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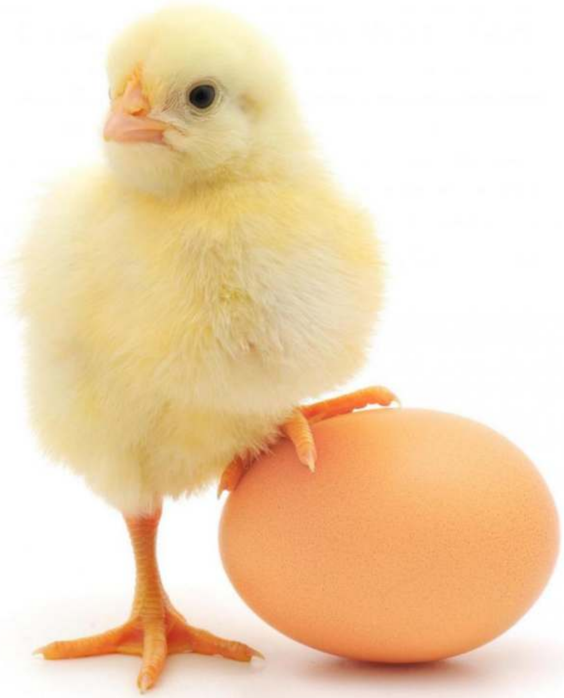

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# Digestible Threonine Requirements for Maintenance in the Starting Turkey

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**Abstract:** The objective of these studies was to determine the digestible threonine requirement for maintenance in turkeys during the starter period. Amino acid requirement data can be determined in multiple fashions. One method for determining amino acid requirements is through modeling. A portion of the data required for a comprehensive model is the maintenance requirement. Two studies were conducted to determine the maintenance requirement for threonine during the starter period for turkeys. Day-old poults (192 birds) were randomly assigned to pens to provide for six replications of eight treatments in each trial and a low protein diet was formulated so that different levels of threonine could be fed to young turkeys. The maintenance requirements of threonine were 25.94 and 29.51 mg/bird/day in experiment 1 and experiment 2, respectively. This information, coupled with the amino acid requirements for growth, will allow for the construction of an effective model to predict amino acid requirements over a wide range of environment and physiological conditions.

**Key words:** Threonine, maintenance, prediction equation, turkeys

## Introduction

Meeting the nutritional requirements for growing turkeys constitutes the majority of costs associated with turkey production. By reducing the level of protein in the diets of these birds, significant cost savings can be realized. Firman (1994) reported that a one percent decrease in protein level could yield savings of five dollars per ton of feed. Although the use of ideal amino acid ratios and digestible formulation have the potential to reduce feed costs significantly, the combination of these concepts with other factors in a model offers the most efficient feeding program.

In order for a model of amino acid requirements to be most effective, amino acid requirements must be determined as precisely as possible, Since amino acid requirements can be partitioned into a requirement for maintenance and a requirement for growth, a comprehensive model must take each of these requirements into account to achieve maximum efficiency. While amino acid requirements for growth are rather easily defined as the amino acid level that produces maximal growth, defining a maintenance requirement is not as straightforward.

Maintenance can be defined as the point of static lean tissue content or static amino acid content. It has been demonstrated in broiler chicks that these two requirements are not the same (Baker *et al.*, 1996; Edwards *et al.*, 1997; 1999; Edwards and Baker, 1999). Regardless of which definition of maintenance is used, there has been little research into the maintenance requirements of poultry. Leveille and Fisher (1959, 1960) and Leveille *et al.* (1960) performed balance studies to determine maintenance amino acid requirements in adult roosters and maintenance requirements for some amino acids have been determined in broiler chicks (Baker *et al.*, 1996; Edwards *et al.*, 1997; 1999; Edwards and Baker, 1999). Currently, no experimentally obtained data on the maintenance amino acid requirements of turkeys in the starter period are available.

