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Growth and Performance of Broiler Chicks During the Starter and Grower Phases in Phase-Feeding

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ABSTRACT

An experiment was conducted to evaluate the efficacy of a nutrition program referred to as "phase-feeding" (PF) over the first 6 weeks posthatching. Diets were formulated using amino acid recommendations from the National Research Council (NRC) (1994) or from linear regression equations generated from best estimates of lysine (Lys), sulfur amino acid (SAA), and threonine (Thr) requirements. Regression equations were used to predict weekly Lys, SAA, and Thr requirements for use in a PF regimen that involved lowering amino acid levels following each respective week of the experiment, resulting in six diets fed over the 6-week period. Over the entire experiment (0 to 6 weeks), birds fed a PF regimen throughout had an increased ($P <$ 0.05) weight gain, feed intake, and weight gain per unit of digestible Thr intake relative to birds fed NRC requirements throughout. No differences ($P < 0.05$) in carcass yield or abdominal fat percentage were noted. These data suggest that PF during the first 6 weeks of age can support growth and carcass yield comparable to diets formulated using NRC requirements. Dietary cost analysis indicates that substantial economic benefits may result from the use of PF during the starter and grower periods.

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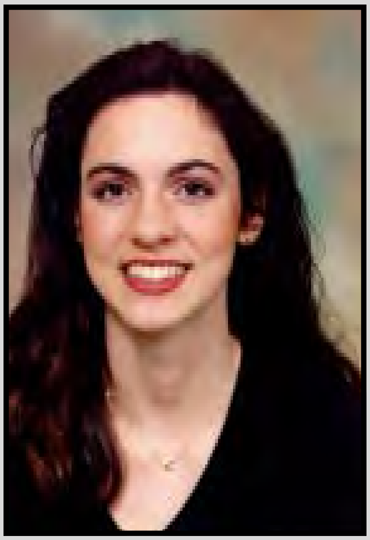
Meet the Student-Author

I graduated from Crossett High School and am now a junior majoring in poultry science, with a minor in communications. I am the Sigma Alpha Outstanding Pledge, and I have received a number of scholarships, including a freshman academic scholarship, Randal Tyson Scholarship, Crossett Junior Auxiliary, Crossett Riding Club, Ashley County Livestock, Darryle and Peggy Greene Poultry Science Scholarship, and the Romeo E. Short and Maurice Smith scholarships.



L. Niki Loupe

During the summer, I did an internship in Washington, D.C. with the National Chicken Council. After graduating, I plan to go to graduate school to obtain a research-oriented or communications position in the poultry science industry or academia.

I am very involved in campus activities, as a Razorback Belle, a member of Sigma Alpha Sorority, a publicity officer in the Poultry Science Club, an Associated Student Government Senator, and a member of the intramural softball team.

I undertook this project at the suggestion of my faculty advisor, Dr. Emmert, so that I could learn about nutrition in poultry. I learned how much work goes into raising chickens and what happens after the birds have been processed. The calculations and graphs I did for this research will help me in graduate school, and I now have a head start in research. This experience has prepared me to do a much better research project in graduate school than I could have otherwise done.

INTRODUCTION

In the poultry industry, a single set of amino acid recommendations is provided by the National Research Council (NRC) (1994) for birds up to 8 weeks of age. These recommendations have been used by nutritionists in the poultry industry as a guideline for broiler diets, but they have several problems. First, they are broken into only three periods: starter (0 to 3 weeks), grower (3 to 6 weeks), and finisher (6 to 8 weeks), but the industry sometimes grows male broilers (cockerels) to 9 or 10 weeks of age. This poses a problem for nutritionists trying to formulate diets for periods beyond 8 weeks of age. Second, the NRC provides only one set of recommendations for both cockerels and pullets (females). Cockerels require a greater amount of dietary amino acids, so pullets are overfed amino acids when they are reared with cockerels. The industry is also moving toward sex-separate rearing to obtain maximum growth performance and feed efficiency.

