STUDIES ON POTASSIUM-LYSINE INTERRELATIONSHIPS IN BROILER CHICKS 1. EFFECT OF POTASSIUM-LYSINE INTERRELATIONSHIPS ON GROWTH PERFORMANCE AND NUTRIENT UTILIZABILITY

H. Y. Shin, I. K. Han[1] and Y. J. Choi

College of Agriculture and Life Sciences
Seoul National University, Suweon 441-744, Korea

Summary

In order to study the effects of dietary potassium and lysine levels on growth performance and nutrient utilizability in broiler chicks, an experiment was conducted in 3 × 3 factorial arrangement with three levels of dietary potassium (0.3, 0.6 and 1.2%) and three supplemented levels of dietary lysine (0.6, 1.2 and 2.4%). A total number of 360 male broiler chicks was used for 6 weeks. Birds fed optimum lysine (1.2%) diets had the highest body weight gain and feed efficiency, followed by those fed low lysine (0.6%) and high lysine (2.4%) diets ($p < 0.01$). But levels of dietary potassium had no effects on the body weight gain and feed efficiency. Interaction between potassium and lysine was not shown ($p > 0.05$). High level of lysine resulted in higher mortality than that of optimum or low level of lysine ($p < 0.01$). The levels of supplemented lysine affected utilizability of ether extract, total carbohydrate, and nitrogen retention ($p < 0.01$). But supplemented potassium levels did not affect nutrient utilizability and interaction between potassium and lysine was not shown ($p > 0.05$).

(**Key Words :** Potassium, Lysine, Interrelationship, Broiler)

Introduction

The lysine-arginine antagonism has been the subject of much investigation. Anderson and Combs (1952) demonstrated a significantly lower weight gain of growing chicks fed a high lysine diet as compared to those fed a basal diet containing adequate levels of lysine. The depressed weight gain was shown to be due to a lysine-arginine antagonism. In this antagonism, excess lysine increases the requirement for arginine. Therefore, the detrimental effects of excess lysine can be overcome by increasing the dietary level of arginine (Austic et al., 1970; Austic and Scott, 1975; O'Dell and Savage, 1966). Some reports demonstrated that cation-anion balance in the diet affects lysine antagonism in the chicks. It is alleviated by sodium and potassium salts of metabolizable organic acids (O'Dell and Savage, 1966; Scott and Austic, 1978) and exacerbated by chloride (Calvert and Austic, 1981). The balance of these electrolytes affect the acid-base status of the chick (Riley and Austic, 1984). Scott and Austic (1978) reported that alkaline potassium salts increased the oxidation of lysine by chicks fed excess lysine and increased the activity of hepatic lysine-α-ketoglutarate reductase, the initial enzyme of lysine catabolism.

The present study was conducted to examine the effects of electrolyte, especially potassium, and lysine interrelationships on growth performance and nutrient utilizability in broiler chicks.

Materials and Methods

The experiment was conducted in 3 × 3 factorial arrangement of treatments with three levels of dietary lysine (0.6, 1.2 and 2.4%) and three levels of supplemented potassium (0.3, 0.6 and 1.2%). Each treatment in the experiment had 5 replicates with 8 birds in each replicate. At 3 days of age, experimental animals were chosen to have similar initial body weight and fed the experimental diets for 6 weeks. 360 male birds were used in present study.

The basal diet for growing broiler chicks (0-3 weeks) was a practical-type corn-soybean meal ration, which was fromulated to contain appro-

[1]Address reprint requests to Dr. I. K. Han, Department of Animal Science and Technology, College of Agriculture and Life Sciences, Seoul National University Suweon 441-744, Korea.

Received March 25, 1991
Accepted December 23, 1991

ximately 23% crude protein (N × 6.25) and 3200 kcal of metabolizable energy per kg of diet (table 1). The basal diets for finishing broiler chicks (4-6 weeks) was formulated to be 20% crude protein (N × 6.25) and 3200 kcal of metabolizable energy per kg of diet (table 1).

