



## Layer Performance Recovery After Feeding Amino Acid-deficient Diets

### Recuperação do Desempenho de Poedeiras Após Alimentação com Dietas Deficientes em Aminoácidos

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#### ABSTRACT

Three hundred and twenty Hy-Line W36<sup>®</sup> commercial laying hens, 39 weeks of age, were used to determine the sequence and the length of time needed for hens to recover performance characteristics after an eight-week period under graded levels of threonine deficiency. Eight experimental diets with Thr levels ranging from 0.35 to 0.53% were randomly fed with eight replicates of five hens each. After the previous experiment, the hens were fed a control diet (0.53% Thr) for a four-week period. Feed consumption (FC), energy intake (EI), egg production (EP), egg weight (EW), egg mass (EM), and body weight (BW) were evaluated. All performance characteristics were impaired on Thr deficient diets. The recovery sequence order was FC and EI; EP, EW and EM, and finally BW, with the length of time of two, three, and four weeks, respectively. The data indicated that an amino acid deficiency does not cause permanent damage to the reproductive system of the hens.

#### RESUMO

Trezentas e vinte poedeiras comerciais *Hy-Line W36<sup>®</sup>* com 39 semanas de idade foram utilizadas com o objetivo de determinar a seqüência e o tempo necessário para as galinhas recuperarem as características de desempenho após um período de oito semanas de alimentação, com dietas contendo diferentes níveis de treonina. Oito dietas experimentais, com níveis de treonina variando de 0,35 a 0,53%, foram distribuídas ao acaso, com oito repetições de cinco aves cada. Após esse prévio experimento, as aves foram alimentadas com a dieta controle (0,53% Thr) por quatro semanas em que as características: consumo de ração (CR), de energia (CE), produção de ovos (PO), peso de ovos (PE), massa de ovos (MO) e peso corporal (PC) foram avaliadas. Todas as características foram prejudicadas com dietas deficientes em Thr, e a seqüência da recuperação ocorreu na seguinte ordem: CR e CE; PO, PE e MO e, por último, PC, nos prazos de duas, três e quatro semanas, respectivamente. Os dados obtidos indicaram que uma deficiência em aminoácidos não causa um dano permanente ao sistema reprodutivo das galinhas.



## INTRODUCTION

Nutritionists usually formulate diets for commercial laying hens to achieve maximum performance and maximum economic return. Feeding programs should meet the nutrient requirements according to the production phase or age of hens. Most of these feeding programs are based on the daily feed intake concept, which was first suggested by Harms et al. (1978) and later modified by Harms (1981).

Dietary manipulation can have different objectives such as increasing early egg weight (Bohnsack & Harms, 2000), reducing egg weight and improving eggshell quality in old and young hens (Roland, 1980a,b), improving egg size classification (Zimmerman, 1997; Harms, 2000), and for diets used just before hens are marketed or molted (Kuchinski & Harms, 1993). However, if the margin of safety is too small and variation of feed ingredients results in considerably less amino acids in the feed, performance of the hen will be reduced (Harms & Russell, 1998).

Harms & Ivey (1993) evaluated the performance of layers fed various supplemental amino acids in a corn-soybean meal diet and concluded that methionine and lysine were the first two limiting amino acids, with tryptophan, arginine or threonine being third. On the other hand, NRC (1994) suggested a daily intake of 470 mg/day of threonine for maximum performance of laying hens.

Therefore, this experiment was conducted to determine the sequence and the length of time needed for hens to recover various performance characteristics after receiving diets deficient in amino acids with threonine being the most limiting.

## MATERIALS AND METHODS

Three hundred and twenty Hy-Line W36® commercial laying hens, 39 weeks of age, were used in this experiment. They were randomly housed one bird per wire cage (25.6 x 42.6 cm) in a windowless, fan-ventilated house. The temperature was controlled to get a uniform feed intake. It was not allowed to fall below 26.7°C and was almost constant because the experiment was conducted in February and March. They were given artificial light (16h light:8h dark). Feed and water were provided ad libitum.

Previously, the hens were fed eight experimental diets with various deficient amino acids levels (Table 1) from

31 to 38 weeks of age. In this previous study (Faria et al., 2002), Diet 1 was a positive control diet containing 0.53% Thr and other amino acids previously found to support maximum performance (Harms & Russell, 1996). Diet 2 contained 0.50% Thr (95% of Diet 1) and other supplemental amino acids (AA), at levels equal to Diet 1 and expected to support maximum performance. Diet 3 contained 0.48% Thr (90% of Diet 1), and other AA were included at 95% of the levels in Diet 2. Diet 4 contained 0.45% Thr (85% of Diet 1), and other AA were included at 90% of the levels in Diet 2. Diet 5 contained 0.42% Thr (80% of Diet 1), and other AA were included at 85% of the levels in Diet 2. Diet 6 contained 0.40% Thr (75% of Diet 1), and other AA were included at 80% of the levels in Diet 2. Diet 7 contained 0.37% Thr (70% of Diet 1), and other AA were included at 75% of the levels in Diet 2. Diet 8 contained 0.35% Thr (65% of Diet 1), and other AA were included at 70% of the levels in Diet 2. At the termination of the previous experiment the hens receiving Diets 2 to 8 were placed on Diet 1 for four weeks (Table 1). The eight replicates of five hens, which were fed these diets for eight weeks, were used to evaluate the performance recovery from each diet.