Phase-feeding (PF) is a nutrition program that was described by Emmert and Baker (1997) as a flexible alternative to the NRC recommendations. Because amino acid requirements of broilers decrease steadily as the birds grow older, there is a need for diets with various levels of amino acids. Instead of the three-step NRC program, PF involves more frequent reduction in dietary amino acid content and allows for the prediction of broiler amino acid requirements for any age during the grow-out period. Phase-feeding has the potential to be a more efficient feeding system because it should result in lower dietary amino acid levels while still maintaining adequate growth performance and carcass yield. Moreover, amino acid levels in the diet of broilers affect nitrogen excretion, so when dietary amino acid levels are decreased the amount of nitrogen that is excreted should be reduced, which would have a positive environmental impact. There is also a great potential for decreasing the cost of production because of increased efficiency and decreased amino acid supplementation of poultry diets.

Phase-feeding has been shown to be effective during individual periods (i.e., starter, grower, and finisher periods) (Warren and Emmert, 2000), but it has not been tested over consecutive periods of production. Our objective was to test the effects of PF on growth performance, carcass yield, and the cost of feed consumed during the starter and grower periods (0 to 6 weeks of age).

MATERIALS AND METHODS

All experimental procedures were reviewed and accepted by the University of Arkansas Institutional Animal Care and Use Committee. A commercial strain of male broiler chicks was used in the trial, and chicks were housed in floor pens containing pine-shaving litter. A 24-hour photoperiod was maintained, and water and experimental diets were freely available. Experimental diets were formulated to be adequate in all essential nutrients (NRC, 1994) (Tables 1 and 2). In the first treatment (NRC/NRC), birds were fed a single diet formulated to contain NRC recommendations for lysine (Lys), sulfur amino acids (SAA), and threonine (Thr) during the starter (0 to 3 weeks) and grower (3 to 6 weeks) periods. In the second treatment (PF/PF), birds were placed on a PF system during the starter and grower phases. In the third treatment (NRC/PF), birds were fed NRC recommendations for Lys, SAA, and threonine during the starter period but were placed on a PF system during the grower period. When PF was implemented in this trial, experimental diets were switched at the end of each respective week to a diet containing decreasing amounts of Lys, SAA, and Thr, thereby eliminating excess Lys, SAA, and Thr from the diet. Six PF diets were used during the starter and grower periods for treatment 2, and three PF diets were used during the grower period for treatment 3. Each treatment was replicated 10 times, and each replicate pen contained 35 birds.

At the start of the experiment, chicks were randomly allotted to experimental pens prepared for brooding and were immediately given experimental diets. Birds and feed were weighed at the end of the experiment to deter-

Table 1. Composition of diets for 0- to 42-day-old chicks.

Ingredient	NRC[z] wk 0–3	NRC[z] wk 3–6	PF[y] wk 1	PF[y] wk 2	PF[y] wk 3	PF[y] wk 4	PF[y] wk 5	PF[y] wk 6
	%							
Corn	55.97	60.31	50.42	53.12	55.82	58.78	61.48	64.30
Soybean meal	34.80	30.91	40.42	37.75	35.07	32.34	29.67	26.98
Poultry fat	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vitamin mix[x]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Mineral mix[x]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Dicalcium phosphate	2.00	1.50	2.00	2.00	2.00	1.50	1.50	1.50
Limestone	1.00	1.35	1.00	1.00	1.00	1.35	1.35	1.35
NaCl	0.40	0.35	0.40	0.40	0.40	0.35	0.35	0.35
Choline Cl (60%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
L-Lysine·HCl	0.1270	–	0.0414	0.0367	0.0333	0.0295	0.0258	0.0212
DL-Methionine	0.1540	0.0344	0.1702	0.1469	0.1237	0.1000	0.0767	0.0531
Sacox Salinomycin[w]	0.05[u]	0.05	0.05	0.05	0.05	0.05	0.05	–
BMD-50 Bacitracin[v]	0.05[u]	0.05	0.05	0.05	0.05	0.05	0.05	–

[z] NRC diets contained lysine, sulfur amino acid, and threonine levels recommended by the National Research Council (1994).

[y] Amino acids in PF (phase-feeding) diets were predicted by linear regression equations (Emmert and Baker, 1997): digestible lysine, $y = 1.22 - 0.0095x$; digestible sulfur amino acid, $y = (0.88 - 0.0063x)/2$; and digestible threonine, $y = 0.8 - 0.0053x$, where y = digestible amino acid level, and x = midpoint (day) of the desired age range.