TABLE 1. FORMULA AND CHEMICAL COMPOSITION OF THE BASAL DIET FOR GROWING BROILER CHICKS (0 6 WEEKS)

Ingredients or chemical composition	Starter	Finisher
	Content (%)	
Ingredients:		
Corn, yellow	59.0	65.0
Soybean oil meal	8.0	10.0
Corn gluten meal	18.5	16.0
Feather meal	3.5	–
Wheat bran	1.5	–
Soybean oil	3.2	2.7
Limestone	1.0	1.0
Vit-min mixture[1]	0.3	0.3
Salt[2]	0.2	0.2
Antibiotics[3]	0.1	0.1
Tricalcium phosphate	1.7	1.7
Variable[4]	3.0	3.0
Total	100.0	100.0
Chemical composition[5]:		
Energy (ME, kcal/kg)	3200.00	3200.00
Crude protein (%)	23.14	20.52
Calcium (%)	1.98	1.76
Phosphorus (%)	0.88	0.86
Lysine (%)	0.60	0.60
Arginine (%)	1.10	1.00
Sodium (%)	0.25	0.23
Potassium (%)	0.42	0.45
Chloride (%)	0.23	0.22
E/B (mEq/kg)	153.21	153.12

[1] Vit-min. mixture contains followings in a kg: Vitamin A, 2,000,000 IU; Vitamin D_3, 400,000 IU; Vitamin E, 900 IU; Vitamin K, 200 mg; Thiamin, 100 mg; Riboflavin, 1,200 mg; Vitamin B_6, 200 mg; Vitamin B_{12}, 1,500 mg; Pantothenic acid, 1,500 mg; Niacin, 2,000 mg; Folacin, 60 mg; Choline, 3,000 mg; Iron, 4,000 mg; Copper, 500 mg; Zinc, 9,000 mg; Iodine, 250 mg; Cobalt, 100 mg; Dried yeast, 20,000 mg.

[2] Refined table salt.

[3] Zinc-bacitracin was used.

[4] Acid washed sand was used.

[5] Calculated value.

Mixtures containing various levels of lysine, potassium bicarbonate and sand replaced the variable parts of the basal diet to prepare practical-type experimental diet (table 2).

All the birds were raised in battery cages made of steel wire and housed in a room with 24 hours illumination and air ventilation. Experimental diets and tap water were provided *ad libitum* during the entire experimental period. Body weight and feed intake were checked weekly. Body weight gains were calculated by the differences between the initial body weight and final body weight. Feed efficiency was calculated by dividing the feed intake by the corresponding body weight gain. During feeding trial mortality was recorded per treatment group.

To investigate the nutrient utilizability of experimental diets, the metabolizability trial was conducted by total collection method during 7 days at the end of feeding trial. Four chicks per each treatment were selected for metabolism trial. All chicks employed for the metabolic trial were caged in metabolic cages individually and experimental diets and water were fed *ad libitum*. After four days of preliminary period for adaptation, total excreta were collected six times a day for three days to avoid the contamination of foreign materials such as feed, feathers and scales. Total excreta were pooled, and one-third of these was dried in an air-forced drying oven at 60℃ for 72 hours to gain constant dry weight. All the sample prepared in this way were ground with Wiley mill and analyzed for proximate composition and mineral content.

Proximate Analyses and minerals of experimental diets and excreta were conducted according to the methods of AOAC (1984).

Data for the present study were subjected to two-way analysis of variances and means were compared according Duncan's multiple range test (1955) using SAS (1985) program with IBM-PC (IBM, 16 bit AT).

Results and Discussion

The data of growth performance obtained in this experiment are summarized in table 3. The highest body weight gain was obtained at optimum lysine and 1.2% potassium supplemented group (OL 1.2) and the lowest at high lysine and 1.2

TABLE 2. FORMULA AND CHEMICAL COMPOSITION OF MIXTURES USED FOR VARIABLE PART IN EXPERIMENTAL DIETS

Treatment Items	LL-0.3	LL-0.6	LL-1.2	OL-0.3	OL-0.6	OL-1.2	HL-0.3	HL-0.6	HL-1.2
Ingredients (%):									
Lysine		—	—	0.6	0.6	0.6	1.8	1.8	1.8
$KHCO_3$	0.3	0.6	1.2	0.3	0.6	1.2	0.3	0.6	1.2
Sand[1]	2.7	2.4	1.8	2.1	1.8	1.2	0.9	0.6	—
Total	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Chemical composition[2] (%):									
Lysine	0.60	0.60	0.60	1.20	1.20	1.20	2.40	2.40	2.40
Potassium	0.54	0.66	0.90	0.54	0.66	0.90	0.54	0.66	0.90
Sodium	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Chloride	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
E/B (mEq/kg)	183.90	214.59	275.97	183.90	214.59	275.97	183.97	214.59	275.97

[1] Acid washed sand was used.
[2] Calculated percentage in feed.