The following experiments were designed to determine the digestible threonine requirement for maintenance in turkeys during the starter period.

## Materials and Methods

Day-old poults were obtained from a commercial hatchery and fed an NRC corn and soybean meal diet until seven days of age. On day 7, after 10 hours of feed deprivation, birds were weighed, wing-banded and randomly assigned to pens to ensure that each pen was of similar weight. Each trial contained 192 birds to provide for six replications of eight treatments. Ten birds with an average weight equal to that of the experimental pens were killed ($CO_2$ asphyxiation) and frozen to provide for initial body composition data.

Diets for the trials were formulated on a digestible basis utilizing Brill least-cost formulation software. Birds were fed semi-purified diets in order to achieve the low amino acid levels required to determine maintenance requirements. Corn and sucrose comprised the majority of the diets, with amino acids, vitamins and other nutrients provided in purified form. Sand was included as filler in all diets. Other than crystalline amino acids, corn was the only amino acid-containing ingredient used in the experimental diets. Amino acid digestibility values for the corn were obtained through previous testing with cecectomized turkeys.

Table 1: Composition of Experimental Diets for Threonine Trials (Experiment 1)

| Threonine Treatment: | 0.08% | 0.155% | 0.23% | 0.305% | 0.38% | 0.455% | 0.53% | 0.605% |
|---|---|---|---|---|---|---|---|---|
| Corn | 36.697 | 71.101 | 76.467 | 76.864 | 73.613 | 72.185 | 68.465 | 65.963 |
| Sucrose | 41.516 | 6.495 | 0 | 0 | 0 | 0 | 0 | 0 |
| Corn Oil | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| Sand | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Dicalcium Phosphate | 3.019 | 2.874 | 2.851 | 2.849 | 2.863 | 2.869 | 2.885 | 2.896 |
| Sodium Bicarbonate | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Lime | 1.155 | 1.235 | 1.247 | 1.248 | 1.241 | 1.237 | 1.229 | 1.223 |
| Potassium Chloride | 1.121 | 0.924 | 0.894 | 0.891 | 0.91 | 0.918 | 0.94 | 0.954 |
| Vitamin A[1] | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 |
| Vitamin D[2] | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Choline Chloride | 0.264 | 0.223 | 0.217 | 0.216 | 0.22 | 0.222 | 0.226 | 0.229 |
| Vitamin K[3] | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 |
| Isoleucine | 0.119 | 0.232 | 0.33 | 0.438 | 0.554 | 0.667 | 0.784 | 0.899 |
| Leucine | 0.137 | 0.265 | 0.449 | 0.672 | 0.923 | 1.159 | 1.413 | 1.657 |
| Phenylalanine | 0.167 | 0.323 | 0.488 | 0.677 | 0.885 | 1.084 | 1.294 | 1.498 |
| Trace Mineral[4] | 0.07 | 0.058 | 0.056 | 0.056 | 0.057 | 0.058 | 0.059 | 0.06 |
| Threonine | 0 | 0 | 0.063 | 0.137 | 0.22 | 0.298 | 0.381 | 0.461 |
| Vitamin Premix[5] | 0.052 | 0.047 | 0.046 | 0.046 | 0.047 | 0.047 | 0.047 | 0.048 |
| Arginine | 0.112 | 0.217 | 0.328 | 0.457 | 0.597 | 0.731 | 0.874 | 1.011 |
| Tryptophan | 0.051 | 0.097 | 0.129 | 0.162 | 0.197 | 0.23 | 0.265 | 0.299 |
| Selenium Premix | 0.031 | 0.032 | 0.031 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Valine | 0.088 | 0.173 | 0.267 | 0.377 | 0.498 | 0.614 | 0.737 | 0.856 |
| Glycine | 0.036 | 0.07 | 0.138 | 0.223 | 0.319 | 0.411 | 0.509 | 0.604 |
| Vitamin $B_{12}$[6] | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 |
| Histidine HCl | 0.053 | 0.102 | 0.158 | 0.222 | 0.294 | 0.363 | 0.435 | 0.506 |
| Vitamin E[7] | 0.143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lysine HCl | 0.332 | 0.644 | 0.86 | 1.087 | 1.323 | 1.554 | 1.792 | 2.025 |
| DL Methionine | 0.093 | 0.147 | 0.239 | 0.347 | 0.468 | 0.582 | 0.705 | 0.822 |
| Cobalt Sulfate | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Iodized Salt | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 |
| Glutamic Acid | 0 | 0 | 0 | 0 | 0 | 0 | 2.19 | 3.219 |