[x] Han and Baker (1993).

[w] Sacox 60, Hoechst-Roussel Agri-Vet Co., Somerville, N.J. Provides 66 mg/kg of salinomycin activity.

[v] BMD-50, AlPharma, Inc., Ft. Lee, N.J. Provides 55 mg/kg of bacitracin methylene disalicylate activity.

[u] Products were withdrawn from the diet during week 6 (prior to processing).

Table 2. Calculated digestible amino acid levels.

	Digestible content (% of diet)[z]				CP	ME_n[y]
	Day	Lysine	SAA	Threonine	(%)	(kcal/kg)
NRC	0–21	1.12	0.79	0.70	22.3	3164
PF	0–7	1.19	0.86	0.78	24.7	3115
PF	7–14	1.12	0.82	0.74	23.6	3140
PF	14–21	1.05	0.78	0.71	22.4	3166
NRC	21–42	0.93	0.63	0.65	20.7	3214
PF	21–28	0.99	0.73	0.67	21.3	3198
PF	28–35	0.92	0.68	0.63	20.2	3223
PF	35–42	0.85	0.64	0.60	19.0	3252

[z] Digestible amino acid, crude protein (CP), and dietary metabolizable energy (ME) content calculated from the analytical values for total lysine, sulfur amino acid (SAA), and threonine in corn and soybean meal and published digestibility coefficients (Parsons, 1991).

[y] Metabolizable energy values for corn, soybean meal, and poultry fat were assumed to be 3350, 2440, and 8800 kcal ME_n/kg, respectively.

mine weight gain, feed intake, and feed efficiency. Birds from each treatment replicate were processed on day 43. Feed was withdrawn from experimental pens for 8 hours prior to processing to facilitate emptying of the digestive tract. A representative sample of five birds from each pen was processed, with three birds from within one standard deviation of the mean and two birds from within two standard deviations of the mean. Selected birds were stunned, bled, defeathered, and eviscerated for determination of carcass yield.

All data were analyzed as a completely randomized design, with pen means considered the experimental unit. The number of replications and birds per pen were chosen to support statistical validity. The General Linear Models (GLM) procedure of SAS (SAS Institute, 1996) was used to analyze variance. Differences among treatment means were established using the least significant difference multiple comparison procedure (Carmer and Walker, 1985).

It is important that growth performance and carcass yield of birds fed diets based on PF not be negatively affected, but the potential economic benefits of PF are of greater potential importance. We calculated the value of feed consumed based on current market ingredient prices, then divided this cost by weight gain, arriving at an estimate of the cost per kilogram ($/kg) of gain.

RESULTS AND DISCUSSION

Chicks fed the PF/PF regimen exhibited the greatest ($P < 0.05$) weight gain, feed intake, and digestible SAA intake, but no differences ($P > 0.05$) in feed efficiency were noted among the treatments (Table 3). In addition, gain per unit of digestible Thr intake was elevated ($P < 0.05$) by the PF/PF regimen relative to birds fed the NRC/NRC regimen (Table 3). No differences ($P > 0.05$) were noted in carcass yield or abdominal fat as a percentage of the live carcass (Table 3).

Previous research has evaluated PF during individual periods within a 9-week grow-out (i.e., starter, grower, and finisher periods) (Warren and Emmert, 2000). Although PF was shown to be effective in supporting maximum growth performance in individual periods, it has not been evaluated over consecutive grow-out periods. Our data indicate that PF during the grower period, whether or not preceded by PF during the starter period, is effective in supporting growth and carcass yield equivalent to chicks fed diets based on NRC recommendations. This observation supports previous work showing that broiler chickens may be switched to a less nutrient-

Table 3. Growth performance of broilers fed NRC- and PF-based diets during the starter and grower period.[z]

	Treatment			
Parameter	NRC/NRC[y]	PF/PF[x]	NRC/PF[w]	SEM
Weight gain (g)	1639 b	1798 a	1660 b	37.2
Feed intake (g)	3054 b	3302 a	3081 b	69.9
Gain:feed (g:kg)	538	544	539	6.96
Digestible lysine intake (g)	29.7	31.4	29.5	0.65
Digestible SAA intake (g)	23.2 b	25.4 a	23.8 b	0.53
Digestible threonine intake (g)	23.0	24.1	22.7	0.52
Gain:digestible lysine intake (g:g)	55.4	57.1	56.3	0.70
Gain:digestible SAA intake (g:g)	70.8	70.8	69.7	0.92
Gain:digestible threonine intake (g:g)	71.5 b	74.4 a	73.3 ab	0.96
Eviscerated carcass (% of live weight)	64.4	64.4	65.6	0.99
Abdominal fat (% of live weight)	1.22	1.27	1.14	0.08

SAA = sulfur amino acid; SEM = standard error of measurement.

