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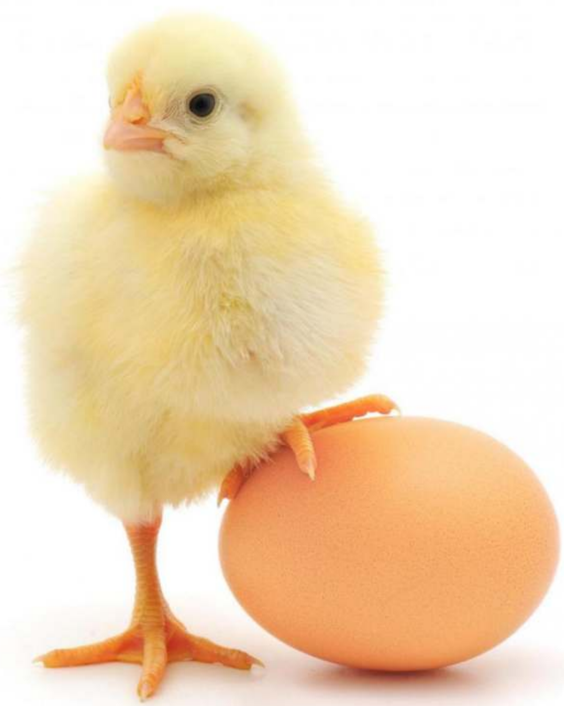

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Accuracy of Omnipro® II Estimations for Amino Acid Requirements of Broilers[1]

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Abstract: Estimation of amino acid requirements is a complex problem where many factors such as experimental conditions, genetic strain, gender, growth rate, protein quality and level of other dietary nutrients may interfere with the response. Due to the difficulties of using empirical research to resolve these problems, several mathematical growth models have been developed which could be useful for this purpose. Among the models proposed, the OmniPro® II growth model was chosen to evaluate its accuracy to estimate protein and amino acid requirements for broilers under a commercial feeding program. Diets formulated based on levels of protein and amino acids estimated by OmniPro® II were compared with diets based on NRC (1994) recommendations. Significant differences between sexes were observed for all variables evaluated. Broilers fed diets formulated with 100% of OmniPro® II estimations had BW that was similar to those fed diets based on NRC or 110% OmniPro, and were significantly heavier than those fed the 90% OmniPro diets. The feed conversion of male broilers fed diets based on OmniPro recommendations was significantly better than that of chicks fed diets based on NRC recommendations. Females fed with diets according to OmniPro or NRC had the highest dressing percentage, and differed only from those fed the 90% OmniPro diets. These data suggest that nutrient estimations generated by the OmniPro® II support performance equal to or better than that of broilers fed diets based on NRC nutrient recommendations.

Key words: Growth models, amino acid, requirements, live performance, carcass traits

Introduction

Mathematical growth models have been proposed as a tool for more accurate estimations of energy, protein and amino acid requirements for poultry, as compared to results from empirical experimentation (Hurwitz *et al.*, 1978; 1980; Parks, 1982; Emmans and Fisher, 1986; Gous *et al.*, 1999). The modeling approach presents an opportunity to include more flexible requirement estimation of nutrients for specific growth rates, environmental, management, and dietary changes (Emmans, 1995; Gous *et al.*, 1999). Even with the benefits that modeling clearly represents, growth models are not frequently used for nutrient requirement estimation in commercial poultry production, principally because the accuracy of the former models has not been as satisfactory as expected for the poultry industry. Recently a new growth model, OmniPro® II (Novus International, Inc., St. Charles MO) has been developed and tested in large-scale experiments with fairly accurate results for predicting body weight and live performance (Harlow and Ivey, 1994; Ivey, 1999). OmniPro® II is a semi-empirical, deterministic and dynamic growth model designed to simulate and optimize nutritional changes (Hurwitz and Talpaz, 1999). Due to the great amount of data used in its calibration, this model has a higher degree of accuracy than previous models (Ivey, 1999). The calibration process of a mathematical model also includes the experimental evaluation of the estimates of requirements and the simulation of changes in these values.

