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Arginine Needs of the Chick and Growing Broiler[1,2]

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Abstract: Two studies were conducted to evaluate Arg responses in broilers. The first study evaluated the Arg need of the female broiler for the period between 21 and 35 days of age. A control diet resembling industry guidelines contained (1.35% Arg). The test diet was formulated to contain 0.95% dietary Arg. Progressive increments of 0.10% Arg at the expense of a filler created the different experimental treatments. No significant trends were observed for the variables analyzed. All dose-response treatments did not differ from the control diet. Based on the lack of response from the first study, a second study was designed to focus on Arg responses at an earlier age (0-18 days). Progressive increments of 0.12% Arg at the expense of a filler created the different experimental treatments. Males optimized body weight gain at 1.15% dietary Arg, while feed conversion required more Arg for optimization (1.28%). Mortality was not influenced by dietary Arg. Data indicated that the chick has considerably acute need for dietary Arg at an earlier age possibly associated with immune system development and early microbial challenges.

Key words: Amino acids, arginine, live performance

Introduction

Due to the lack of a complete urea cycle, uricotelic species such as the commercial broiler are incapable of synthesizing Arg de novo (Cohen and Hayano, 1946; Tamir and Ratner, 1963). Therefore, it becomes of considerable importance to supply adequate amounts of dietary Arg for all bodily functions that require this amino acid. Different studies have been able to recognize the importance of Arg on growth (Allen and Baker, 1972; Burton and Waldroup, 1979; Cuca and Jensen, 1990; Kidd *et al*., 2001; Corzo *et al*., 2003), immunity (Collier and Vallance, 1989; Kidd *et al*., 2001), and wound healing (Efron and Barbul, 1998; Evoy *et al*., 1998).

Requirements for Arg have been determined in proportion to Lys after recognizing their relationship during absorption at the intestinal mucosa (Riley *et al*., 1989). An increase in the requirement for Arg has also been attributed to excess dietary lysine where an increase in kidney arginase activity has been shown to accentuate the degradation of Arg (Jones *et al*., 1967; Austic and Nesheim, 1970). Methionine has also been shown to interact with Arg demand through a common pathway that leads to biosynthesis of creatine (Keshavarz and Fuller, 1971). All previously described inter-relationships indicate that Lys, Arg and Met may need to be present at adequate levels if optimum growth is desired.

Under practical conditions Met and Lys are the first two limiting amino acids in corn-soybean meal diets, but fortunately there are feed-grade forms available for these two amino acids. Under most circumstances Arg will not be limiting due to its high presence in soybean meal, but it might become a concern when other proteinaceous feedstuffs start replacing soybean meal. For that purpose, a series of studies were designed to estimate the Arg need of the growing female broiler and male chick under practical conditions.

Materials and Methods

Experiment 1: Commercial Ross x Ross 508 female chickens were obtained from a local hatchery where they had been vaccinated for Marek's Disease virus, Newcastle Disease virus, and infectious bronchitis virus. Upon arrival to the Poultry Science Research Farm at Mississippi State University, chicks were randomly allocated in 48 floor pens of an open-sided house having thermostatically controlled heating and ventilation (12 birds per pen; 6 pens/trt; 0.09m^2/bird). Each pen had a nipple line with 3 nipples, and a tube feeder. Birds had free access to feed and water. The lighting regimen consisted of 23 hours of light and 1 hour of darkness. Birds were provided a common diet in mash form from days 0 to 21, formulated to meet nutritional requirements (NRC, 1994). The titration diet (Table 1) was formulated to contain 0.95% Arg, to which progressive increments of 0.1% Arg were added to the basal diet in the form of L-Arg at the expense of a filler generating 7 experimental treatments. All other essential amino acids were formulated to provide at least 100% of recommended

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Table 1: Composition of experimental diets

	Experiment 1		Experiment 2
	---------- (g/kg) ----------		
Ingredient	Titration diet	Control diet	Titration diet
Yellow corn	686.36	634.72	572.85
Soybean meal 48%	143.63	280.51	98.94
Corn gluten meal	100.00	-----	150.00
Wheat middlings	-----	-----	100.00
Dicalcium phosphate	18.89	18.24	17.91
Poultry oil	16.62	43.97	20.17
Limestone	11.36	10.76	14.62
Sodium bicarbonate	6.55	-----	6.46
Filler[1]	6.50	0.50	6.50
L-lysine Hcl	4.36	0.69	6.91
Vitamin/mineral premix[2]	2.50	2.50	2.50
Sodium chloride	1.26	4.61	0.45
L-Threonine	1.14	0.73	1.01
DL-Methionine	0.55	1.43	1.68
L-Isoleucine	0.22	-----	-----
L-Tryptophan	0.07	-----	-----
L-Arginine	-----	1.34	-----
Calculated composition			
ME (Kcal/kg)	3,150	3,150	3,100
Crude protein (%)	19.0	19.0	20.57
Lysine (%)	1.05	1.05	1.21
Total sulfur AA (%)	0.76	0.76	0.95
Arginine (%)	0.95	1.35	0.95

[1] Filler represent inert space (sand) in the diet to which L-arginine was added at its expense.

