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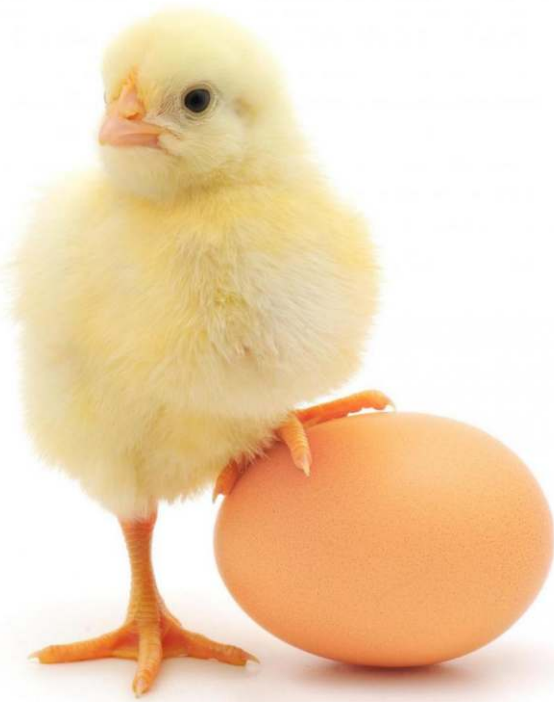

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Low Crude Protein Corn and Soybean Meal Diets with Amino Acid Supplementation for Broilers in the Starter Period 1. Effects of Feeding 15% Crude Protein

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Abstract: Two experiments were conducted with the objective of testing the effects of feeding a 15% CP diet with crystalline amino acid supplementation on the performance of broilers from 0-3 weeks of age. In both experiments, commercial broilers were fed a diet formulated to meet NRC requirements for the first seven days. The diet contained 23% CP and 3200 kcal/kg ME and also served as the Positive Control diet (PC). On day 7, birds were sorted by weight into battery pens with 5 birds per pen. Both experiments utilized the same six dietary treatments with eight replicates per treatment for a total of 48 pens. The remaining treatments consisted of: a 15% CP negative control diet with crystalline amino acids added back to meet required levels (NC), a NC diet + 0.1% cystine (NC + C), a NC diet + 0.1% threonine (NC + T), a NC diet + 0.1% glycine (NC + G) and a NC diet + 0.1% cystine, threonine and glycine (NC + C,T,G). Glutamic acid was added to all diets to maintain a 20% protein equivalent. All diets were formulated on a digestible basis and were designed to be isocaloric. At the conclusion of the experiments, Body Weight Gain (BWG), Feed Intake (FI) and Feed:Gain (F:G) were measured. In Experiment 1, significant differences ($p<0.05$) were found in BWG between the PC treatment and PC + C,T,G, although no significant differences in FI or F:G were observed. There were no significant differences ($p>0.05$) in BWG, FI, or F:G among any of the other treatments. In Experiment 2, treatments had no effect ($p>0.05$) on performance. Overall, these results suggest that feeding a 15% CP diet + crystalline amino acids to broilers in the starter period can yield similar performance to a 23% CP diet.

Key words: Low crude protein, broilers, amino acids, digestible feed formulation, performance

INTRODUCTION

Meeting the nutritional requirements for growing birds constitutes the majority of costs associated with poultry production (May *et al.*, 1998) and certainly is becoming an issue of even greater significance as the prices of feed ingredients continue to rise. A large portion of that cost involves meeting the amino acid requirements of the birds (Corzo *et al.,* 2004; Firman and Boling, 1998; Eits *et al.*, 2005; Firman, 1994). By reducing the level of crude protein in the diet it is possible to achieve significant cost savings. Firman (1994) reported that it is possible to save five dollars per ton of feed by reducing the protein level in the diet of turkeys by one percent. In addition to reducing feed costs, the ability to lower crude protein in the diet can result in decreased nitrogen excretion (Kidd *et al.*, 1996; Ferguson *et al.*, 1998; Nahm, 2002; Namroud *et al.*, 2008), improved ability to cope with heat stress and allow for the use of a greater variety of feedstuffs (Kidd *et al.*, 1996), which can be valuable in itself as a method to increase flexibility in the choice of locally available feedstuffs, potentially decreasing transportation costs.

