The Effect of Varying Levels of Tryptophan on Growth Performance and Carcass Characteristics of Growing and Finishing Broilers

L. C. Hsia*, J. H. Hsu and C. T. Liao

Dept. of Animal Science, National Pingtung University of Science and Technology, 1 Hsueh-Fu Road, Lao-Pi Nei-Pu, Pingtung 912, Taiwan, ROC

ABSTRACT : The purpose of this experiment was to study the effect of varying levels of tryptophan on the performance and carcass character of broiler. Trial 1: Ninety-six, five-week-old male Hubbard chickens, average weight 1.97 kg, were used in the trial. All birds were allocated into 3 treatments of 32 birds each. Each bird was kept in an individual cage. The trial period was 3 weeks. Treatment 1: Tryptophan content 0.198%. Treatment 2: Tryptophan content 0.228%. Treatment 3: Tryptophan content 0.258%. Trial 2: Ninety-six, three-week-old male Hubbard chickens, average weight 1.23 kg, were randomly distributed into the following two treatments. Each treatment had 48 birds. Treatment 1: Tryptophan content 0.167%. Treatment 2: Tryptophan content 0.198%. Trial 3: Ninety-six, two-week-old Hubbard chickens, average body weight 0.72 kg, were used in this experiment. There were three treatments as follows. Treatment 1. Tryptophan content 0.136%. Treatment 2. Tryptophan content 0.167%. Treatment 3. Tryptophan content 0.198%. The result of Trial 1 showed that the feed intake, performance, and carcass characteristics were not influenced by tryptophan content in the diet which between 0.198% and 0.258% ($p>0.05$). There was no significant difference ($p>0.05$) in feed intake in either treatment in Trial 2. However, weight gain, feed conversion efficiency, and most carcass characteristics in the 0.198% treatment were significantly better ($p<0.05$) than in the 0.167% treatment. There was a trend that feed intake increased with increasing level of tryptophan, but there was no significant difference in Trial 3. The weight gain and feed conversion efficiency were significantly reduced for the broiler in the 0.136% treatment. This series of experiment showed that broilers need about 0.198% of tryptophan. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 2 : 230-234)***

Key Words : Broiler, Tryptophan, Performance, Carcass Characteristics

INTRODUCTION

Feed intake is one of the important factors which influences broiler live performance and carcass characteristics. The original ideal protein hypothesis is based on the balance between amino acids and their final products, meat, egg, milk, embryo, semen, etc. However, today's research findings indicate that the specific amino acid requirement may also need to consider some other special functions of amino acids. Two attractive examples for livestock and poultry production are: firstly, whether some amino acids control feed intake; and secondly, whether amino acid balance of feed depends on the specific requirements of antibodies. Tryptophan is the precursor of serotonin (Voet and Voet, 1995), which plays an important role in feed intake (Henry and Seve, 1993). NRC pointed out the requirement of tryptophan for 1-3 week broiler chickens has been reduced from 0.23 to 0.2%. Minimal research has been conducted on tryptophan requirement of the broiler at more than 3 weeks (NRC, 1994). The purpose of the present experiment was to study: (i) whether tryptophan can improve feed intake, live performance, and carcass characteristics of broiler, and (ii) what is the optimum tryptophan level for growing and finishing broiler.

* Corresponding Author: L. C. Hsia. Tel: +886-8-7701094, Fax: +886-8-7700984, E-mail: lchsia@mail.npust.edu.tw

Received August 17, 2003; Accepted January 20, 2004

MATERIALS AND METHODS

There were three trials involved in the experiment. Trial 1 was to study whether the feed intake of finishing chickens could be improved by adding more tryptophan when control diet reached the recommended level for young chickens (1-3 weeks) (NRC, 1994). Trial 2 was to study whether a reduced tryptophan level can cause detrimental effect on growing and finishing chickens. Trial 3 was to study whether reduced tryptophan level can cause differences between sex of growing and finishing chickens.

Trial 1

Ninety-six, five-week-old male Hubbard chickens, average weight 1.97 kg, were used in the trial. All birds were distributed into the following 3 treatments. Each treatment had 32 birds. Each bird was kept in an individual cage. The trial continued for 3 weeks.

Treatment 1: Tryptophan content 0.198%.
Treatment 2: Tryptophan content 0.228%.
Treatment 3: Tryptophan content 0.258%.

Feed formulation is shown in Table 1.