[1]A vitamin A source was created by diluting vitamin A with cornstarch to provide 563.41 IU/kg of vitamin A; [2]A vitamin D source was created by diluting vitamin D with cornstarch to provide 220,000 ICU/kg of vitamin D; [3]A vitamin K source was created by diluting vitamin K with cornstarch to provide 840 mg/kg of vitamin K; [4]Trace Mineral Premix supplied the following per kg of diet: zinc, 140,000 mg; copper, 8,000 mg; manganese, 140,000 mg: iron, 130,000 mg; [5]Vitamin Premix provided the following amounts per kg of diet: thiamin, 2,200 mg: niacin, 110,000 mg: folacin, 2,750 mg: vitamin $B_{12}$, 22 mg: riboflavin, 13,200 mg: pantothenic acid, 33,000 mg: pyridoxine, 4,400 mg: biotin, 440 mg; [6]A vitamin $B_{12}$ source was created by diluting vitamin $B_{12}$ with cornstarch to provide 10,900 mg/kg of vitamin $B_{12}$; [7]A vitamin E source was created by diluting vitamin E with cornstarch to provide 2.750 IU/kg of vitamin E

Table 2: Nutrient Composition[1,2,3] of Experimental Diets for Threonine Trials. (Experiment 1)

| Threonine Treatment: | 0.08% | 0.155% | 0.23% | 0.305% | 0.38% | 0.455% | 0.53% | 0.605% |
|---|---|---|---|---|---|---|---|---|
| Crude Protein, % | 4.23 | 8.17 | 9.76 | 11.09 | 12.23 | 13.47 | 16.79 | 19.00 |
| ME, kcal/kg | 3701 | 3600 | 3582 | 3581 | 3587 | 3589 | 3596 | 3600 |
| Calcium, % | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Available Phosphorous, % | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

[1]Other nutrients, with the exception of essential amino acids, were provided according to NRC (1994); [2]As the subject amino acid treatment level increased. Essential amino acids were added according to the Missouri Ideal Turkey Ratio with a 15% safety margin. At the time of diet formulation the ratio was as follows: Lys 100%, TSAA 59%, Thr 55%, Val 61%, Arg 71%, His 36%, Ile 69%, Leu 124%, Phe+Tyr 105% and Thr 16%; [3]Values were calculated based on the amino acid analysis of corn and multiplied by the digestibility coefficients determined in turkeys

The treatment levels of percent threonine in the diets of the first trial were as follows; 0.08, 0.155, 0.23, 0.305, 0.38, 0.455, 0.53 and 0.605 (Table 1 and 2). The treatment levels of percent threonine in the diets of the second trial were as follows: 0.08, 0.13, 0.18, 0.23, 0.28, 0.33, 0.38 and 0.43 (Table 3 and 4). All other amino acids were maintained at 15% excess relative to threonine level based on the Missouri Ideal Turkey Ratio. Glutamic acid was added to the diets to prevent confounding of results due to a generalized nitrogen deficit.