As advances in feeding and formulation techniques have been made, it has become a relatively easy task in areas such as the United States that have access to a variety of quality feed ingredients to meet the nutritional requirements of poultry. Compared to many other industries, the poultry industry is considerably advanced in terms of understanding how to feed birds to meet maximum growth. Indeed, one needs only to feed all nutrients in excess to meet such growth, although this is a far from ideal method for a variety of reasons, including efficiency and expense. As a result, the current goal has shifted away from just feeding to reach certain growth standards to meeting maximum growth in the most cost efficient manner, or finding the least cost per unit of gain. Developing feeding programs that utilize concepts such as ideal protein, formulation programs that calculate the ingredient combinations that will closely meet the birds' nutritional requirements at the least possible cost (Pesti and Miller, 1992), digestible amino acid values and crystalline amino acid supplementation has allowed the poultry industry to reduce dietary crude protein to decrease excess amounts of amino acids and the cost of rations (Kidd *et al.*, 1996). However, the lowest level to which crude protein can be reduced with amino acid supplementation in broiler diets without reducing bird performance is still unknown and additional research on the subject could yield significantly greater cost savings in the future.

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It is known that there is no requirement for protein in the diet, *per se*, but actually a requirement for the amino acids found in protein (NRC, 1994). Because of this, it may be possible to supplement low CP diets with crystalline amino acids and achieve similar performance as with diets higher in CP. Research from the University of Missouri found that the amount of CP in turkey diets can be reduced from 28% to 10% with the addition of essential amino acids and achieve adequate performance (Moore *et al.*, 2001). Previous research with broilers indicated that it may be possible to feed broilers a 15% crude protein diets and obtain similar performance to birds consuming a standard diet (Brooks, 2003). However, the requirements of amino acids must be well defined for these diets to be successful. Feeding a broiler diet low enough in CP that individual amino acids can be titrated may lead to a better understanding of these requirements and to diets that more closely meet the birds' requirements. Additional research is needed in order to discover the minimum levels of amino acids necessary to achieve maximum growth and efficiency. The objective of these experiments was to determine if 15% crude protein rations with crystalline amino acid supplementation can support performance of broilers from 0-3 weeks of age.

MATERIALS AND METHODS

Bird husbandry: Day-old straight run broiler chicks were obtained from a commercial hatchery and fed a NRC-type corn and soybean meal diet until seven days of age. On day seven, birds were wing-banded and weighed. Birds were computer sorted by weight into battery pens with 5 birds per pen to obtain similar starting pen weights and bird weight distribution. Each trial utilized 240 birds to provide eight replications of six treatments. Chicks were provided access to experimental diets and water *ad libitum* for fourteen days and trials were terminated on day 21. Chicks were housed in stainless steel batteries with 24 hrs of fluorescent lighting. The room was thermostatically controlled with temperatures maintained near 90 degrees F for the first week post-hatch and a two degree reduction in temperature every four days thereafter. Birds were cared for using husbandry guidelines derived from University of Missouri standard operating procedures.

Dietary treatments: All diets were formulated on a digestible basis utilizing least-cost formulation software. The amino acid digestibility values used in these experiments for the corn and SBM were obtained previously by precision feeding a known sample of each ingredient to cecectomized roosters that had been removed from feed for 24 hrs to clear the gut. Excreta were collected for 48 hrs after precision feeding and were then dried in a forced air oven and ground. Samples were sent to the University of Missouri Agricultural Experiment Station Chemical Laboratory for a complete amino acid analysis and digestibility values were then determined.

Table 1: Amino acid levels[1] of 15% crude protein diets (Experiments 1 and 2)

Treatment	NC
Crude protein	15.000
Protein equivalent	20.000
Amino acid	
Lysine	1.278
Methionine	0.622
Cystine	0.248
Met + Cys	0.870
Threonine	0.782
Valine	1.052
Arginine	1.673
Leucine	1.984
Histidine	0.652
Isoleucine	1.005
Phenylalanine	1.594
Tyrosine	0.444
Phe + Tyr	2.042
Tryptophan	0.324
Glycine	0.748
Serine	0.358
Gly + Ser	1.106

[1]All values are expressed an a digestible basis

In each experiment, a 23% CP, 3200 kcal/kg ME NRC-type diet was utilized as the Positive Control (PC). For all other diets, a 15% crude protein ration was formulated and the levels of amino acids that were supplied by the corn and SBM were determined. The essential amino acid levels were then brought up to the total digestible levels found in a 15% CP diet from previous research conducted at the University of Missouri (Table 1). After careful examination of this diet, cystine, threonine and glycine were determined to be at levels slightly below NRC requirements, so four treatments were designed to account for these deficiencies. The remaining treatments consisted of: a 15% CP negative control diet with crystalline amino acids added back to meet the levels found in the previous trial (NC), a NC diet + 0.1% cystine (NC + C), a NC diet + 0.1% threonine (NC + T), a NC diet + 0.1% glycine (NC + G) and a NC diet + 0.1% cystine, threonine and glycine (NC + C,T,G). Glutamic acid was added to the diets in order to maintain a 20% protein equivalent and to prevent confounding of results due to a generalized nitrogen deficiency and all amino acids were added at the expense of sucrose as its energy content is comparable to that of crystalline amino acids. The compositions of dietary treatments in Experiments 1 and 2 are shown in Table 2.