Each cage had 3,400 cm^3 space, 24 cm×10 cm feed trough, and a nipple drinker. Feed and water were provided *ad libitum*. Everyday routine management included: (1)

Table 1. Feed formulation of Trial 1

Ingredient/treatment	Tryptophan level (%)		
	0.198	0.228	0.258
Corn	64.35	64.40	64.45
Soy meal	19.94	19.86	19.78
Meat and bone meal 50%	10.0	10.0	10.0
Tallow	5.0	5.0	5.0
Lysine	0.12	0.12	0.12
Methionine	0.08	0.08	0.08
Tryptophan	0.01	0.04	0.07
Salt	0.3	0.3	0.3
Vitamin premix*	0.1	0.1	0.1
Mineral premix*	0.1	0.1	0.1
Calculated value			
Crude protein	18.8	18.8	18.8
DE (kcal)	3,400	3,400	3,400
Lysine	1.1	1.1	1.1
Methionine	0.38	0.38	0.38
Tryptophan	0.198	0.228	0.258

Each kg of premix contained Fe, 70 g; Cu, 15 g; Mn, 80 g; Zn 100 g; Co 0.5 g; I, 2 g; Se, 0.15 g.

Each kg of premix contained vitamin A, 1,500,000 IU; vitamin D_3, 250,000 IU; vitamin E, 40 g; vitamin K_3, 3 g; vitamin B_1, 3 g; vitamin B_2, 6 g; vitamin B_6, 4 g; vitamin B_{12}, 0.04 g; pantothenic acid, 16 g; niacin, 30 g; folic acid, 1 g; biotin, 0.12 g.

Table 2. Feed formulation of Trial 2

Ingredient/treatment	Tryptophan level (%)	
	0.167	0.198
Corn	66.95	64.35
Soy meal	15.59	19.94
Meat and bone meal 50%	11.76	10.0
Tallow	5.0	5.0
Lysine	0.12	0.12
Methionine	0.08	0.08
Tryptophan	-	0.01
Salt	0.3	0.3
Vitamin premix*	0.1	0.1
Mineral premix*	0.1	0.1
Calculated value		
Crude protein	18.0	18.8
DE (kcal)	3,400	3,400
Lysine	1.0	1.0
Methionine	0.380	0.380
Tryptophan	0.167	0.198

Each kg of premix contained Fe, 70 g; Cu, 15 g; Mn, 80 g; Zn 100 g; Co 0.5 g; I, 2 g; Se, 0.15 g.

Each kg of premix contained vitamin A, 1,500,000 IU; vitamin D_3, 250,000 IU; vitamin E, 40 g; vitamin K_3, 3 g; vitamin B_1, 3 g; vitamin B_2, 6 g; vitamin B_6, 4 g; vitamin B_{12}, 0.04 g; pantothenic acid, 16 g; niacin, 30 g; folic acid, 1 g; biotin, 0.12 g.

17:00 clean excretion, (2) 17:30 collect and weigh residue feed, (3) 18:00 feed weighed feed. Except for the initial body weight, the body weight of chicken was weighed every three days. After the last weighing, twelve chickens of each treatment were fasted for 24 h and then slaughtered. The twelve chickens were selected from each treatment according to the rank of final body weight. The selected chickens in each treatment were on the ranks of final body weight of 1-4, 16-19 and 33-36. Blood and feather were also weighed. The following parts were also weighed: head, neck, wing, breastbone, breast, thigh, leg, back, leaf fat, organs, heart and liver.

Table 3. Feed formulation of Trial 3

Ingredient/treatment	Tryptophan level (%)		
	0.136	0.167	0.198
Corn	68.33	66.95	64.35
Soy meal	7.32	15.59	19.94
Meat and bone meal 50%	18.65	11.76	10.0
Tallow	5.0	5.0	5.0
Lysine	0.12	0.12	0.12
Methionine	0.08	0.08	0.08
Tryptophan	-	-	0.01
Salt	0.3	0.3	0.3
Vitamin premix*	0.1	0.1	0.1
Mineral premix*	0.1	0.1	0.1
Calculated value			
Crude protein	18.0	18.0	18.8
DE (kcal)	3,400	3,400	3,400
Lysine	1.0	1.0	1.0
Methionine	0.38	0.38	0.38
Tryptophan	0.136	0.167	0.198

Each kg of premix contained Fe, 70 g; Cu, 15 g; Mn, 80 g; Zn 100 g; Co 0.5 g; I, 2 g; Se, 0.15 g.

Each kg of premix contained vitamin A, 1,500,000 IU; vitamin D_3, 250,000 IU; vitamin E, 40 g; vitamin K_3, 3 g; vitamin B_1, 3 g; vitamin B_2, 6 g; vitamin B_6, 4 g; vitamin B_{12}, 0.04 g; pantothenic acid, 16 g; niacin, 30 g; folic acid, 1 g; biotin, 0.12 g.

Trial 2

Ninety-six, three-week-old male Hubbard chickens, average weight 1.23 kg, were randomly distributed into the following two treatments. Each treatment had 48 birds.

