	*	*	NS	*	*
DEB×phytase		*	*	*	*	*	*

a-e Mean in columns with different superscripts are significantly different (P < 0.05).

As presented in Table 2, the main effect of the dietary electrolyte balance was significant ($P < 0.05$) for feed intake, feed conversion ratio and body weight in 42 d of age, whereas effect of the dietary electrolyte balance was not significant ($P > 0.05$) for other productive traits. Increasing dietary electrolyte balance values from 200 to 275 mEq/kg decreased body weight in 42 d of age. The highest weight gain and live body weight was observed when diets contained 200 mEq/kg. This result indicate that 200 mEq/kg is the optimal level of dietary electrolyte balance for maximum weight gain and live body weight in 42 d of age on this experimental condition. Johnson and Karunajeewa [8] concluded that a diet with less than 180 mEq/kg or more than 300 mEq/kg decreased weight gain in birds assessed at 42 days. The best feed conversion ratio was observed when diets contained 275 mEq/kg.

The main effect of phytase was significant ($P < 0.05$) for feed intake, weight gain, body weight, livability and production index. In this case, feed intake, weight gain, body weight, livability and production index was increased by phytase addition to diets. The positive effects of phytase on performance in our study are consistent with previous studies reporting improvement in feed intake [2, 9, 10], body weight [2, 9, 10, 11], body weight gain [2, 4, 9]. The feed conversion ratio was unaffected ($P > 0.05$) by increasing phytase levels. It is that phytase may improve feed conversion ratio [8, 17] but this improvement is not always consistent in the literature. Phytase may have many nutritional benefits, but it is hard to attribute the improved performance to the improved availability of one nutrient. The interaction between dietary electrolyte balance and microbial phytase was significant (P < 0.05) for all productive traits, percentage of livability and production index.

Results indicate that phytase addition improved body weight, weight gain, percentage of livability and production index at all dietary electrolyte balance levels. The hypothesis of this study was that dietary electrolyte balance influences responses to phytase supplementation for performance, because phytate and phytase alter patterns of Na secretion into the gut lumen, which effectively influence the dietary electrolyte balance. At a dietary electrolyte balance of 200 mEq/kg and 500 FUT/kg microbial phytase improved body weight and weight gain by 8.6% (2346.38 vs. 2144.45) and 10.49% (61.99 vs. 51.50), respectively, but at a dietary electrolyte balance of 275 mEq/kg and 500 FUT/kg microbial phytase improved above traits by 4.2% (2280.53 vs. 2185.19) and 7.6% (60.46 vs. 55.86), respectively. Similar trends observed for the different dietary electrolyte balance levels and 750 FUT/kg phytase. This tendency for a dietary electrolyte balance × phytase interaction does suggest that phytase is likely to be more effective on the body weight and weight gain of broiler at a low dietary electrolyte balance.

In conclusion, results of the present study showed that the microbial phytase is more likely to enhance the body weight and weight gain of broiler chickens in diets with low dietary electrolyte balance.

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