The OmniPro® II model optimizes growth results and requirements based on the best growth pattern that matches the conditions or constraints used to specify the optimization process (Talpaz *et al.*, 1986). Growth curves are normally used to evaluate nutritional, management and genetic selection treatments applied to different animals. The effect of several treatments during the period of growth has an accumulative effect on the development of animals. Growth curves help to visualize when one component of the treatment, like one diet in the feeding program, could be changed to improve the performance of chickens. Also, growth curves help to estimate live weight at ages where data was not collected, which is important for economical analysis. For economic reasons it is important that the models do not overestimate the nutritional needs to support a stated level of gain. Therefore, this study was conducted to evaluate the amino acid requirement estimations made by OmniPro® II using sexed broiler chickens of a commercial strain, using feed change intervals that represent the most common times used in the United States.

Materials and Methods

Requirement estimates : To achieve accuracy in

[1] Published with approval of the Director, Arkansas Agricultural Experiment Station. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the University of Arkansas and does not imply its approval to the exclusion of other products that may be suitable.

Table 1: Composition (g/kg) of experimental diets formulated according to 100% of OmniPro® II estimations and NRC (1994) recommendations and fed to broiler chickens from 1 to 49 d in two feeding programs

Ingredients	OMNIPRO ® II GROWTH MODEL DIETS						NRC DIETS		
	starter (1 – 14D)		grower (14 – 35D)		finisher (35 – 49D)		starter	grower	finisher
	Males	Females	Males	Females	Males	Females	(1 – 21D)	(21 – 42D)	(42 – 49D)
Yellow corn	530.5	586.0	577.7	600.8	631.3	655.7	540.7	616.4	731.0
Soybean meal	386.4	337.1	332.8	314.5	285.2	262.8	349.2	293.9	203.6
Poultry oil	35.9	29.7	49.1	45.1	47.6	46.5	64.4	51.0	30.8
Ground limestone	11.9	12.1	10.9	10.9	10.1	10.2	9.4	12.6	13.1
Dicalcium phosphate	17.3	17.6	16.1	16.2	14.8	14.9	22.0	13.9	10.5
Lysine HCl	0.7	0.6	-	-	-	-	-	-	0.6
Alimet 88%	1.9	1.5	2.3	1.3	1.6	0.5	2.2	0.9	0.6
Threonine	-	-	-	-	-	-	-	-	0.8
Salt	5.3	5.3	4.8	4.9	4.4	4.4	5.8	5.0	5.0
Sand	3.8	3.8	-	-	-	-	-	-	-
Vit.-Min. premix[A,B]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0
Choline Cl 60%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Coban 60[C]	0.8	0.8	0.8	0.8	-	-	0.8	0.8	-
BMD-50[D]	0.5	0.5	0.5	0.5	-	-	0.5	0.5	-
Total	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

[A] Provided per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; choline 465 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; thiamin (from thiamine mononitrate) 1.54 mg; pyridoxine (from pyridoxine hydrochloride) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg.

[B] Provided per kg of diet: Mn (from $MnSO_4 \bullet H_2O$) 100 mg; Zn (from $ZnSO_4 \bullet 7 H_2O$) 100 mg; Fe (from $FeSO_4 \bullet 7 H_2O$) 50 mg; Cu (from $CuSO_4 \bullet 5 H_2O$) 10 mg; I (from $Ca(IO_3)_2 \bullet H_2O$) 1 mg.

[C] Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. Provides 60 g/lb. (132 g/kg) monensin activity.

[D] Alpharma, Inc., Ft. Lee, NJ 07024. Provides 50 g/lb (110 g/kg) bacitracin activity as bacitracin methylene disalicylate.

Table 2: Nutrient content (%) of diets formulated according to OmniPro® II estimations and NRC (1994) recommendations and fed to broilers through the experiment [D]