Poults were housed in stainless steel batteries in a thermostatically controlled room with constant fluorescent lighting. Access to experimental diets and

Table 3: Composition of Experimental Diets for Threonine Trials (Experiment 2)

| Threonine Treatment: | 0.08% | 0.13% | 0.18% | 0.23% | 0.28% | 0.33% | 0.38% | 0.43% |
|---|---|---|---|---|---|---|---|---|
| Corn | 36.697 | 59.633 | 77.136 | 76.134 | 75.137 | 74.136 | 73.134 | 72.134 |
| Sucrose | 40.42 | 17.687 | 0 | 0 | 0 | 0 | 0 | 0 |
| Corn Oil | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| Sand | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Dicalcium Phosphate | 3.019 | 2.922 | 2.848 | 2.852 | 2.857 | 2.861 | 2.865 | 2.869 |
| Sodium Bicarbonate | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Lime | 1.155 | 1.208 | 1.249 | 1.247 | 1.244 | 1.242 | 1.24 | 1.237 |
| Potassium Chloride | 1.121 | 0.99 | 0.87 | 0.895 | 0.901 | 0.907 | 0.913 | 0.918 |
| Vitamin A[1] | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 | 1.007 |
| Vitamin D[2] | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Choline Chloride | 0.264 | 0.23 | 0.216 | 0.217 | 0.218 | 0.219 | 0.221 | 0.222 |
| Vitamin K[3] | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 | 0.208 |
| Isoleucine | 0.199 | 0.221 | 0.255 | 0.33 | 0.406 | 0.48 | 0.555 | 0.63 |
| Leucine | 0.3 | 0.277 | 0.294 | 0.452 | 0.61 | 0.768 | 0.927 | 1.084 |
| Phenylalanine | 0.306 | 0.317 | 0.356 | 0.489 | 0.621 | 0.754 | 0.888 | 1.02 |
| Trace Mineral[4] | 0.07 | 0.062 | 0.056 | 0.056 | 0.057 | 0.057 | 0.058 | 0.058 |
| Threonine | 0 | 0 | 0.012 | 0.064 | 0.116 | 0.168 | 0.221 | 0.273 |
| Vitamin Premix[5] | 0.052 | 0.049 | 0.046 | 0.046 | 0.047 | 0.047 | 0.047 | 0.047 |
| Arginine | 0.205 | 0.214 | 0.24 | 0.329 | 0.418 | 0.509 | 0.598 | 0.688 |
| Tryptophan | 0.075 | 0.089 | 0.106 | 0.129 | 0.151 | 0.173 | 0.197 | 0.219 |
| Selenium Premix | 0.031 | 0.03 | 0.029 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Valine | 0.169 | 0.171 | 0.191 | 0.268 | 0.345 | 0.422 | 0.499 | 0.577 |
| Glycine | 0.278 | 0.305 | 0.351 | 0.458 | 0.565 | 0.672 | 0.779 | 0.887 |
| Vitamin $B_{12}$[6] | 0.027 | 0.027 | 0.02 | 0.027 | 0.027 | 0.027 | 0.027 | 0.027 |
| Histidine HCl | 0.1 | 0.101 | 0.113 | 0.159 | 0.204 | 0.249 | 0.295 | 0.341 |
| Vitamin E[7] | 0.143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lysine HCl | 0.498 | 0.595 | 0.706 | 0.861 | 1.015 | 1.17 | 1.324 | 1.478 |
| DL Methionine | 0.156 | 0.15 | 0.164 | 0.241 | 0.316 | 0.393 | 0.469 | 0.546 |
| Cobalt Sulfate | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Iodized Salt | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 |
| Glutamic Acid | 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[1]A vitamin A source was created by diluting vitamin A with cornstarch to provide 563.41 IU/kg of vitamin A; [2]A vitamin D source was created by diluting vitamin D with cornstarch to provide 220,000 ICU/kg of vitamin D; [3]A vitamin K source was created by diluting vitamin K with cornstarch to provide 840 mg/kg of vitamin K; [4]Trace Mineral Premix supplied the following per kg of diet: zinc. 140,000 mg: copper. 8,000 mg: manganese 140,000 mg: iron. 130,000 mg; [5]Vitamin Premix provided the following amounts per kg of diet: thiamin 2,200 mg: niacin 110,000 mg: folacin 2,750 mg: vitamin $B_{12}$ 22 mg: riboflavin 13,200 mg: pantothenic acid 33,000 mg: pyridoxine 4,400 mg: biotin 440 mg; [6]A vitamin $B_{12}$ source was created by diluting vitamin $B_{12}$ with cornstarch to provide 10,900 mg/kg of vitamin $B_{12}$.; [7]A vitamin E source was created by diluting vitamin E with cornstarch to provide 2,750 IU/kg of vitamin E

