

# EFFECTS OF DIETARY TRYPTOPHAN LEVEL AND FOOD INTAKE ON ENERGY UTILIZATION BY MALE GROWING CHICKS

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## Summary

Two experiments involving comparative slaughter procedures were conducted to see if the decrease in total energy retention (ER) resulted from the decreased food intake in growing chicks fed on a diet containing tryptophan less than the requirement. *Ad libitum*-feeding a diet containing 50% of tryptophan of a control diet (1.5 g/kg) decreased body weight gain, apparent metabolizable energy intake (AMEI), ER and ER:AMEI ratio. When both the control diet and the 0.75 g/kg tryptophan diet were tube-fed at the two levels of food intake, body weight gain was significantly lower in chicks on the low tryptophan diet than in the control chicks at each level of intake. AME: gross-energy ratio decreased only when the low tryptophan diet was tube-fed at the higher level of intake. Energy retained as protein was significantly decreased by the low tryptophan level and reduction of food intake. Energy retained as fat was affected by food intake. ER and ER:AMEI ratio were unaffected by dietary tryptophan level and were proportional to AMEI. Heat increment of feeding was affected by neither tryptophan nor food intake. These results indicate that the decreased ER in chicks fed on the low tryptophan diet was due mainly to the decreased food intake and not to the decreased efficiency of ME utilization.

(Key Words: Tryptophan Deficiency, Food Intake, Energy Retention, Chicks)

## Introduction

Deficiencies of some single essential amino acids decrease food intake, body weight gain, and ER. Tasaki et al. (1972) and Yanaka and Tasaki (1980) showed the efficiency of ME utilization to be a main factor affecting ER in growing chicks fed on a diet deficient in lysine or sulfur amino acids. Recently, the decreased ER in chicks fed on a diet deficient in arginine or sulfur amino acids has been reported to be associated with the decreased food intake (Sugahara et al., 1985, Sugahara and Kubo, 1992). Tryptophan (TRP) is regarded as the third limiting amino acid in corn-soybean type diets for growing chicks. In order to determine if levels of dietary TRP affect the efficiency of energy utilization by growing chicks we fed *ad libitum* diets containing four levels of TRP to chicks in experiment 1. Experiment 2 in which chicks were tube-fed on the

diets containing two levels of TRP at two levels of food intake was carried out to see if changes in ER was associated with different intakes of the high and low TRP diets.

## Materials and Methods

Two experiments were conducted, and the procedures were identical in the two experiments unless otherwise indicated.

In each experiment 200 one-day-old male layer-strain chicks were fed *ad libitum* on a commercial chick starter diet (crude protein (CP) 200 g/kg, AME 12.1 MJ/kg) for 4 days. At 5 days of age 48 chicks were selected according to body weight after 3 hours of starvation. They were fed *ad libitum* (experiment 1) or tube-fed 3 times a day (experiment 2) on the control diet for the following three days. At 8 days of age 25 chicks were selected from the 48 chicks and were divided into 5 groups of 5 chicks each so that the initial body weight was as uniform as possible. The 4 groups were individually housed in metabolism cages and randomly allocated to the experimental treatments from 8 to 22 days of posthatching. The other group was killed for

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analysis of initial body composition. The experimental treatments of experiment 1 included the four dietary TRP levels (0.375, 0.75, 1.125 and 1.5 g/kg) with *ad libitum* feeding (figure 1). In experiment 2 a 2 × 2 factorial experimental design (dietary TRP level: 0.75 and 1.5 g/kg and food intake level: 213.5 and 118 g/chick/14 days) was used (figure 1). The higher and lower levels of food intake were designed to be equal to the food consumption of chicks fed *ad libitum* on the diets containing 1.5 and 0.75 g/kg TRP, respectively, in experiment 1. The method of tube-feeding was used to control the amount of food intake and the pattern of intake. The diets had been mixed with water in the ratio 1:0.66 (w:w) immediately before they were administered into the crop using a syringe with a tube 3 times daily, at 09:00, 13:00 and 18:00 hours.

