Modeling Amino Acid Requirements for Turkeys

J.D. Firman and E.R. McGill

University of Missouri-Columbia

Introduction

Feed costs are the major cost of live turkey production. With recent use of grain and oilseeds for bio-energy production and increased need for feed worldwide, we have seen significant cost increases for feed ingredients and thus to the overall cost of turkey feed. While initially this was thought to be a market swing, it now appears that higher input costs are the norm and thus efforts to reduce feed costs are needed. The potential of modeling has not been fully realized especially in the turkey. While models are in use in the broiler and pig industries, models for turkeys have been primarily of academic interest and used merely to describe the growth of the turkey. While this has some value as a starting point, it has little value in terms of economic significance. In previous trials with turkeys, we have utilized the Ideal Protein Concept, the main goal of which is to provide a combination of essential amino acids that precisely meet an animal's requirement for protein accretion and maintenance while avoiding deficiencies and excesses. Each indispensible amino acid is expressed as an ideal ratio, or percentage, of lysine. In past research in our laboratory, we have seen similar performance from birds fed diets formulated to those fed standard, industry-type diets, and our ideal protein research has been shown to reduce cost as much as 8%. The goal of the current trial was to attempt a more novel approach to reducing feed costs utilizing both the Ideal Protein Concept and modeling.

Materials and Methods

The approach for this trial included constructing a model based on our previously collected data on ideal protein in turkeys, running the model to generate requirements on a daily basis and formulating a set of diets from 0-147 days of age based on the requirement data set, evaluating diet costs relative to nutrient needs, and finally testing the requirements through a 21-week turkey trial with formulated cost structures against an industry-type diet to determine if cost savings are possible with similar growth. We were able to construct a model in which we took the lysine requirements from previously conducted trials and, using the regression equation $Y = 0.0031(x*x*x)-(0.0354(x*x))-0.0291x+1.14657$, determined daily lysine requirements. We then used the ideal ratio concept to determine the requirements from 0-147 days for each of the amino acids (Table 1). Similar methods were used to determine daily metabolizable energy, calcium, and phosphorus requirements.

Table 1. Ideal Ratios for Determining Daily AA Requirements – Based on Current Minimum Amino Acid Requirements Recommended in Diet Formulation (% of Diet, digestible basis, toms)

AA	Feeding Phase						
	0-3 weeks	3-6 weeks	6-9 weeks	9-12 weeks	12-15 weeks	15-18 weeks	18-21 weeks
Lysine	1.40	1.30	1.14	0.98	0.80	0.70	0.57
Met + Cys	0.84	0.78	0.68	0.59	0.50	0.47	0.45
Ideal ratio	0.5995	0.5995	0.5995	0.5995	0.6250	0.6714	0.7895
Threonine	0.80	0.74	0.67	0.59	0.51	0.48	0.40
Ideal ratio	0.5760	0.5760	0.5760	0.6020	0.6375	0.6857	0.7018
Valine	0.97	0.94	0.86	0.76	0.64	0.53	0.50
Ideal ratio	0.6929	0.7231	0.7544	0.7755	0.8000	0.7571	0.8772
Isoleucine	0.80	0.80	0.75	0.65	0.54	0.46	0.38
Ideal ratio	0.5714	0.6154	0.6579	0.6655	0.6655	0.6655	0.6655

A set of 147 diets was then formulated based on the requirement data set, and diet costs were evaluated relative to nutrient needs. A positive control (PC) diet consisted of a traditionally formulated diet utilizing industry requirements. The ideal protein negative control (IPNC) diet was formulated on a digestible basis, based on the ideal protein ration, and consisted of traditional 3-week diet phase changes. Two additional treatments were designed, both utilizing the ideal protein rations but changing diets at varying intervals in an attempt to reduce overall feeding costs, and were designated Ideal Protein Diet Change 1 (IPDC1) and Ideal Protein Diet Change 2 (IPDC2). The final step was to test the requirements with the formulated cost structure against an Agristats standard (PC) diet to determine if cost savings with similar growth are possible. This was accomplished by running a 21-week trial with tom turkeys where body weight gain, feed intake, and feed conversion were measured, as well as processing yields at the conclusion of the trial. 480 birds were utilized to provide 6 replicate pens per treatment with 20 birds per pen. Feed and water was provided *ad libitum* for the duration of the trial.