Nutrients	100% OMNIPRO ® GROWTH MODEL DIETS						NRC DIETS		
	Starter (1 – 14 D)		Grower (14 – 35 D)		Finisher (35 – 49 D)		Starter (1 – 21D)	Grower (21 - 42 D)	Finisher (42– 49 D)
	Males	Females	Males	Females	Males	Females			
ME[1], kcal/kg	3024	3037	3150	3150	3200	3219	3200	3200	3200
Crude protein (C)	23.42	21.47	21.05	20.36	19.20	18.32	22.00	19.49	16.19
Crude protein (A)	24.36	22.86	21.78	21.12	20.04	19.26	22.97	20.08	17.24
Lysine (C)	1.36	1.22	1.16	1.11	1.03	0.96	1.22	1.05	0.85
Lysine (A)	1.57	1.44	1.21	1.16	1.04	0.94	1.22	1.12	0.87
Methionine (C)	0.53	0.47	0.53	0.43	0.45	0.34	0.54	0.39	0.32
Methionine (A)	0.42	0.40	0.34	0.32	0.31	0.28	0.54	0.30	0.28
Cystine	0.38	0.35	0.35	0.34	0.32	0.31	0.36	0.33	0.28
Methionine + cystine	0.91	0.82	0.88	0.77	0.77	0.65	0.90	0.72	0.60
Tryptophan	0.33	0.29	0.29	0.28	0.26	0.24	0.30	0.26	0.20
Threonine (C)	0.89	0.81	0.80	0.78	0.73	0.69	0.84	0.74	0.68
Threonine (A)	0.99	0.91	0.78	0.76	0.74	0.68	0.84	0.72	0.68
Isoleucine	0.99	0.89	0.89	0.85	0.80	0.76	0.93	0.81	0.65
Valine	1.09	1.00	0.99	0.95	0.90	0.86	1.02	0.91	0.75
Leucine	2.01	1.87	1.85	1.80	1.72	1.66	1.90	1.74	1.51
Arginine	1.57	1.42	1.40	1.35	1.25	1.18	1.47	1.28	1.00
Phenylalanine	1.13	1.03	1.02	0.98	0.92	0.88	1.06	0.94	0.76
Tyrosine	0.93	0.85	0.84	0.81	0.76	0.72	0.84	0.77	0.62
Calcium	0.95	0.95	0.87	0.87	0.80	0.80	0.90	0.90	0.80
Phosphorus available	0.45	0.45	0.42	0.42	0.39	0.39	0.45	0.35	0.30
Chloride	0.37	0.37	0.34	0.34	0.31	0.32	0.41	0.35	0.37
Sodium	0.24	0.24	0.22	0.22	0.20	0.20	0.25	0.23	0.22

[A] Analyzed; [B] Metabolizable Energy, kcal/kg; [C] Calculated; [D] Chemical analyses were in close agreement to calculated values. Differences in methionine values are due to utilization of HMB as a methionine source.

simulation, OmniPro® II uses tools to calibrate its values based on historical variables that affect broiler growth at the farm. For this experiment, OmniPro® was calibrated based on: 1) Genetic line growth curve by sex (Management Guideline Cobb-500, 2001), 2) Historical in-house weekly temperature recorded at the University of Arkansas research farm, 3) Commercial bird density, and 4) Body weight observed previously at the farm with this genetic line.

To obtain nutritional requirement values for optimum performance, it is necessary to indicate the feeding program to be used. The commercial feeding schedule consisted of: starter (1 to 14 d), grower (15 to 35 d) and finisher (35 to 49 d) diets, typical of the U.S. broiler. The ingredient composition suggested by the provider of the OmniPro model (Novus International, Inc.) was adjusted for differences in crude protein composition and used for all intact sources of protein. Corn, soybean meal and poultry oil were used as primary ingredients with supplements of lysine HCl, methionine hydroxy analogue-free acid, and threonine available for use by the computer.

The OmniPro® II model optimized the diets for each period under this feeding program, temperature, and density conditions.

The amino acid composition of the diets estimated by the model was used to establish 100% of essential amino acid requirements for the experiment. All other nutrients in the simulation were kept under NRC (1994) recommendations for birds with similar age.

Birds and housing: Day-old male and female chicks of a commercial strain (Cobb-500) were obtained from a local hatchery and randomly assigned to floor pens. Sixty males or sixty females were placed in each of 64 pens (32 pens of each sex) for a total of 3,840 birds. Males and females were fed diets with different nutrient content estimated for each sex in each feeding period. Eight pens were assigned to each of the eight treatments. Each pen was equipped with one automatic water fount and one tube-type feeder. Previously used softwood shavings were top dressed with new litter.

Diets and experimental treatments: The eight experimental treatments consisted of a combination of two sexes (male and female) and three levels of model estimates (90, 100 and 110% of OmniPro® II model estimations for protein and amino acids) for a total of six treatments; two additional treatments were fed with one diet based on NRC (1994) recommendations for both genders as controls. The feeding intervals of diets based on model estimates used in the experiment were the same used for the simulation. The control NRC diets were fed for 1 to 21 d, 21 to 42 d and 42 to 49 d of age feeding periods on which the NRC recommendations are based.