The composition of the control diet is shown in table 1. The diets containing 0.375, 0.75, and

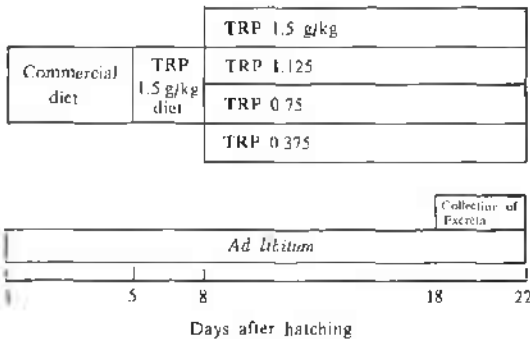
1.125 g/kg TRP were formulated by reducing 75, 50 and 25% of TRP of the control diet, respectively. The dietary level of niacin was made to be 100 mg/kg. The CP and gross-energy (GE) levels of the experimental diets were kept at 145 g/kg and 18.5 MJ/kg, respectively.

TABLE 1. COMPOSITION OF CONTROL DIET

Ingredients	g/kg
Cornstarch	552.2
Amino acid mixture <sup>1</sup>	192.5
Corn oil	150.0
Cellulose	30.0
Mineral mixture <sup>2</sup>	53.3
Sodium bicarbonate	10.0
Vitamin mixture <sup>2</sup>	10.0
Choline chloride	2.0
Total	1,000.0
CP	145 g/kg
GE	18.5 MJ/kg

<sup>1</sup> Composition of amino acid mixture (g/kg diet): L-arginine · HCl 12.1, L-cystine 3.5, L-glutamic acid 100.0, glycine 12.0, L-histidine · HCl 3.75, L-isoleucine 6.0, L-leucine 12.0, L-lysine · HCl 11.9, DL-methionine 3.5, L-phenylalanine 5.0, L-proline 2.0, L-threonine 6.5, L-tryptophan 1.5, L-tyrosine 4.5, and L-valine 8.2 g/kg.

<sup>2</sup> Velu et al. (1971). For details see Sugahara et al. (1984).

Experiment 1 (*Ad libitum* feeding)

## Experiment 2 (Tube-feeding)

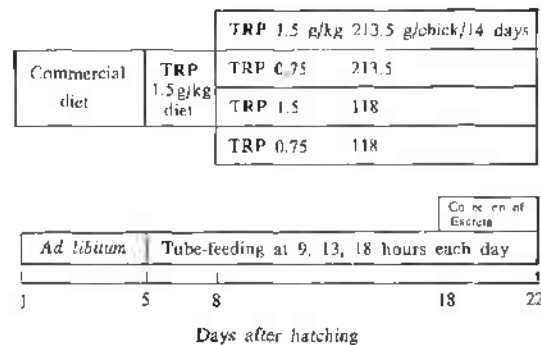


Figure 1. Designs of experiments.

ERP and ERF were derived by calculation from protein (Nitrogen × 6.25) and fat retentions with energy coefficients of 23.68 kJ/g for protein and 39.12 kJ/g for fat. ER was a sum of ERP and ERF. The procedures for grinding carcasses and determining their nitrogen and fat content were similar to those of our previous study (Sugahara et al., 1985). Heat increment was calculated as the difference between ER plus starving heat production and AMEI. Starving heat production was estimated to be 400 kJ/kg<sup>0.75</sup> day (Sugahara et al., 1984; Sugahara et al., 1988) and assumed not to be affected by dietary TRP level. Dietary AME value was calculated as the difference of the GE of the diets eaten and the excreta voided during the last 4 days of the experiments.

Lighting was continuously provided with flu-

orescent lamps. The environmental temperature ranged from 32 to 35°C.

### Results and Discussion

The effects of the dietary TRP level on the performance of growing chicks are presented in table 2. Food intake, body weight gain, feed conversion efficiency, AMEI, and ERP continued decreasing down to the lowest level fed. Chicks fed on the diet containing 0.375 g/kg TRP could not maintain their initial body weight.

AME:GE ratio was not affected by the dietary TRP level. As the dietary TRP level decreased to 0.375 g/kg, ERF and ER decreased by 400 kJ and 600 kJ, respectively. There was no significant difference in ER or ERF between the diets containing TRP at 0.75 and 0.375 g/kg. ER:AMEI ratio was significantly lower at the two lower levels of TRP than at the two higher levels. In general, the effects of *ad libitum* feeding the diets containing TRP below the control level on the efficiency of energy utilization are in agreement with those of the diet deficient in arginine (Sugahara et al., 1985).