Results

The results for body weight gain (Table 2), feed intake (Table 3), feed conversion (Table 4), and processing yields (Table 5) are shown. At the conclusion of the trial, it was determined that changing diet intervals did not work well as they resulted in significantly reduced body weight gain, and that the cost savings using this strategy would be minimal. The diet constructed using the ideal protein ratios with traditional 21-day diet changes was more cost effective, and resulted in the lowest cost per unit of gain with a savings of 4.5 cents/pound of meat over the traditional Agristats control diet (Table 6).

Table 2. Body weight gain (kg) of male turkeys fed Positive Control (PC) and the Ideal Protein (IP) Negative Control (NC), Diet Change 1 (DC1) and Diet Change 2 (DC2) diets from 0 – 21 weeks of age[1].

Treatment	3 weeks	6 weeks	9 weeks	12 weeks	15 weeks	18 weeks	21 weeks
PC	0.52[a]	2.51[a]	6.22[a]	9.92[a]	12.84[a]	17.08[a]	20.70[a]
IPNC	0.49[ab]	2.19[b]	5.31[b]	8.83[b]	11.54[b]	15.46[b]	18.25[b]
IPDC1	0.46[bc]	2.18[b]	5.58[b]	8.53[bc]	10.51[c]	13.45[c]	15.94[c]
IPDC2	0.43[c]	2.07[b]	5.48[b]	8.19[c]	10.23[c]	12.94[c]	15.51[c]
Pooled SEM	0.450	0.056	0.084	0.120	0.149	0.198	0.206

[a-c]Values with differing letters are significantly ($P < 0.05$) different.
[1]Data are means of six replicate pens with 20 turkeys per pen.

Table 3. Feed intake (kg) of male turkeys fed Positive Control (PC) and the Ideal Protein (IP) Negative Control (NC), Diet Change 1 (DC1) and Diet Change 2 (DC2) diets from 0 – 21 weeks of age[1].

Treatment	3 weeks	6 weeks	9 weeks	12 weeks	15 weeks	18 weeks	21 weeks
PC	0.888[a]	3.97[a]	10.31[a]	19.96[a]	31.79[a]	46.88[a]	62.71[a]
IPNC	0.882[a]	3.72[b]	9.34[b]	17.97[b]	27.52[b]	41.13[b]	52.81[b]
IPDC1	0.885[a]	3.71[b]	9.64[ab]	18.08[b]	26.53[b]	37.72[b]	47.44[c]
IPDC2	0.892[a]	3.65[b]	9.28[b]	17.45[b]	26.22[b]	37.66[b]	47.72[bc]
Pooled SEM	0.015	0.063	0.226	0.419	0.617	0.951	1.30

[a-c]Values with differing letters are significantly ($P < 0.05$) different.
[1]Data are means of six replicate pens with 20 turkeys per pen.

Table 4. Feed to gain ratio (kg:kg) adjusted for mortality of male turkeys fed Positive Control (PC) and the Ideal Protein (IP) Negative Control (NC), Diet Change 1 (DC1) and Diet Change 2 (DC2) diets from 0 – 21 weeks of age[1].