Means within a row lacking a common letter differ significantly ($P < 0.05$).

[z] Values are means of 10 pens of 35 male chicks fed the experimental diets from 0 to 42 days posthatching; average initial weight was 46 g.

[y] NRC/NRC birds were fed diets based on National Research Council (1994) requirements from 0 to 42 days.

[x] PF/PF birds were fed diets based on phase-feeding (PF) requirements (Emmert and Baker, 1997) from 0 to 42 days.

[w] NRC/PF birds were fed diets based on NRC (1994) requirements from 0 to 21 days, followed by diets based on PF requirements (Emmert and Baker, 1997) from 21 to 42 days.

dense grower diet earlier than the recommended 3 weeks of age without sacrificing 6-week growth performance or carcass yield (Watkins *et al.*, 1993; Saleh *et al.*, 1995; Saleh *et al.*, 1996a, b).

A potential concern of PF is the decreased dietary crude protein that occurs (Table 2) when diets are formulated to contain lower levels of amino acids. Specifically, one may wonder whether dietary indispensable nitrogen levels are sufficient to support dispensable amino acid synthesis. Our results suggest that despite CP reductions associated with the latter periods of PF, indispensable nitrogen levels were sufficient to support growth performance and carcass yield. Previous research also suggests that growth performance may be maintained when dietary protein levels are slightly to moderately decreased if diets are supplemented with Lys and methionine (Daghir, 1983; Han *et al.*, 1992; Morris *et al.*, 1992; Deschepper and De Groote, 1995). However, other researchers (Fancher and Jensen 1989a, b) have been unable to maintain growth performance and protein accretion when feeding CP levels at which other researchers have noted no impact on performance; this discrepancy may reflect differences in experimental protocols such as assay length and age of chick.

Lower CP levels associated with PF could also potentially affect carcass composition. Birds consuming low-protein diets for a period of weeks have been shown to have elevated abdominal fat levels (Fancher and Jensen, 1989a, b; Deschepper and De Groote, 1995). Low-protein diets contain fewer excess amino acids that require energy expenditure for catabolism, thereby likely increasing the net energy of the diet and the dietary energy available for fat synthesis. However, these data indicate that carcass fat was not affected by the PF regimen, suggesting that the net energy of the diet was not greatly affected.

For NRC/NRC, PF/PF and NRC/PF diets, $/kg of gain values were 0.215^{a}, 0.212^{b}, and 0.214^{ab} ($P < 0.05$; standard error of measure = 0.0007). The calculated savings per bird is therefore as follows: 0.215 – 0.212 = 0.003 $/kg of gain, which translates into $0.0054 per bird for the PF/PF regimen (0.003 • 1.798 kg gain). Although seemingly insignificant on a per bird basis, this savings would translate into approximately $6.3 million per year in Arkansas and $42 million per year across the United States. Previous economic estimates (Warren and Emmert, 2000) have estimated that an additional $0.003 per bird may be saved by using PF during the finisher period.

Phase-feeding would not be economically feasible if six or more diets were fed during the grow-out period, because of increased costs associated with diet preparation, transport, and storage. It may be possible to accomplish PF by initially delivering a nutrient-dense starter-type diet and a less dense grower-type diet, which could be blended at a desired rate to achieve gradual decreases in dietary amino acid levels. Further investigation is needed to verify the efficacy of PF over the entire grow-out period including the finisher period. In addition, the impact of factors such as dietary energy level and bird density should be investigated. However, early indications suggest the PF may offer nutritionists a flexible alternative that facilitates application to commercial poultry nutrition programs. Substantial savings in the cost of production may be possible if PF is proven feasible under commercial conditions.

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