Table 4: Nutrient Composition[1,2,3] of Experimental Diets for Threonine Trials (Experiment 2)

| Threonine Treatment: | 0.08% | 0.13% | 0.18% | 0.23% | 0.28% | 0.33% | 0.38% | 0.43% |
|---|---|---|---|---|---|---|---|---|
| Crude Protein, % | 5.29 | 7.38 | 9.19 | 1.06 | 10.93 | 11.80 | 12.67 | 13.54 |
| ME, kcal/kg | 3696 | 3628 | 3576 | 3576 | 3577 | 3578 | 3578 | 3579 |
| Calcium, % | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Available Phosphorous, % | .6 | .6 | .6 | .6 | .6 | .6 | .6 | .6 |

[1]Other nutrients, with the exception of essential amino acids, were provided according to NRC (1994); [2]As the subject amino acid treatment level increased. Essential amino acids were added according to the Missouri Ideal Turkey Ratio with a 15% safety margin. At the time of diet formulation the ratio was as follows: Lys 100%, TSAA 59%, Thr 55%, Val 61%, Arg 71%, His 36%, Ile 69%, Leu 124%, Phe+Tyr 105% and Thr 16%; [3]Values were calculated based on the amino acid analysis of corn and multiplied by the digestibility coefficients determined in turkeys

water was provided *ad libitum* for 7 days. Poults were deprived of feed for 10 hours to remove gut fill prior to being killed ($CO_2$ asphyxiation), weighed and frozen for later analysis.

Frozen birds were ground and a sub-sample was retained for analysis. Samples were weighed and dried in a laboratory oven at 60°C for 48 hours. Dried samples were weighed to determine dry matter content prior to being ground. Ground samples were analyzed by LECO® to determine nitrogen content.

Analysis of data was performed using pen means as the experimental unit. The JMP (SAS®) statistical software package was used to provide linear regression equations.

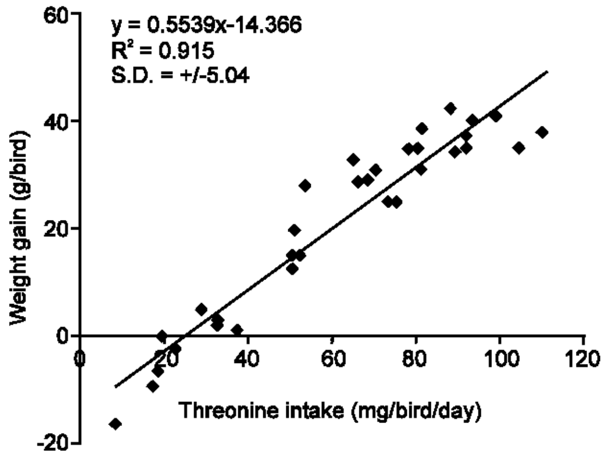


Fig. 1: Plot of Weight Gain (Y) as a Function of Threonine Intake (X), Experiment 1