Treatment	3 weeks	6 weeks	9 weeks	12 weeks	15 weeks	18 weeks	21 weeks
PC	1.71[a]	1.57[a]	1.70[a]	1.99[a]	2.37[a]	2.60[a]	2.83[a]
IPNC	1.83[b]	1.70[b]	1.76[a]	2.00[a]	2.33[a]	2.56[a]	2.76[a]
IPDC1	1.91[b]	1.71[b]	1.73[a]	2.06[a]	2.41[a]	2.62[a]	2.79[a]
IPDC2	2.08[c]	1.76[b]	1.69[a]	2.09[a]	2.47[a]	2.70[a]	2.88[a]
Pooled SEM	0.027	0.029	0.026	0.031	0.035	0.045	0.041

[a-c]Values with differing letters are significantly ($P < 0.05$) different.
[1]Data are means of six replicate pens with 20 turkeys per pen.

Table 5. Relative processing yields (% chilled carcass weight) of male turkeys fed Positive Control (PC) and the Ideal Protein (IP) Negative Control (NC), Diet Change 1 (DC1) and Diet Change 2 (DC2) diets from 0 – 21 weeks of age[1].

Treatment	Yield (%)	Major (%)	Minor (%)	Fat Pad (%)	Leg (%)	Thigh (%)	Wing (%)
PC	78.95[a]	25.58[a]	4.95[a]	1.41[a]	13.65[a]	14.00[a]	10.62[a]
IPNC	78.50[a]	23.80[b]	4.98[a]	1.81[ab]	13.89[a]	13.58[a]	10.93[a]
IPDC1	78.31[a]	21.82[c]	4.59[a]	1.91[b]	14.80[b]	14.79[a]	11.58[a]
IPDC2	78.38[a]	21.65[c]	4.91[a]	2.02[b]	14.82[b]	14.16[a]	11.82[a]
Pooled SEM	0.450	0.400	0.119	0.114	0.208	0.382	0.153

[a-c]Values with differing letters are significantly ($P < 0.05$) different.
[1]Data are means of 18 carcasses per treatment

Table 6. Cost comparison (cents/lb of gain) between Positive Control (PC) and Negative Control (NC) treatments fed from 0-21 weeks of age

	Positive Control			Negative Control		
Period	PC Feed Consumption (tons)	PC Diet Cost/ton ($)	PC Diet Cost/phase ($)	NC Feed Consumption (tons)	NC Diet Cost/ton ($)	NC Diet Cost/phase ($)
0-21	0.0010	314.06	0.3068	0.0010	286.61	0.2781
21-42	0.0034	306.68	1.0358	0.0031	271.95	0.8467
42-63	0.0070	298.48	2.0801	0.0062	273.87	1.6963
63-84	0.0105	292.71	3.0785	0.0092	272.82	2.5152
84-105	0.0120	292.54	3.5143	0.0103	265.55	2.7431
105-126	0.0156	282.62	4.4181	0.0139	258.24	3.5853
126-147	0.0155	274.17	4.2377	0.0120	251.23	3.0070
Total Cost	0.0649		18.6713	0.0557		14.6716
Overall Gain (lb)			45.54			40.15
Cost (cents/lb gain)			41.00			36.54
Cost Savings (cents/lb)						4.46

Discussion

The observed results were somewhat unexpected, as past research in our laboratory has resulted in similar performance between turkeys fed ideal protein negative control rations and industry standard positive control rations. After close, further examination and analysis of the feed ingredients, it was determined that analyzed nutrient levels in the rations did not meet expected levels. For the birds consuming the negative control ideal protein diet, formulated to meet digestible amino acid requirements as closely as possible, this resulted in amino acid deficiencies and, therefore, reduced growth.

Feeding turkeys makes up a large percentage of the total cost of production. The current goal in the industry 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, 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. Formulation of diets with a reduced level of crude protein alone can achieve significant cost savings. Using ideal protein ratios appears to be the best nutritional approach for cost savings, but it is imperative to have confirmed values for amino acid levels and digestibilities in the feedstuffs and to use a safety factor when formulating for commercial diets. It does not appear that changing diets based on diet costs is a cost-effective strategy, as bird growth is impaired. Formulation strategies are likely the other main approach to cost savings, and further research in this area is necessary.