Heat increment of feeding was slightly greater in the groups fed 0.75 and 0.375 g/kg TRP diets than in those fed 1.5 and 1.125 g/kg, though the difference was not statistically significant.

The results of experiment 1 indicate that compared with the control level, the dietary level of TRP at 1.125 g/kg was not sufficient for the growing chicks in terms of body weight gain, AMEI, ERP, ERF, and ER. ER:AMEI ratio was significantly lower at 0.75 than at 1.125 g/kg. The dietary level of TRP at 0.75 g/kg (50% of the control) was considered deficient. Carow et al. (1983) showed that body weight gain of broiler chicks aged from 2 to 4 weeks was significantly decreased by feeding the diets containing TRP at 50 or 25% of the control level. In experiment 2 this level was used to examine the effects of the dietary TRP level and food intake on the energy utilization.

The results of tube-feeding the diets containing 0.75 and 1.5 g/kg TRP are summarized in table 3. Chicks tube-fed the low TRP diet at the high level of intake were forced to be given 190% feed which they could eat under *ad libitum* feeding. There was a significant interaction between food

intake and TRP levels for body weight gain. Body weight gain in chicks receiving the low TRP diet was larger at the higher level of intake than at the lower level but significantly less than the control counterparts, which indicates that food intake accounted for only part of the decreased body weight gain due to the lower level of dietary TRP.

There was a significant interaction between food intake and TRP levels for AME:GE ratio. AME:GE ratio of the control diet was not affected by the level of food intake. Chicks tube-fed on the low TRP diet showed lower AME:GE ratio at the higher level of intake than at the lower intake. Tube-feeding the low TRP diet above the level which can be voluntarily eaten may be associated with the lower AME:GE ratio. Reduction of AMEI observed in chicks fed on the low TRP diet was more pronounced at the higher level of intake than at the lower level, which produced a significant interaction between TRP level and food intake.

Significant main effects of TRP and food intake on ERP were observed. ERP was greater in chicks fed on the high TRP diet than in those on the low TRP diet at each level of intake.

ERF was significantly affected by food intake level, being greater at the higher level of intake than at the lower. The low TRP tended to increase ERF, though not significantly. The low concentrations of dietary arginine, lysine or sulfur amino acid have been reported to increase ERF (Sugahara et al., 1985; Sibbald and Wolynetz, 1986; Sugahara and Kubo, 1992).

In contrast with body weight gain, TRP-deficient chicks retained as much body energy as the control chicks at each level of food intake, though the contribution of ERP to ER decreased. The reduction of ERP was almost identical with the increased ERF. ER was larger at the higher intake than at the lower intake. These results are in agreement with Sibbald and Wolynetz (1987) and Sugahara and Kubo (1992), who showed that ER was independent of the dietary lysine or sulfur amino acid concentration. ER:AMEI ratio was not affected by TRP deficiency and was larger at the higher intake than at the lower intake.

Heat increment of feeding was affected by neither dietary TRP level nor food intake. The absence of an effect of the low level of dietary

TABLE 2. EFFECT OF FEEDING AD LIBITUM DIETS CONTAINING GRADED LEVELS OF TRYPTOPHAN ON BODY WEIGHT GAIN, FOOD INTAKE, GAIN / FEED AND ENERGY UTILIZATION (EXPERIMENT 1)

Dietary tryptophan level	Food intake g/chick/14 days	Body weight gain g/chick/14 days	Gain/feed	AME/GE	AME intake	Energy retention		Total energy		Heat increment <sup>1</sup> kJ/100 kJ AMEI
						Protein kJ/chick/14 days	Fat	Total	AMEI	
1.5 g/kg	215.6 <sup>a</sup>	109.9 <sup>a</sup>	0.51 <sup>a</sup>	0.955 <sup>a</sup>	3,771 <sup>a</sup>	442 <sup>a</sup>	1,056 <sup>a</sup>	1,448 <sup>a</sup>	0.400 <sup>a</sup>	28.4 <sup>a</sup>
1.125	175.8 <sup>b</sup>	70.1 <sup>b</sup>	0.39 <sup>b</sup>	0.922 <sup>a</sup>	2,830 <sup>b</sup>	310 <sup>b</sup>	608 <sup>b</sup>	918 <sup>b</sup>	0.318 <sup>a</sup>	30.8 <sup>a</sup>
0.75	113.3 <sup>c</sup>	18.4 <sup>b</sup>	0.16 <sup>b</sup>	0.951 <sup>a</sup>	1,996 <sup>c</sup>	111 <sup>c</sup>	193 <sup>c</sup>	304 <sup>c</sup>	0.151 <sup>b</sup>	42.1 <sup>a</sup>
0.375	71.2 <sup>d</sup>	-3.0 <sup>a</sup>		0.960 <sup>b</sup>	1,249 <sup>d</sup>	35 <sup>d</sup>	-1 <sup>c</sup>	34 <sup>c</sup>	0.029 <sup>c</sup>	35.0 <sup>a</sup>
Pooled SE	7.5	4.8	0.02	0.007	119	15	53	66	0.016	3.9