TABLE 3. BODY WEIGHT GAIN, FEED INTAKE, FEED EFFICIENCY AND MORTALITY OF BROILER CHICKS (0-6 WEEKS)

Treatment	Initial body weight (g)	Final body weight (g)	Body weight gain[3] (g)	Feed intake (g)	Feed efficiency (feed/gain)	Mortality (%)
LL-0.3	46.1	1142.0	1095.9 ± 260^{B}[1]	2314.7 ± 266^{BC}	2.14 ± .34^{B}	5.0
LL-0.6	46.2	966.0	920.4 + 44^{B}	2048.5 ± 175^{C}	2.24 ± .13^{B}	5.0
LL-1.2	45.9	1006.9	961.0 ± 66^{B}	2252.5 ± 352^{C}	2.36 ± .48^{B}	8.14
OL-0.3	46.1	1521.3	1475.3 ± 42^{A}[1]	2817.7 ± 106^{AB}	1.92 ± .04^{B}	5.0
OL-0.6	45.9	1531.1	1485.2 + 63^{A}	2789.0 ± 112^{AB}	1.88 ± .04^{B}	0.0
OL-1.2	45.9	1562.8	1516.9 ± 69^{A}	2913.9 ± 128^{A}	1.94 ± .09^{B}	7.5
HL-0.3	46.0	712.5	666.5 ± 139^{C}	2040.5 ± 585^{C}	3.18 ± .57^{A}	35.0
HL-0.6	45.8	761.3	715.5 ± 300^{C}	1967.8 ± 364^{C}	3.06 ± .79^{B}	35.0
HL-1.2	45.8	674.2	628.3 ± 177^{C}	2029.0 ± 738^{C}	3.50 + 1.1^{A}	27.5
Among lysine levels						
LL	46.1	1038.3	992.4 ± 165^{B}	2205.3 + 280^{BC}	2.24 ± .33^{B}	6.0 ± 10.3^{B}
OL	46.0	1538.4	1492.5 ± 58^{A}	2840.2 ± 121^{A}	1.91 ± .06^{B}	4.2 ± 6.1^{B}
HL	45.9	716.0	670.1 ± 240^{C}	2012.5 ± 541^{B}	3.25 ± .80^{A}	32.5 ± 15.5^{A}
Among K ($KHCO_3$) supplemented levels						
0.3	46.1	1125.3	1079.2 ± 377^{NS}[2]	2391.0 ± 482^{NS}	2.41 ± .67^{NS}	15.0 ± 16.5^{NS}
0.6	46.0	1538.4	1040.4 ± 375^{NS}	2268.4 ± 443^{NS}	2.39 ± .67^{NS}	13.3 ± 17.3^{NS}
1.2	45.9	1071.3	1035.4 ± 394^{NS}	2398.5 ± 589^{NS}	2.60 ± .93^{NS}	14.4 ± 18.7^{NS}

[1] A,B,C: Mean values with different superscript within the same column are significantly different ($p < 0.01$).
[2] NS: Means non-significant
[3] Values are mean ± SD; n=5.

% potassium supplemented group (HL-1.2). Body weight gain of these two groups were 1516.9 and 628.3 g, respectively. Among lysine levels, body weight gain of optimum lysine level group was significantly highter than that of low or high lysine level groups ($p < 0.05$). The results of this experiment agree with previous studies (Edwards et al., 1956; Grau et al., 1946; Seaton et al., 1978). The poorer weight gains of high dietary lysine group (2.4%) may have been due to lysine-arginine antagonism. In this study, lysine × potassium interaction was not found, and increasing dietary potassium did not alleviate the lysine-arginine antagonism. Among potassium supplemented levels, the highest body weight gain was obtained at 0.3% potassium supplemented group but there is no significant difference ($p > 0.05$). Mongin and Sauveur (1977) estimated the influence of sodium, potassium and chloride on broiler growth. Adding various combinations of sodium and chloride produced a distinct shaped growth curve with optimal performance occuring in the 250 mEq net cations. Johnson and Karunajdewa (1985) also showed that the excellent growth in chicks fed diets containing between 250 and 300 mEq/kg. In present study, the best growth was obtained at 1.2% lysine and 275.97 mEq group (OL-1.2).