Performance of the last week of the previous experiment is indicated as week -1. Feed consumption (FC), energy intake (EI), egg production (EP), egg weight (EW), egg mass (EM), and the final body weight were used to indicate the severity of the amino acid deficiency. Egg mass was obtained for multiplying EP by EW. Hens were individually weighed at the termination of the previous experiment and bi-weekly during the next four weeks. Body weight (BW) change was calculated biweekly from initial BW during the four-week period. Weekly FC, EI, EP, EW, and EM were obtained and replicate values were used for statistical analyses. The data were subject to a one-way ANOVA using the general linear model procedure of SAS® (SAS Institute, 1996). Duncan's multiple-range test (1955) was used to determine significant differences among treatment means.

## RESULTS

### FEED CONSUMPTION AND ENERGY INTAKE

Feed consumption and energy intake were significantly reduced when hens were fed the three diets containing the lowest levels of amino acids, as indicated at week -1 (Table 2). There was a small recovery of FC and EI when hens were fed the control diet for one



week. However, FC and EI were equal to control after hens had received the control diet for two weeks.

There were no differences in FC and EI among treatments during weeks 3 and 4. This indicated that the severity of the amino acid deficiencies did not affect the recovery for these measurements. This disagrees with a previous report (Harms & Russell, 1998) that hens fed a diet with a very low level of Trp significantly increased FC during the first two weeks after they were fed the control diet. Possibly, it indicates that the hen responds differently to deficiencies of various amino acids.

### **EGG PRODUCTION**

Egg production was significantly reduced for hens fed the three diets containing the lowest levels of amino acids in week -1 (Table 3). Egg production gradually increased during the first two weeks after returning the hens to the control diet. During weeks 3 and 4 there were no significant differences in EP among the treatments. The recovery in EP when the hens were previously fed a diet extremely low in amino acids is the same response as previously found for Trp (Harms & Russell, 1998). The lack of an increase during the first two weeks was expected because the number of ova that had started to mature when the hens were returned to the control diet determined the number of eggs during this period.

### **EGG WEIGHT**

Egg weight was significantly reduced for hens fed the three diets containing the lowest levels of amino acids in week -1 (Table 3). There was an increase in EW after the hens received the control diet for one week. Egg weight continued to increase during the second week. During the third week there was no differences in EW among treatments. The recovery in EW from hens previously fed a diet extremely low in amino acids agrees with a previous report (Harms & Russell, 1998) that hens fed a diet extremely low in Trp restored EW in three weeks.

### **EGG MASS**

Egg mass was significantly reduced for hens fed the three diets containing the lowest levels of amino acids in week -1 (Table 3). Egg mass from hens previously fed diets deficient in amino acids was

increased at the end of one week. The EM continued to increase during week 2. There were no significant differences in EM among all treatments during weeks 3 and 4.

### **BODY WEIGHT AND BODY WEIGHT CHANGE**

Body weight was significantly reduced when the hens previously received diets deficient in amino acids (Table 4). Hens previously fed amino acids deficient diets gained significantly more weight during the first two weeks after receiving the control diet. They also continued to gain more weight during the second two weeks. Hens previously fed the diet containing the lowest level of amino acids weighed significantly less at the end of fourth week than control hens.

### **DISCUSSION**

Hens previously fed the three diets containing the lowest levels of amino acids during eight weeks (Faria et al., 2002) showed a reduction in feed consumption and energy intake about 21 and 16%, respectively, in comparison to control diet. Also, egg production, egg weight, egg mass, and body weight were reduced about 27, 7, 30, and 13%, respectively. The findings about reductions in EP and EW are in agreement with findings of Morris & Gous (1988). They stated that the egg size does not decrease below 90% of its maximum value until amino acid intake is well below 50% of the optimum value, whereas; rate of lay is only 70% of its potential value when amino acid intake is half the optimum.

The results of this experiment indicated that hens fed a diet deficient in amino acids will return to normal performance in three weeks when fed a nutritionally adequate diet. Figure 1 shows the length of time needed for hens to recover FC, EP, EW, and BW, and the recovery percentage each week after hens have received the control diet.