Measurements: Dietary treatments were evaluated from 7-21 days of age by measuring feed intake, body weight gain and feed:gain. Feed:gain was adjusted for mortality by adding each mortality weight to the appropriate pen gain then dividing feed consumed by gain.

Table 2: Composition of experimental diets (Experiments 1 and 2)

Treatment	PC	NC	NC + C	NC + T	NC + G	NC + C,T,G
Corn	51.624	64.704	64.704	64.704	64.704	64.704
Soybean meal	39.822	21.104	21.104	21.104	21.104	21.104
Lard	4.648	2.431	2.431	2.431	2.431	2.431
Dicalcium phosphate	1.699	1.861	1.861	1.861	1.861	1.861
Limestone	1.174	1.198	1.198	1.198	1.198	1.198
Sodium bicarbonate	0.300	1.000	1.000	1.000	1.000	1.000
Salt	0.256	0.260	0.260	0.260	0.260	0.260
Sucrose[3]		1.752	1.752	1.752	1.752	1.752
Coban	0.075	0.075	0.075	0.075	0.075	0.075
Vitamin premix[1]	0.075	0.075	0.075	0.075	0.075	0.075
Choline chloride	0.050	0.050	0.050	0.050	0.050	0.050
Calcium trace mineral[2]	0.100	0.100	0.100	0.100	0.100	0.100
Selenium premix[2]	0.030	0.030	0.030	0.030	0.030	0.030
Copper sulfate	0.013	0.013	0.013	0.013	0.013	0.013
DL methionine	0.116	0.329	0.329	0.329	0.329	0.329
Arginine		0.674	0.674	0.674	0.674	0.674
Glycine		0.304	0.304	0.304	0.404	0.404
Histidine		0.221	0.221	0.221	0.221	0.221
Isoleucine		0.312	0.312	0.312	0.312	0.312
Leucine		0.491	0.491	0.491	0.491	0.491
Lysine		0.567	0.567	0.567	0.567	0.567
Phenylalanine		0.797	0.797	0.797	0.797	0.797
Threonine		0.198	0.198	0.298	0.198	0.298
Tryptophan		0.177	0.177	0.177	0.177	0.177
Valine		0.272	0.272	0.272	0.272	0.272
Cystine			0.100			0.100
Glutamic acid		0.906	0.806	0.806	0.806	0.608
Calculated to contain						
Crude protein, %[4]	23.000	15.000	15.000	15.000	15.000	15.000
Protein equivalent, %[5]	23.000	20.000	20.000	20.000	20.000	20.000
ME, kcal/kg	3200.000	3200.000	3200.000	3200.000	3200.000	3200.000
Calcium, %	1.000	1.000	1.000	1.000	1.000	1.000
Available phosphorus, %	0.450	0.450	0.450	0.450	0.450	0.450

[1]Vitamin premix provided the following amounts per kilogram of diet: vitamin D3, 200 IU; vitamin A, 1,500 IU; vitamin E, 101 IU; niacin, 35 mg; D-Pantothenic acid, 14 mg; riboflavin, 4.5 mg; pyridoxine, 3.5 mg; menadione, 2 mg; folic acid, 0.55 mg; thiamine, 1.8 mg.

[2]Mineral premix provided the following amounts per pound of premix per ton of feed: Mn, 11.0%; Zn, 11.0%; Fe, 6.0%; I, 2,000 ppm; Mg, 2.68%; Se, 600 ppm.

[3]Synthetic amino acids and glutamic acid added at expense of sucrose.

[4]Crude protein values calculated from protein provided from corn and soybean meal.

[5]Protein equivalent calculated from protein provided from corn and soybean meal plus protein from synthetic amino acids

Statistical analysis: Data were analyzed with pen gain as the experimental unit using the JMP® statistical analysis software package (SAS Institute; Cary, NC). Analysis of Variance (ANOVA) with a one-way design using the general linear model was performed and the level of significance was established at $p<0.05$. Mean comparisons for all pairs were conducted using the Least Significant Difference test.

RESULTS AND DISCUSSION

In these experiments, body weight gain, feed intake and feed:gain were measured in order to determine whether low crude protein rations with crystalline amino acid supplementation can support similar performance to that achieved with a NRC-type diet.

In Experiment 1, significant differences ($p<0.05$) in BWG were observed between the PC treatment and the NC + 0.1% C,T,G treatment. All other treatments were statistically the same ($p>0.05$). There were no differences ($p>0.05$) among treatments with respect to feed intake or feed:gain. Results from Experiment 1 are displayed in Table 3. Experiment 2 was conducted in order to test the results obtained in Experiment 1. In Experiment 2, no significant differences ($p>0.05$) were seen in gain, feed intake, or feed:gain among any of the dietary treatments. Results from Experiment 2 are shown in Table 4.