Six series of diets were formulated based on protein and amino acid predictions made by the OmniPro® II optimizer for each sex (Table 1 and 2), and levels 10% above or under, in each feeding period. The other nutrient levels were specified as suggested by the NRC (1994). All diets were fortified with complete vitamin and trace mineral premixes, and contained monensin (90 g/ton) and bacitracin methylene disalicylate (50 g/ton). Energy and protein levels were maintained constant or with minimum variation. The energy and crude protein equivalents of the supplemental amino acids (NRC, 1994) were used in the formulation.

One additional set of diets was formulated following all nutrient recommendations of NRC (1994) in each feeding period (Table 1). The starter diets and finisher diets were fed as mash, while grower diets were pelleted. These formulations produced a total of 7 different diets for each period (Table 1). All diets were analyzed for crude protein, total amino acid content and added levels of methionine hydroxy analogue-free acid (Table 2).

Measurements: Birds were group weighed by pen at 14, 35 and 49 d of age, with feed consumption determined at the same time. At 49 d, five birds per pen were randomly selected for processing. Feed, but not water, was withheld for 8 h prior to processing. Final flock uniformity percentage by treatment was estimated with the empty live body weight of all broilers processed. Dressing percentage and parts yield were determined. Mortality and environmental temperature were recorded daily. The weight of dead birds was used to adjust feed conversion ratio (FCR).

Statistical analysis and model simulations: Pen means were used as the experimental unit. The data were analyzed (SAS Institute, 2000) as a complete factorial arrangement with sex and essential amino acid levels as main effects and all interactions included. Mortality and all percentage data were transformed to $\sqrt{n+1}$ prior to analysis; these data are presented as natural numbers. All statements of statistical significance are based on a probability of $P \leq 0.05$. Tukey's multiple comparison was performed when the F-test was significant.

In addition to these measurements, individual live weights of chickens, identified by wing-band number, were taken at 1, 7, 14, 21, 48 and 50 days of age. These data were analyzed by the PROC NLIN procedure of SAS. For each bird, the following form of the Gompertz non-linear function was fitted (Larbier and Leclercq, 1994):

$$W_t = W_0 \exp (L/K)^* (1 - \exp (-K^*t))$$

Where: exp. = The exponential function; W_t = Live weight at age t (days); W_0 = Live weight at hatching (t = 0); L = Initial rate of growth; K = Constant of decelerating growth rate, the rate of exponential decay of the initial growth rate, a measure of the decline in growth rate; t = Indicates time (days)

Table 3: Live performance of sexed broilers fed diets formulated according to OmniPro® II model estimations or NRC (1994) from 1 to 49 d of age

Sex	Source of requirement: Growth model levels: 90% OmniPro	OmniPro	110%OmniPro	Tables NRC	Mean by sex	ANOVA Source by level in sex: P value	SEM
	(kg)						
BW[A] 49 d							
Males	2.44^{b}	2.62^{a}	2.58^{ab}	2.69^{a}	2.58^{x}	0.0053	0.01
Females	2.31^{c}	2.44^{b}	2.49^{a}	2.41^{b}	2.41^{y}	0.0003	0.03
Mean by level	2.46^{b}	2.58^{a}	2.59^{a}	2.55 ± 0.03^{a}			
Mean		2.54 ± 0.02			2.54		
Total feed intake							
Males	4.92	4.99	5.06	5.18	5.03^{x}	0.1982	0.09
Females	4.66	4.75	4.78	4.74	4.73^{y}	0.6651	0.07
Mean by level	4.86	4.90	4.95	4.94 ± 0.05			
Mean		4.90 ± 0.03			4.91		
	(kg)						
Feed:gain							
Males	1.904^{a}	1.775^{b}	1.864^{a}	1.881^{a}	1.868^{x}	0.0272	0.02
Females	1.975^{a}	1.883^{b}	1.867^{b}	1.897^{b}	1.905^{y}	0.0012	0.02
Mean by level	1.917^{a}	1.842^{c}	1.843^{c}	1.89 ± 0.01^{b}			
Mean		1.868 ± 0.007			1.873		

[A] Body weight at 49 days of age; [a-d] Means within a row lacking a common superscript differ significantly ($P < 0.05$).
[x-z] Means within a column for each parameter, lacking a common superscript differ significantly ($P < 0.05$) .