Egg production and EW gradually increased, and by the end of week 3 was equal to the EP and EW of control hens. The small increase in EP during the first two weeks was a result of the growth of ova, which had started during the previous experiment when hens were fed deficient diets. A more rapid increase in EW was observed as FC increased, which furnished more amino acids for formation of yolks. The increase in EM during the first two weeks was due to the increase of EP and EW.

The hens previously fed amino acid deficient diets increased FC during the first two weeks after receiving the control diet. The increased energy and amino acid intakes resulted in increase BW, EP, EW, and EM. These increases resulted in no significant difference among



treatments after four weeks, except in BW. This indicates no permanent damage was done to the reproductive system from feeding an amino acid deficient diet for eight weeks. This is important when reducing the margin of safety for amino acids.

A new program has recently been developed to more precisely calculate the needed amino acids (Harms & Faria, 2001). This program also allows for the early detection of an amino acid deficiency, which can be rapidly corrected.

## CONCLUSIONS

Feeding of diets deficient in amino acids reduces egg production, egg weight, egg mass, and body weight about 27, 7, 30, and 13%, respectively.

Hens returned to a complete diet rapidly return to normal production parameters. Feed consumption was recovered within two weeks; egg production, egg weight, and egg mass were recovered within three weeks. Body weight was recovered within four weeks, except for hens fed the diet with extremely low level of amino acids. Therefore, there is no permanent damage to the reproductive system when hens were fed amino acid deficient diets for eight weeks.

**Table 1** - Composition of experimental diets.

Ingredient (%)	Diet							
	1	2	3	4	5	6	7	8
Yellow corn	71.39	72.88	74.61	76.27	78.00	79.67	81.39	83.06
Soybean meal (48%)	18.63	16.97	15.22	13.54	11.79	10.11	8.36	6.67
Limestone	7.51	7.51	7.50	7.49	7.48	7.48	7.47	7.46
Dicalcium phosphate <sup>1</sup>	1.27	1.30	1.33	1.36	1.40	1.43	1.46	1.49
Salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Vitamin mix <sup>2</sup>	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral mix <sup>3</sup>	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.08	0.09	0.08	0.08	0.07	0.06	0.05	0.04
Lys-HCl	0.12	0.18	0.18	0.19	0.20	0.20	0.21	0.22
Trp	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Ile	0.07	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Val	0.03	0.07	0.06	0.06	0.06	0.05	0.05	0.04
<b>Calculated analysis<sup>4</sup> (%)</b>								
Protein	14.44	13.87	13.16	12.48	11.77	11.09	10.38	9.69
Calcium	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Phosphorus	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Thr	0.53	0.50	0.48	0.45	0.42	0.40	0.37	0.35
Met	0.34	0.34	0.32	0.31	0.29	0.27	0.26	0.24
Lys	0.82	0.82	0.78	0.74	0.70	0.66	0.62	0.57
Trp	0.19	0.19	0.18	0.17	0.16	0.15	0.14	0.13
Ile	0.65	0.65	0.62	0.59	0.55	0.52	0.49	0.46
Val	0.70	0.70	0.67	0.63	0.59	0.56	0.53	0.49
ME, kcal/kg	2,860	2,876	2,891	2,905	2,920	2,935	2,950	2,964

1 - Contains 18.5% P and 21% Ca.

2,3 - See Harms & Russell (2000).

4 - Based on analysis of corn and soybean meal

**Table 2** - Feed consumption and energy intake of commercial laying hens.

<i>Dietary Thr</i>	<i>Week -1</i>	<i>Week 1</i>	<i>Week 2</i>	<i>Week 3</i>	<i>Week 4</i>
<b>Feed consumption (g/hen/day)</b>					
0.53	97.77a	100.12a	93.31a	97.68a	93.63a
0.50	100.12a	100.60a	92.99a	101.09a	94.18a
0.48	95.33a	97.68ab	91.85a	94.93a	93.31a
0.45	96.21a	99.39a	93.80a	96.35a	93.07a
0.42	94.44a	99.30a	94.12a	97.68a	96.09a
0.40	85.62b	91.69c	93.31a	97.68a	95.42a
0.37	83.02b	92.70bc	89.91a	95.13a	93.96a
0.35	69.74c	86.18d	92.66a	97.20a	94.61a
CV (%)	5.80	5.54	5.53	6.55	4.76
<b>Energy intake (kcal ME/hen/day)</b>					
0.53	280a	286a	267a	279a	268a
0.50	288a	289a	267a	291a	271a
0.48	276a	282ab	266a	274a	270a
0.45	280a	289a	273a	280a	270a
0.42	276a	290a	275a	285a	281a
0.40	251b	269bc	274a	287a	280a
0.37	245b	273ab	265a	281a	277a
0.35	207c	255c	275a	288a	280a
CV (%)	5.82	5.56	5.55	6.54	4.75

a-d: Means with the same superscript within a column do not differ significantly ( $p < 0.05$ ).