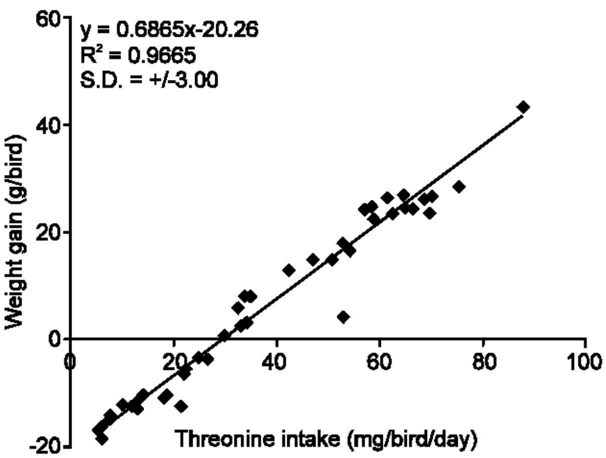


Fig. 2: Plot of Weight Gain (Y) as a Function of Threonine Intake (X), Experiment 2

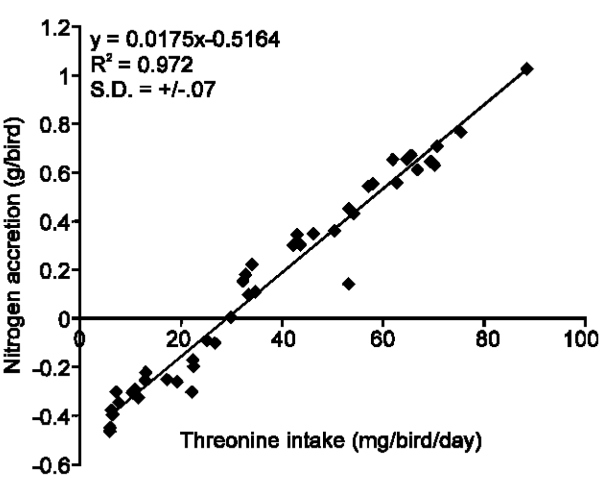


Fig. 3: Plot of Nitrogen Accretion (Y) as a Function of Threonine Intake (X), Experiment 2

## Results and Discussion

In both of the trials, weight gain responded linearly to threonine intake ($p<0.001$) and in the second experiment, nitrogen accretion also responded linearly to threonine intake ($p<0.001$). For reasons that will be explained later, nitrogen analysis was not conducted for the second trial.

In the first experiment, the relationship of weight gain to threonine intake (Fig. 1) was linear with the following form; Y = 0.5539X-14.366 ($R^2$ = 0.915). The predicted requirement resulting from this equation is 25.94 mg/bird/day of threonine to maintain body weight and including body weight in the equation yields a requirement of 250.48 mg/kg body weight/day.

The second experiment reinforced the linear relationship of weight gain to threonine intake (Fig. 2) that was found in the previous study. The relationship was illustrated by the equation Y = 0.6865X-20.26 ($R^2$ = 0.97), which predicts a requirement of 29.51 mg/bird/day of threonine to maintain body weight. Nitrogen accretion also exhibited a straight-line response to threonine intake (Fig. 3); Y = 0.0175X-0.5164 ($R^2$ = 0.97). Based on this equation, the requirement for maintenance of nitrogen level is 29.51 mg/bird/day of threonine. In both instances, the requirement as a function of body weight was 261.38 mg/kg body weight/day.

Due to the possibility of complications due to high mortality in the first trial, it was determined that a second trial would be beneficial in determining the correct requirement. As a result of this decision, nitrogen analysis was not conducted for the first trial.

Based on the strength of the linear responses ($p<0.001$) of the measured parameters to threonine intake, it is very likely that the relationship between threonine accretion and threonine intake is also linear. The titrations of threonine in the experimental diet were lowered for the second trial since there were not sufficient data points below the maintenance level. The threonine levels used for the second experiment were such that a good distribution of data points occurred both above and below the maintenance requirement.

Although these levels of dietary threonine were adequate for the maintenance of body weight and nitrogen levels, it is a possibility that the requirement for maintenance of threonine accretion could be found to be higher than the requirement for nitrogen accretion as in broilers (Edwards *et al.*, 1997).

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