Table 4: Total nutrient intake of sexed broilers fed diets formulated according to OmniPro® II model estimations or NRC (1994) recommendations from 1 to 49 d of age

Sex	Source of requirement: Growth model levels: 90% OmniPro	OmniPro	110%OmniPro	Tables NRC	Mean by sex	ANOVA Source by level in sex: P value	SEM
	(Mega calories ME/bird)						
ME[A]							
Males	15.54	15.77	16.00	16.56	15.97^{x}	0.0717	0.27
Females	14.77	15.05	15.14	15.17	15.03^{y}	0.5786	0.22
Mean by level	15.38	15.51	15.67	15.82 ±0.16			
Mean		15.15 ± 0.09			15.59		
	(kg)						
Protein							
Males	0.91^{b}	1.02^{a}	1.14^{b}	0.99^{a}	1.02^{x}	0.0001	0.02
Females	0.82^{c}	0.93^{b}	1.03^{a}	0.92^{b}	0.92^{y}	0.0001	0.01
Mean by level	0.88^{d}	0.99^{b}	1.10^{a}	0.96 ± 0.02^{c}			
Mean		0.99 ± 0.01			0.98		
	(g)						
Lysine							
Males	49.4^{c}	55.6^{b}	63.6^{a}	53.4^{b}	55.5^{x}	0.0001	0.9
Females	43.9^{c}	50.7^{b}	56.8^{a}	49.2^{b}	50.0^{y}	0.0001	0.8
Mean by level	47.7^{d}	53.6^{b}	61.1^{a}	51.2 ± 0.2^{c}			
Mean		54.1 ± 0.7			53.4		
Methionine							
Males	36.9^{c}	41.5^{b}	46.4^{a}	38.5^{c}	40.8^{x}	0.0001	0.7
Females	30.2^{c}	34.3^{b}	37.9^{a}	35.5^{b}	34.5^{y}	0.0001	0.5
Mean by level	34.8^{d}	39.0^{b}	43.4^{a}	36.8 ± 0.9^{c}			
Mean		39.1 ± 0.6			38.5		

[a-d] Means within a row lacking a common superscript differ significantly ($P < 0.05$). [x-z] Means within a column for each parameter, lacking a common superscript differ significantly ($P < 0.05$) . [A] Metabolizable energy intake

This equation is not dependent on the maximum mature live weight and can be used with data that does not reach this point. The initial values were for Wo= 39 (g), L = 0.1635 and K = 0.0336305. All data were fitted by the

Table 5: Percentages of mortality and culled birds of sexed broilers fed diets formulated according to OmniPro® II growth model estimations or NRC (1994) recommendations from 1 to 49 d of age

Sex	Source of requirement				Mean by sex	ANOVA Source by level in sex	
	Growth model levels			Tables NRC		P value	SEM
	90% OmniPro	OmniPro	110%OmniPro				
	(%)						
Total mortality							
Males	5.7	5.0	6.4	3.1	5.1	0.2538	1.2
Females	3.1	4.7	3.9	4.9	4.2	0.6056	1.0
Mean by level	4.1	3.7	5.3	4.3 ± 0.6			
Mean		4.3 ± 0.4			4.3		
Total culled							
Males	11.2[a]	7.8[ab]	7.8[ab]	2.1[c]	7.2[x]	0.0271	2.0
Females	3.8	3.2	2.6	3.4	3.3[y]	0.7519	0.8
Mean by level	5.7[a]	4.2[a]	4.3[a]	2.4 ± 0.9[b]			
Mean		4.7 ± 0.5			4.1		

[a-d] Means within a row lacking a common superscript differ significantly (P < 0.05).
[x-z] Means within a column for each parameter, lacking a common superscript differ significantly (P < 0.05).