**Table 3** - Egg Production, egg weight, and egg mass from commercial laying hens.

<i>Dietary Thr</i>	<i>Week -1</i>	<i>Week 1</i>	<i>Week 2</i>	<i>Week 3</i>	<i>Week 4</i>
<b>Egg production (% egg/hen/day)</b>					
0.53	88.93a	90.00a	90.54a	87.86a	87.86ab
0.50	88.30a	89.02a	88.21ab	87.50a	85.83b
0.48	86.88a	88.21ab	88.75ab	88.13a	87.14ab
0.45	90.27a	89.46a	91.34a	87.23a	92.02 <sup>a</sup>
0.42	85.00a	83.57bc	91.43a	89.64a	87.14ab
0.40	73.93b	79.11c	85.71bc	87.86a	87.50ab
0.37	70.09b	72.68d	83.48c	86.43a	87.23ab
0.35	53.93c	65.36e	85.00bc	88.57a	89.80a
CV (%)	6.08	5.78	4.18	4.04	4.76
<b>Egg weight (g)</b>					
0.53	58.62ab	59.39ab	59.30ab	59.54a	60.36ab
0.50	59.80a	59.99a	60.24a	59.97a	61.28a
0.48	58.03b	59.55ab	58.75ab	59.33a	59.70ab
0.45	57.12bc	57.86bcd	58.22b	59.38a	58.73b
0.42	57.66bc	58.21bc	59.00ab	58.97a	60.43ab
0.40	56.13c	58.34abc	57.81b	59.31a	58.96b
0.37	56.26c	57.14cd	58.68ab	60.36a	61.10a
0.35	54.29d	56.26d	57.84b	58.61a	58.51b
CV (%)	2.85	2.64	2.74	2.86	3.03
<b>Egg mass (g/hen/day)</b>					
0.53	52.11a	53.47a	53.69a	52.32a	53.01a
0.50	52.78a	53.40a	53.12a	52.51a	52.58a
0.48	50.42ab	52.53a	52.13ab	52.26a	52.02a
0.45	51.56ab	51.75a	53.20a	51.78a	54.02a
0.42	49.00b	48.61b	53.98a	52.86a	52.66a
0.40	41.46c	46.13b	49.56bc	52.10a	51.53a
0.37	39.46c	41.57c	48.95c	52.17a	53.25a
0.35	29.25d	36.80d	49.20c	51.90a	52.52a
CV (%)	6.18	6.23	5.14	4.83	4.53

a-d: Means with the same superscript within a column do not differ significantly ( $p < 0.05$ ).



Table 4 - Body weight and body weight change of commercial laying hens.

Dietary Thr	Initial body weight	Week 2	Week 4
<b>Body weight (g)</b>			
0.53	1,521ab	1,550ab	1,556b
0.50	1,589a	1,613a	1,650a
0.48	1,485bc	1,530ab	1,507b
0.45	1,492bc	1,539ab	1,537b
0.42	1,498bc	1,554ab	1,564b
0.40	1,419cd	1,486b	1,492b
0.37	1,385d	1,468b	1,493b
0.35	1,258e	1,384c	1,391c
CV (%)	5.44	5.46	5.44
<b>Body weight change (g)</b>			
0.53	1,521ab	29.0ed	7.6bc
0.50	1,589a	25.0e	25.3abc
0.48	1,485bc	45.0cde	3.6c
0.45	1,492bc	47.0cde	13.5bc
0.42	1,498bc	56.0bcd	14.8bc
0.40	1,419cd	67.0bc	33.5ab
0.37	1,385d	82.0b	25.8abc
0.35	1,258e	126.0a	43.3a
CV (%)	5.44	42.94	120.61

a-e: Means with the same superscript within a column do not differ significantly ( $p < 0.05$ ).

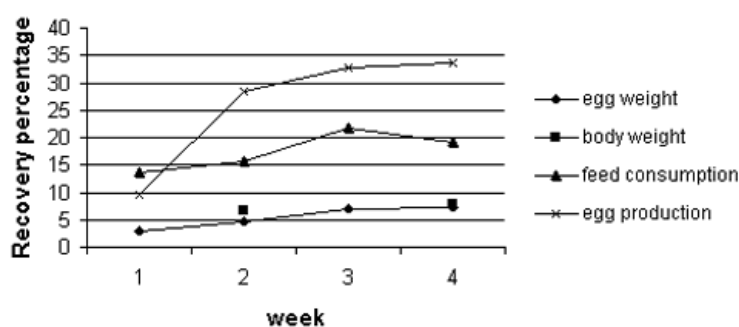


Figure 1 - Recovery percentage of feed consumption, egg production, egg weight and body weight of hens fed amino acid-deficient diets.

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