[2] The vitamin and mineral premix contained per kg of diet: retinyl acetate, 2,654 μg; cholecalciferol, 110 μg; dl-α-tocopherol acetate, 9.9 mg; menadione, 0.9 mg; B_{12}, 0.01 mg; folic acid, 0.6 μg; choline, 379 mg; d-pantothenic acid, 8.8 mg; riboflavin, 5.0 mg; niacin, 33 mg; thiamin, 1.0 mg; d-biotin, 0.1 mg; pyridoxine, 0.9 mg; ethoxiquin, 28 mg; manganese, 55 mg; zinc, 50 mg; iron, 28 mg; copper, 4 mg; iodine, 0.5 mg; selenium, 0.1 mg.

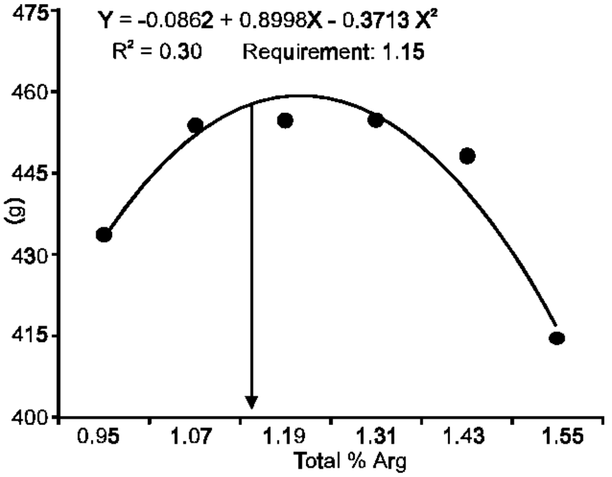

Fig. 1: Dietary arginine need for maximization (95% of upper asymptote) of body weight gain of broiler males from 0 to 18 days of age.

levels (NRC, 1994). The titration diet included a 10% inclusion of corn gluten meal to create a diet marginally deficient in Arg. A control diet with no corn gluten meal was formulated to contain 1.35% Arg (Table 1) and was used as a control. Experimental diets were fed to the birds from 21 to 35 days of age at the end of which body weight gain and feed consumption were determined. Mortality was weighed and recorded daily and used to adjust feed consumption and feed conversion.

Experiment 2: Commercial Ross x Ross 308 male broiler chicks were obtained from a local hatchery where they had the same vaccination program as birds from the first experiment. Upon arrival to the Poultry Science Research Farm at Mississippi State University, chicks were randomly allocated in 36 floor pens of an open-sided house having thermostatically controlled heating and ventilation (30 birds per pen; 6 pens/trt; $0.11 m^2$/bird). Each pen had a tube feeder and a nipple drinker (6 nipples/pen). Birds had free access to feed and water, and lighting regimen consisted of 23 hours of light per 1 of dark.

The titration diet (Table 1) was formulated to contain 0.95% Arg, to which progressive increments of 0.12% Arg were added to the diet at the expense of a filler generating 6 experimental treatments. Experimental

Table 2: Live performance of broiler females fed supplemented levels of arginine from 21 to 35 days of age

Dietary arginine %	BW gain (g)	Feed intake (g)	Feed:gain[1]
Control (1.35%)	756	1426	2.10
0.95	795	1564	1.99
1.05	775	1507	2.00
1.15	775	1568	2.06
1.25	760	1440	2.15
1.35	775	1472	1.93
1.45	765	1554	2.04
1.55	781	1447	2.17
SEM	22.6	75.6	0.101
Analysis of variance			
Probability			
Arg	0.42	0.21	0.90
Arg linear	0.34	0.18	0.34
Arg quadratic	0.83	0.87	0.76
Arg cubic	0.41	0.77	0.91

[1] Values corrected for body weight.