Table 6: Carcass characteristics of sexed broilers fed diets formulated according to OmniPro® II growth model estimations or NRC (1994) recommendations at 49 d of age

Sex	Source of requirement				Mean by sex	ANOVA Source by level in sex	
	Growth model levels			Tables NRC		P value	SEM
	90% OmniPro	OmniPro	110%OmniPro				
	(%)						
Dressing[A]							
Males	71.4	72.3	72.1	72.6	72.1[x]	0.3300	0.5
Females	69.5[b]	71.1[a]	70.0[ab]	71.1[a]	70.4[y]	0.0450	0.5
Mean by level	70.8	71.7	71.3	71.8 ± 0.3			
Mean		71.3 ± 0.2			71.4		
Uniformity							
Males	84.8	87.6	85.6	89.4			
Females	87.4	86.6	87.3	88.4			
Carcass traits[B]							
Breast meat yield							
Males	27.3[b]	28.5[a]	29.3[a]	28.5[a]	28.5[x]	0.0126	0.4
Females	26.3	26.7	27.7	26.6	26.9[y]	0.2568	0.5
Mean by level	26.6[c]	27.5[b]	28.3[a]	27.4 ±0.3[b]			
Mean		27.1 ± 0.2			27.5		
Leg quarter							
Males	34.2	33.5	32.9	32.9	33.4[x]	0.1599	0.5
Females	31.6	31.7	31.3	31.4	31.5[z]	0.3242	0.4
Mean by level	32.8[a]	32.7[a]	32.2[b]	32.0 ±0.3[b]			
Mean		32.6 ± 0.2			32.4		
Abdominal fat							
Males	1.3[b]	1.4[b]	1.1[b]	1.8[a]	1.3[y]	0.0035	0.1
Females	2.1[a]	1.9[a]	1.6[b]	1.8[a]	1.9[x]	0.0190	0.1
Mean by level	1.9[a]	1.7[a]	1.4[b]	1.8 ± 0.1[a]			
Mean		1.6 ± 0.1			1.7		

[A] Dressed carcass without giblets as percentage of live carcass prior to slaughter; [B] Parts yield expressed as percentage of chilled carcass weight; [a-d] Means within a row lacking a common superscript differ significantly (P < 0.05); [x-z] Means within a column for each parameter, lacking a common superscript differ significantly (P < 0.05).

Gompertz function. The Gompertz parameters were compiled in a data set. Means of the three growth parameters by treatment were compared by one-way analysis of variance. Multiple comparison of means was done using Tukeys' and Dunnetts' tests (SAS, 2000).

Results

Live performance: Significant differences by sex ($P \leq 0.001$) were observed for final BW, total feed intake, and FCR (Table 3), percentage of birds culled (Table 5), and total protein, ME, lysine and methionine intake (Table 4).

Broilers fed diets in which requirements were estimated using the OmniPro® II growth model had similar final BW to those fed diets based on NRC (1994) recommendations or 110% OmniPro diets. However, they were significantly heavier ($P \leq 0.05$) than broilers fed the 90% OmniPro diets.

Total feed and ME intake did not differ ($P > 0.05$) among dietary treatments, but males had higher intakes than females. Feed, total protein and lysine intakes of male and female broilers fed with diets formulated using NRC recommendations did not differ significantly ($P > 0.05$) from those of males and females fed diets based on 100% OmniPro® II estimations, but males fed 100% OmniPro diets had higher ($P \leq 0.001$) total methionine intake than those fed NRC.

The FCR of male chickens was significantly better ($P \leq 0.001$) for the 100% OmniPro treatment compared with other treatments (Table 3). Female broilers fed with 90% OmniPro estimations had worse FCR than those in treatments fed according to NRC recommendations or other OmniPro treatments.

There were no significant differences ($P \geq 0.05$) in mortality due to sex or protein and amino acid dietary levels, but there was a significant sex by amino acid level interaction. Significant differences in percentage of culled birds due to sex ($P \leq 0.001$), level ($P \leq 0.05$) and sex by level interaction ($P \leq 0.05$) were observed. Males had the highest percentage of culled birds when they were fed with diets formulated according to the growth model estimations or levels 10% above or under these estimations (Table 5).

Carcass characteristics: Dressing percentage, yield of breast meat and leg quarters, and abdominal fat percentage were significantly ($P \leq 0.001$) affected by sex (Table 6). The highest dressing, breast, leg quarter, and the lowest abdominal fat pad percentages were observed in male birds. The uniformity of the birds processed was higher when they were fed the NRC diets but this was not statistically significant.