Throughout the experimental period, total feed consumptions are summarized in table 3. The data showed that the highest feed consumption was obtained at optimum lysine and 1.2% potassium supplemented group (OL-1.2) and the lowest feed consumption at high lysine and 0.6% potassium supplemented group (HL-0.6). Feed consumption of these two groups were 2913.9 and 1967.8 g, respectively. Among lysine levels, feed consumption of optimum lysine level group was superior to those of low and high lysine level group with significantly difference ($p < 0.05$). Chicks fed high level (2.4%) of dietary lysine had poorer feed consumption than that of low level (0.6%) of dietary lysine. Among the potassium levels, feed consumption was not affected by the potassium level. Lysine × potassium interaction was not found in feed consumption ($p > 0.05$).

Feed efficiency data for the overall experimental periods are shown in table 3. The best feed efficiency was obtained in optimum lysine and 0.6% potassium supplemented group (OL-0.6), eventhough the highest body weight gain was obtained in optimum lysine and 1.2% potassium supplemented group (OL-1.2) and the worst feed efficiency was shown in high lysine and 1.2% potassium supplemented group (HL-1.2). Feed efficiencies of these two treatment groups were 1.92 and 3.50, respectively. Among lysine levels, the best feed efficiency was obtained in optimum lysine level with significant difference ($p < 0.05$). But dietary potassium levels did not affect feed efficiency ($p > 0.05$). There was no interaction between lysine and potassium in feed efficiency.

Mortality data are shown in table 3. The highest mortality was observed at high lysine and 0.3%, 0.6% potassium supplemented groups (HL-0.3 and HL-0.6). Mortality of these two groups were 35.0%. Among lysine levels, mortality of high lysine treatment group was significantly higher than that of the other treatment groups ($p < 0.05$). The highest mortality of high lysine treatment group may due to lysine-arginine antagonism. But supplementation of potassium did not alleviate lysine-arginine antagonism.

The effects of lysine and potassium on the utilization of the dry matter, nitrogen, crude fat, total carbohydrate are summarized in table 4. In general, feed utilizability increased considerably ($p < 0.01$) in optimum level of lysine (1.2%). Dry matter availability was affected by level of dietary lysine ($p < 0.05$), but not by electrolyte balance. The highest dry matter availability was shown at optimum lysine and 1.2% potassium supplemented group (OL-1.2) and the lowest at high lysine and 0.3% potassium supplemented group (HL-03). Among the lysine levels, the highest retention of nitrogen and total carbohydrate utilizability were obtained at optimum lysine level ($p < 0.01$). Interaction between dietary lyine and electrolyte balance was not found to be significant in nitrogen and fat utilizability ($p > 0.05$). Crude fat utilizability was affected by level of dietary lysine ($p < 0.01$). The best utilizability of crude fat was obtained at optimum lysine and the worst at high lysine. In total carbohdrate utilization, the highest utilization was obtained at optimum lysine and the lowest obtained at high lysine group. The utilizabilities of these two groups were 86.45 and 76.54%, respectively. Among the lysine levels, total carbohydrate utilization was highly decreased ($p < 0.01$) in high lysine group (2.4%). The utilizability of all nutrients was not affected by dietary potassium levels ($p > 0.05$).

TABLE 4. EFFECTS OF LYSINE AND POTASSIUM LEVELS ON NUTRIENT UTILIZABILITY AND NITROGEN RETENTION OF BROILER CHICKS (%)