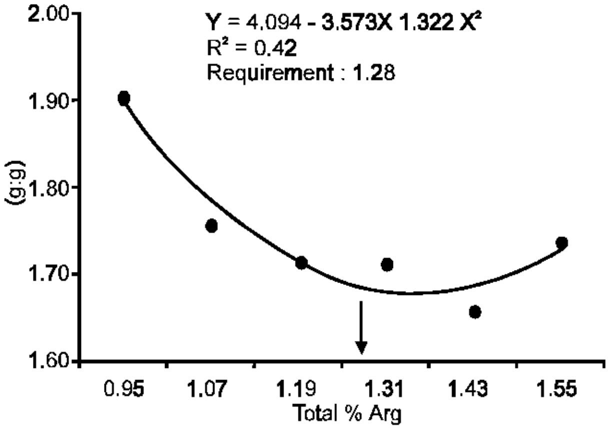

Fig. 2: Dietary arginine need for maximization (95% of lower asymptote) of feed conversion of broiler males from 0 to 18 days of age.

diets in mash form were fed to the birds from placement until 18 days of age. Weight gain and feed consumption were measured for the 1 to 18 d period. Mortality was weighed and recorded daily and used to adjust feed consumption and feed conversion.

Statistical analysis: In both studies pen was used as the experimental unit for analyses. Experiments were designed as completely randomized designs, and all data were analyzed using the General Linear Model procedure of SAS (SAS, 1996). Differences among means ($P<0.05$) were separated with repeated t test using the LSMEANS procedure of SAS. Quadratic responses were measured using the General Linear Model procedure of SAS, and when quadratic responses ($P< 0.05$) were detected, Arg optimization was calculated by extrapolating 95% of the asymptote.

Table 3: Live performance of broiler males fed supplemented levels of arginine from 0 to 18 days of age

Dietary arginine %	BW gain (g)	Feed:gain[1]	Livability (%)
0.95	433.4^{ab}	1.90^{a}	98.3
1.07	454.2^{a}	1.76^{b}	96.1
1.19	454.1^{a}	1.71^{bc}	98.9
1.31	454.1^{a}	1.71^{bc}	98.3
1.43	447.5^{a}	1.66^{c}	97.8
1.55	413.6^{b}	1.74^{bc}	97.8
SEM	9.74	0.037	1.16
Analysis of variance			
Probability			
Arg	0.032	0.002	-----
Arg linear	0.002	0.002	-----
Arg quadratic	0.002	0.003	-----

[1] Values corrected for body weight. $^{a-c}$Means within a column not sharing a common superscript differ ($P < 0.05$). Cubic responses were not significant ($P > 0.05$).

Results and Discussion

Female broilers during the first study did not respond to the Arg deficiency in the titration diet. Thus, all live performance variables displayed no treatment effect (Table 2). It is unlikely that this response occurred as a consequence of a demand for methyl donors for creatine synthesis as described by Keshavarz and Fuller (1971) and Chamruspollert *et al.* (2001). Methionine content of the diet was not limiting, nor was any other nutrient that could have aided in methyl-group donation for creatine synthesis. Hence, the Arg content of the diet was first limiting above any other. With the exception of Arg content in the titration diets, the control diet in experiment 1 had the same nutrient specifications, and because the basal and the control groups responded similarly it may suggest that Arg is not as crucial as it may be during earlier stages of growth. Association of available Arg with microbial challenges occurring at younger ages has been shown to have a more profound impact on performance and health of the bird (Ramirez *et al.*, 1997; Kidd *et al.*, 2001).

Due to lack of response observed, a follow-up study at a younger age (0-18 days) was designed to evaluate the dietary Arg need. Corn gluten meal did not depress feed intake nor weight gain during the first study, thus it was used again in the second study as a means of reducing the Arg content of the basal to a level that would be considered deficient (Burton and Waldroup, 1979; Cuca and Jensen, 1990; Labadan *et al.*, 2001). In terms of growth performance, chicks responded to Arg additions as illustrated in Table 3. Analyses of the data showed quadratic responses for both body weight gain and feed conversion. Body weight gain data suggested an Arg need of 1.15% (Fig. 1) and a feed conversion need of 1.28% (Fig. 2). Even though no cubic effect was noted, both equations displayed a cubic trend, and an explanation for it is elusive; such effect was previously observed by Corzo *et al.* (2003). Similar Arg recommendations were reported by Chamruspollert *et al.* (2001); Labadan *et al.* (2001), where a higher need of Arg for feed conversion than that for body weight was observed. During this study dietary Arg had no effect on livability.

Based on present experimentation, NRC (1994) recommendations of 1.25% Arg for the 0-18 day period seem to be sufficient to support maximum growth and feed conversion. It is unlikely that an Arg deficient diet would occur during this time phase when corn and soybean meal are the primary ingredients in a diet and moderate dietary CP levels are employed (above 21.5% CP). Explanation for a lack of Arg effect during the first study is elusive and warrants more research to address Arg needs subsequent to the first 3 weeks of age.

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