Females fed with diets formulated according to OmniPro® II estimations or the NRC recommendations had the highest dressing percentage. These did not differ significantly from those fed the 110% OmniPro estimations, but differed ($P < 0.05$) from female birds fed 90% of OmniPro estimations. Males and female chickens fed with 90% OmniPro diets had the lowest breast meat percentage compared to higher levels. Independent from the gender, all broilers fed the 90% OmniPro diets and the 100% OmniPro diets had the highest leg quarter percentage (Table 6). No significant differences in wing percentages were observed due to all factors analyzed. Males fed with diets according to NRC recommendations had the highest percentage of fat pad. The lowest fat pad percentage in female chickens was observed in groups fed with 110% OmniPro diets.

Analysis of growth curves: No significant differences were observed for the initial parameter W_0 in any of the two genders evaluated (Table 7). The initial rate of growth (L parameter) and the exponential decay of the initial growth rate (K parameter) differed among treatments in males ($P < 0.05$), but did not differ ($P > 0.05$) among the female groups.

Discussion

The OmniPro® II growth model estimated protein and amino acid requirements for this commercial feeding program with a good degree of accuracy. Diets formulated to be 10% under these requirements resulted in lower live performance and worse carcass traits than the model estimations itself. Diets that were 10% above the model estimations did not consistently improve these variables. The FCR was better when male chickens were fed in the commercial program with diets formulated with 100% of the growth model estimations.

OmniPro® II optimizes nutrient requirements by manipulation of broiler growth curves. Based on the analysis of growth curves, it was possible to observe that the initial rate of growth of chickens fed NRC diets was higher, even though not significantly different ($P > 0.05$) from those fed OmniPro diets, indicating that their maintenance requirements were higher latter on during the growth period. Consequently, the values of rate to maturity (K parameter) were also higher in this treatment, showing reduction in growth.

Although there were apparent benefits observed with the estimations of the growth model, the higher levels of protein and amino acids suggested by the model could make the diets more expensive. Broilers fed with diets according to the growth model estimations ate an average of 32 g, 2.5 g, and 2.2 g more protein, lysine and methionine, respectively, than broilers fed with diets based on NRC recommendations to obtain similar final body weight and better FCR after a period of 49 d. This represents a feed intake of these nutrients in the commercial program that were 3.4, 4.8 and 6% higher, respectively. It is necessary to evaluate whether the growth model is overestimating these values or if these are the real nutritional needs for these periods in this commercial feeding program. Café *et al.* (2001) observed that the NRC (1994) recommendations for amino acids are not adequate when they are used in a feeding schedule different from that used in the determination of the requirements.

In males and females, treatments formulated to be 10% under the OmniPro® II growth model estimations had lower rates of initial growth (L) and lower rates of decay of the initial growth (K). This could be due to a deficiency to fulfill nutritional requirements in the first period;

Table 7: Gompertz growth parameter comparison of sexed broilers fed diets formulated according to OmniPro® II growth model estimations or NRC (1994) recommendations

SEX	Source of requirement				Mean by sex[D]	Anova by treat. P value
	Growth model levels			NRC (1994)		
	90% OmniPro	OmniPro®	110%OmniPro®			
Males						
W_0A	31.2 ± 11.8	28.8 ± 9.5	30.5 ± 11.8	20.0 ± 7.5	27.6 ± 10.8	0.1355
L[B]	0.224 ± 0.05[b]	0.237 ± 0.04[a]	0.241 ± 0.06[a]	0.292 ± 0.04[a]	0.249 ± 0.05	0.0296
K[C]	0.045±0.003[b]	0.047±0.002[a]	0.047±0.003[a]	0.055 ±0.001[a]	0.048 ± 0.01	0.0381
Females						
W_0	28.2 ± 9.73	35.1 ± 9.48	31.7 ± 10.11	30.6 ± 10.13	31.4 ± 9.7	0.5719
L	0.239 ± 0.036	0.226 ±0.028	0.247 ±0.029	0.252 ± 0.044	0.241± 0.034	0.4892
K	0.045 ±0.005	0.048±0.005	0.051±0.030	0.052 ± 0.006	0.050 ± 0.005	0.3019

[A] Initial body weight in grams; [B] Initial rate of growth; [C] Exponential decay of the initial rate of growth; [D] NS ($P > 0.05$).
[a-b] Means within a row lacking a common superscript differ significantly ($P < 0.05$).

however, the lower rates to maturity indicate a compensatory gain effect that could have significance latter on. This implies that if the growth pattern continues constant these chickens could have a body weight similar to that of chickens fed with the other diets.