Overall, these results indicate that a 15% crude protein is capable of supporting performance of broilers in the starter period that is similar to that of a 23% protein diet. A number of researchers have obtained similar results (Lipstein and Bornstein, 1975; Waldroup *et al*., 1976; Han *et al*., 1992; Kerr and Kidd, 1999; Dean *et al*., 2006; Namroud *et al*., 2008). In the case of Dean and others (2006), a 25% reduction in crude protein with amino acid supplementation and higher than normal levels of

Table 3: Performance of broiler chicks fed low protein diets from 7-21 days of age (Experiment 1)

Treatment	Weight gain (g)	Feed intake (g)	Feed:Gain
PC	614[a]	807[a]	1.31[a]
NC	601[ab]	803[a]	1.34[a]
NC + C	594[ab]	801[a]	1.35[a]
NC + T	599[ab]	791[a]	1.32[a]
NC + G	577[ab]	812[a]	1.33[a]
NC + C,T,G	572[b]	767[a]	1.34[a]
Pooled SEM	9.4	11.3	18.5

[ab]Values with differing letters are significantly ($p<0.05$) different

Table 4: Performance of broiler chicks fed low protein diets from 7-21 days of age (Experiment 2)

Treatment	Weight gain (g)	Feed intake (g)	Feed:Gain
PC	657[a]	856[a]	1.30[a]
NC	642[a]	847[a]	1.34[a]
NC + C	630[a]	850[a]	1.34[a]
NC + T	636[a]	826[a]	1.34[a]
NC + G	645[a]	858[a]	1.30[a]
NC + C,T,G	645[a]	861[a]	1.32[a]
Pooled SEM	10.2	11.7	16.4

[ab]Values with differing letters are significantly ($p<0.05$) different

glycine + serine was successful in supporting performance similar to that observed in birds consuming high protein control rations. Parr and Summers (1991) utilized a 23% CP control diet and low CP diets ranging from 16.5% to 21% CP in which the essential amino acids were kept balanced. They observed no significant differences between the control treatment and the low CP treatments.

Other researchers have reported decreased performance in birds fed low protein, amino acid supplemented diets with reductions of crude protein in some cases of only 3 or 4 percent (Fancher and Jensen, 1989; Pinchasov *et al.*, 1990; Ferguson *et al.*, 1998; Bregendahl *et al.*, 2002; Si *et al.*, 2004). A number of explanations for the discrepancies in performance between low CP experiments have been proposed, including differences in the level of crude protein and amino acid fortification, dietary ingredients utilized, chosen amino acid requirements, as well as bird age and strain (Corzo *et al.*, 2005). Aletor and others (2000) suggest that in addition to differences in the degree of crude protein reduction and the age and class of the birds, some of the discrepancy may be due to the inclusion or exclusion of the crude protein and metabolizable energy contributions from the amino acid supplements and whether or not the ratios of the intact protein sources were kept constant to minimize amino acid imbalances.

One of the most important questions raised by these experiments is why the 15% CP rations resulted in body weight gain values that, although not statistically different from the control, were consistently lower than control values. One possible answer for this question is that the amino acid levels in the 15% CP ration were so near the true requirement that any slight difference in ingredient amino acid levels could cause a deficiency and therefore growth depression. This might also help explain the differences in results from the first and second trials in which different batches of corn and SBM from the mill were utilized. The margin of safety that nutritionists put into place with a 23% CP diet is essentially removed with a 15% CP diet, leaving any variation in the amino acid content or digestibility of the ingredients capable of depressing performance.

It is unclear why the NC + 0.1% C,T,G treatment resulted in decreased growth when compared to the other treatments in Experiment 1. It is possible that an amino acid imbalance may have caused the depression in growth, but it is difficult to draw any conclusions on this issue, especially considering that these results were not duplicated in Experiment 2. The results from these experiments indicate that a 15% CP diet with crystalline amino acid fortification can be utilized for broilers in the starter period and can support similar growth to an NRC-type ration.

Conclusion: In order to meet increasing worldwide demand for poultry, combat environmental pollution concerns and maintain profitability, it is important to find new ways to stay competitive within the industry by decreasing the costs of production while still producing a high quality product. If a diet low enough in crude protein can be developed that still achieves adequate performance, it would be possible to more closely determine the digestible requirements for the essential amino acids by using that diet to individually study each amino acid through titration experiments and eventually allow formulation of economically efficient diets that precisely meet birds' requirements with little or no excess. From these experiments, it is concluded that a 15% crude protein diet may be capable of supporting performance that is similar to that of birds fed 23% crude protein diets formulated to meet or exceed NRC requirements and may be close to the level at which individual amino acids can be titrated in order to determine more precise requirements. The lowest level to which crude protein can be reduced with amino acid supplementation in broiler diets without reducing bird performance is still unknown and additional research on the subject could yield significantly greater cost savings in the future.

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