Average initial body weight was 70.1 g.

Average initial body protein, fat, and water were 16.2%, 10.1% and 70.4%, respectively.

Mean values of 5 chicks within a row with different superscripts differed significantly ( $p < 0.05$ ).

<sup>1</sup> AME intake - (total energy retention + 400 × body weight (kg)<sup>0.75</sup>).

TABLE 3. EFFECT OF LEVELS OF TRYPTOPHAN AND FOOD INTAKE ON BODY WEIGHT GAIN, GAIN / FEED, AND ENERGY UTILIZATION IN TUBE-FED CHICKS (EXPERIMENT 2)

Food intake level	Dietary tryptophan g/kg	Body weight gain g/chick/14 days	Gain/feed	AME/GE	AME intake	Energy retention		Total energy		Heat increment <sup>1</sup> kJ/100 kJ AMEI
						Protein kJ/chick/14 days	Fat	Total	AMEI	
High <sup>2</sup>	1.5	124.0 <sup>a</sup>	0.58	0.959 <sup>a</sup>	3,541 <sup>a</sup>	454	1,264	1,718	0.485	16.8
High	0.75	93.8 <sup>b</sup>	0.44	0.906 <sup>b</sup>	3,313 <sup>b</sup>	317	1,352	1,669	0.502	15.2
Low <sup>2</sup>	1.5	57.6 <sup>c</sup>	0.40	0.959 <sup>a</sup>	1,966 <sup>c</sup>	244	469	713	0.363	15.2
Low	0.75	46.2 <sup>d</sup>	0.39	0.958 <sup>a</sup>	1,942 <sup>c</sup>	167	554	721	0.371	14.7
Pooled SE		2.2	0.01	0.004	14	8	35	38	0.012	1.4

Analysis of variance

Tryptophan \*\*

Food intake \*\*

Interaction \*\*

Average initial body weight was 65.0 g.

Average initial body protein, fat, and water were 16.1%, 9.4% and 69.4%, respectively.

\*\* $p < 0.01$ , \* $p < 0.05$ , NS: Not significant

Mean values of 5 chicks per group.

Mean values of 5 chicks within a row with different superscripts differed significantly ( $p < 0.05$ ).

<sup>1</sup> AME intake - (total energy retention + 400 × body weight (kg)<sup>0.75</sup>). <sup>2</sup> 213.5 g/chick/14 days. <sup>3</sup> 118.0 g/chick/14 days.

TRP on heat increment indicates that the partial efficiency of ME utilization was similar in the TRP-control and TRP-deficient chicks. This result is in agreement with Sugahara et al. (1985) and Sugahara and Kubo (1992) but disagrees with some earlier studies (Shoji et al., 1966; Tasaki et al., 1972; Yanaka and Tasaki, 1980; Reid and Maiorino, 1984). Carew et al. (1983) assumed that TRP-deficient chicks converted the consumed ME to more heat than the pair-fed controls. Unfortunately, they measured no body composition. MacLeod (1990, 1991) found that chicks receiving a diet with low crude-protein:energy ratio converted excess energy ingested to body fat without increased heat production. No difference in ER between the TRP deficient and TRP-control chicks implies that heat production was not affected by TRP deficiency under the conditions of the tube feeding experiment, which supports MacLeod (1990, 1991) rather than Carew et al. (1983).

The results of the present experiments indicate that the effect of the deficiency of TRP on the energy retention was associated mainly with the food intake and not with the heat increment of feeding.

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