It can be argued that statistical analysis of growth curves is a more fair evaluation of treatments when they affect accumulatively the growth performance in different periods of life. This methodology helps to understand how the model optimizes the growth curves, and estimates the nutrient requirements to follow this predicted pattern. It is important to notice that even though no significant differences were observed in total mortality, there was a significantly higher percentage of culled birds for all treatments that used the growth model estimations compared with those in the NRC treatments.

The gender of the broilers had a significant effect on all variables. Diets formulated with specific requirements for each gender could probably improve performance and carcass characteristics. Growth models can predict these requirements with higher accuracy than the rigid NRC table and in different commercial feeding programs. Jackson (1987) evaluated the amino acid estimations of a growth model based on the methodology proposed by Hurwitz *et al.* (1978). He observed that the model underestimated amino acids requirements by 20 to 10%, and there were differences by gender in the accuracy of the estimations. The OmniPro® II growth model seems to be more accurate than previous models.

In summary, it may be concluded that the OmniPro® II growth model estimates amino acid requirements for new feeding commercial programs with a good degree of accuracy for each gender according to the performance variables and carcass traits observed. This growth model predicts levels of total amino acids that are higher than NRC recommendations with a significant improvement in feed conversion but not in other variables. The output of the model shows a recommendation for a minimum crude protein content, higher than those already known to be necessary to obtain optimal broiler performance. It is necessary to determine whether or not the diets could support a good performance if the crude protein is reduced and amino acid levels are kept constant, using more synthetic amino acids to fulfill the growth model estimates.

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References

Café, M. B., C. A. Fritts and P. W. Waldroup, 2001. Interaction of methionine and lysine in broiler diets changed at NRC or industry time intervals. Poult. Sci., 80(Suppl. 1): 166 (Abstr.).

Emmans, G. C., 1995. Problems in modeling the growth of poultry. World's Poult. Sci. J., 51:77-89.

Emmans, G. C. and C. Fisher, 1986. Problems in nutritional theory. Pages 9-39 in: Nutrient Requirements of Poultry and Nutritional Research. C. Fisher and K.N. Boorman, Ed. Butterworths, London, United Kingdom.

Gous, R. M., E. T. Moran Jr., H. R. Stilborn, G. D. Bradford and G. C. Emmans,1999. Evaluation of the parameters needed to describe the overall growth, the chemical growth, and the growth of feathers and breast muscles of broilers. Poult. Sci., 78 :812-821.

Harlow, H. B. and F. J. Ivey, 1994. Accuracy, precision, and commercial benefits of growth modeling for broilers. J. Appl. Poult. Res., 3: 391-402.

Hurwitz, S., I. Plavnik, I. Bartov and S. Bornstein, 1980. The amino acid requirements of chicks: Experimental validation of model-calculated requirements. Poult. Sci., 59: 2470-2479.

Hurwitz, S., D. Sklan and I. Bartov, 1978. New formal approaches to the determination of energy and amino acid requirements of chicks. Poult. Sci., 57: 197-205.

Hurwitz, S. and H. Talpaz, 1999. The broiler model OmniPro™. LIDM Software Systems, Herzlia, Israel.

Ivey, F. J., 1999. Desenvolvimento e aplicação de modelos de crescimento para frangos de corte. Pages 22-35 in Proc. I Simp. Internl. ACAV-Embrapa Nutr. Frangos de Corte. Concórdia, SC. Brazil.

Jackson, M. E., 1987. The development of computer models to estimate nutrient requirements of the broiler chicken. PhD. Dissertation. University of Arkansas. Fayetteville, AR.

Larbier, M. and B. Leclercq, 1994. Nutrition and feeding of poultry. J. Wiseman, Ed. Nottingham University Press, Loughborough, Leicestershire, UK.

National Research Council, 1994. Nutrient Requirements of Poultry. 9th rev. Ed. National Academy Press, Washington, D. C.

Parks, J.R., 1982. A theory of feeding and growth of animals. Springer-Verlag, Berlin, Germany.

SAS Institute, 2000. SAS® User's Guide:Statistics. Version 8.0. SAS Institute,Inc., Cary, NC.

Talpaz, H., J. R. de la Torre, P. J. H. Sharpe and S. Hurwitz, 1986. Dynamic optimization model for feeding of broilers. Agric. Sys., 20: 121-132