Treatment	Utilizability			Nitrogen retention
	Dry matter[4]	Ether extract	Total carbohydrate	
LL-0.3	75.63 ± 1.6^{NS}	78.25 ± 1.1^{C1}	78.64 ± 0.9^{C}	76.55 + 1.1^{B}
LL-0.6	76.52 ± 3.2^{NS}	81.32 ± 1.9^{B}	81.47 ± 0.8^{B}	77.02 ± 1.5^{B}
LL-1.2	76.42 ± 2.8^{NS}	80.22 ± 1.1^{BC}	80.65 ± 0.9^{B}	76.60 ± 1.2^{B}
OL-0.3	78.58 + 1.9^{NS3}	84.54 ± 1.3^{B}	84.91 ± 1.0^{A}	82.41 + 3.1^{AB}
OL-0.6	79.75 ± 0.8^{NS}	86.31 ± 1.6^{A}	86.45 ± 1.3^{A}	84.61 ± 1.4^{A}
OL-1.2	81.84 ± 1.4^{NS}	87.57 ± 0.9^{A}	84.54 ± 1.2^{B}	83.98 ± 0.9^{A}
HL-0.3	73.54 + 0.7^{NS}	80.39 ± 1.4^{B}	79.75 + 0.8^{B}	74.21 + 1.3^{C}
HL-0.6	74.94 ± 1.2^{NS}	79.87 ± 1.4^{C}	77.31 ± 0.4^{C}	75.67 ± 1.4^{B}
HL-1.2	74.71 ± 1.3^{NS}	78.28 ± 0.8^{C}	76.54 ± 0.7^{C}	75.28 ± 0.9^{BC}
Among lysine levels				
LL	76.19 ± 2.5^{ab2}	79.93 ± 1.4^{B}	80.25 ± 0.9^{B}	76.72 ± 1.3^{B}
OL	80.06 ± 1.4^{a}	86.14 ± 1.3^{A}	85.30 ± 1.2^{A}	83.67 ± 1.8^{A}
HL	74.40 + 1.1^{b}	79.51 + 1.2^{B}	77.87 ± 0.7^{C}	75.05 ± 1.2^{B}
Among K ($KHCO_3$) supplemented levels				
0.3	75.92 ± 1.4^{NS}	81.06 ± 1.3^{NS}	81.10 ± 1.0^{NS}	77.72 ± 1.8^{NS}
0.6	77.07 + 1.7^{NS}	82.60 ± 1.5^{NS}	81.74 + 1.0^{NS}	79.10 ± 1.4^{NS}
1.2	77.66 ± 1.8^{NS}	82.02 ± 1.0^{NS}	80.58 ± 1.1^{NS}	78.62 ± 1.0^{NS}

[1] A,B,C: Mean values with different superscript within the same column are significantly different ($p < .01$).
[2] a,b,c: Mean values with different superscript within the same column are significantly different ($p < .05$).
[3] NS: Means non-significant.
[4] Values are mean + SD; n=4.

In conclusion, it would be suggested that dietary potassium levels between 183.90 and 275.97 mEq/kg did not affect growth performance and nutrient utilizability. But dietary lysine levels between 0.6 and 2.4% influenced growth performance and nutrient availability. There was no interaction between potassium and lysine on growth performance and nutrient utilizability.

Literature Cited

A.O.A.C. 1984. Official method of analysis. 14th ed. Association of official analytical chemists. Washington, D.C.

Andersen, J. O. and G. F. Combs. 1952. Effect of single amino acid excesses on glucose metabolism and chick growth as influenced by the dietary amino aicd balance. J. Nutr. 46:161

Austic, R. E. and M. C. Nesheim. 1970. Role of kidney arginase in variations of the arginine requirements of chicks. J. Nutr. 100:855

Austic, R. E. and M. L. Scott. 1975. Involvement of food intake in the lysine-arginine antagonism of chicks. J. Nutr. 105:1122.

Calvert, C. C. and R. E. Austic. 1981. Lysine-chloride interactions in the growing chick. Poultry Sci. 60: 1468.

O'Dell, B. L. and J. E. Savage. 1966. Agrinine-lysine antagonism in the chick and its relationship to dietary cations. J. Nutr. 90:364

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11:1.

Edwards, H. M., Jr., L. C. Norris and G. F. Heuser. 1956. Studies on the lysine requirement of chicks. Poultry Sci. 35:385

Grau, C. R., F. H. Kratzer and V. S. Asmundson. 1946. The lysine requirements of poults and chicks. Poultry Sci. 25:529.

Johnson, R. J. and H. Karunajdewa, 1985. The effects of dietary minerals and electrolytes on the growth and physiology of the young chick. J. Nutr. 115: 1680.

Mongin, P. and B. Sauveur. 1977. Interrelationships between mineral nutrition, acid base balance, growth and cartilage abnormalities. Growth and Poultry Meat Production. pp. 257-259.

Riley, Jr. W. W. and R. E. Austic. 1984. Influence of dietary electrolyte on digestive tract pH and acid base status of chicks. Poultry Sci. 62:2247

SAS. 1985. SAS User's Guide: Statistics, SAS Inst. Inc. Cary, NC.

Scott, M. L. and R. E. Austic. 1978. Influence of dietary potassium on lysine metabolism in the chick. J. Nutr. 108:137.

Seaton, K. W., O. P. Thomas, R. M. Gous and E. H. Bossard. 1978. The effect of diet on liver glycogen and body composition in the chick. Poultry Sci. 57:692