Treatment 1: Tryptophan content 0.167%.
Treatment 2: Tryptophan content 0.198%.

Feed formulation is shown in Table 2.

Each bird was kept in an individual cage, which had the same size, a trough, and a drinker as used in Trial 1. The trial lasted for 4 weeks. Feed and water were provided for chickens *ad libitum*. The weighing frequency was every 7 days. The cleaning, feeding, and weighing of chickens were the same as practiced in Trial 1. The room temperature was kept constant at 25°C.

The slaughter methods and carcass measurements were the same as for Trial 1. The total number of selected chickens was 30 birds. The selected method for slaughtering chickens was the same as for Trial 1.

Trial 3

Ninety-six, two-week-old Hubbard chickens, average body weight 0.72 kg, were used in the present experiment.

Table 4. Effect of tryptophan level of feed on performance of broiler (Trial 1)

Day/ treatment	Tryptophan level (%)			SE
	0.198	0.228	0.258	
	Feed intake (g/day/chicken)			
1-3	130.3	125.6	124.9	21.0
4-6	142.2	136.1	144.1	23.8
7-9	140.3	141.8	145.5	22.9
10-12	141.8	129.9	141.0	28.4
13-15	143.4	129.8	142.0	34.2
16-18	152.4	141.8	137.0	34.8
19-21	147.9	145.0	142.2	34.7
1-21	142.6	137.2	140.0	22.1
	Weight gain (g/day/chicken)			
1-3	50.4^{a}	51.5^{a}	37.2^{b}	22.1
4-6	67.4^{ab}	59.6^{b}	71.3^{a}	16.6
7-9	69.8	66.2	71.4	19.6
10-12	71.9^{a}	53.1^{b}	53.4^{b}	29.5
13-15	60.7	63.1	60.5	21.3
16-18	60.5^{b}	89.3^{a}	61.0^{b}	30.1
19-21	61.0^{b}	90.4^{a}	58.5^{b}	36.4
1-21	61.1	63.9	58.8	8.8
	Feed efficiency (g/g)			
1-3	3.2	3.8	3.6	2.7
4-6	2.2	3.0	2.1	1.8
7-9	2.2	2.3	2.1	0.6
10-12	2.3	3.1	3.3	1.9
13-15	2.5	2.6	2.6	0.7
16-18	2.7	2.2	2.5	1.0
19-21	2.8	2.3	2.9	1.5
1-21	2.4	2.4	2.4	0.3

$^{a, b, c}$ Means within the same row without the same superscript letters are significantly different ($p<0.05$).
Day 1=38 days old chicken.

There were three treatments.

Treatment 1: Tryptophan content 0.136%.
Treatment 2: Tryptophan content 0.167%.
Treatment 3: Tryptophan content 0.198%.

Feed formulation is shown in Table 3.

The housing facility and temperature control program used in the trial were the same as for Trial 2. Body weight was measured at 13:30 every day from the first week. Residual feed was cleaned about 17:30. Chickens were fed at 18:00. The slaughter methods, carcass measurements, and selection methods for slaughtering chickens were the same as for Trial 1. The slaughtered number of each treatment was 12 chickens. Half of them were male and half of them were female.

RESULTS AND DISCUSSION

Trial 1

The results of this trial showed that there were no significant differences ($p>0.05$) among the three treatments on feed intake, weight gain, feed conversion rate (Table 4), or carcass characteristics (Table 5). NRC (1971, 1977, 1984, 1994) pointed out that tryptophan requirement for broiler was about 0.18 and 0.22%. The present trial showed that the feed intake, performance and carcass were not influenced by tryptophan content in the diet between 0.198% and 0.258%.

Table 5. Effect of tryptophan content of feeds on broiler carcass characteristics

Carcass/ treatment	Tryptophan level (%)			SE
	0.198	0.228	0.258	
Head	94.4^{b}	102.8^{b}	142.2^{a}	21.7
Neck	133.8	201.3	128.5	93.8
Wing	83.6	76.7	82.7	8.3
Breastbone	176.8	176.3	180.1	19.4
Breast	630.2	623.3	617.8	40.5
Thigh	550.0	541.0	523.8	41.8
Leg	267.0^{b}	274.8^{ab}	287.3^{a}	18.3
Back	714.8^{ab}	703.4^{b}	744.0^{a}	37.7
Leaf fat	139.8^{b}	139.9^{b}	150.0^{a}	11.4
Viscera*	64.1	68.7	69.4	20.2
Blood	255.0	241.2	238.6	29.6
Feather	45.3	44.6	42.5	3.8
Heart	15.8^{a}	14.3^{ab}	13.7^{b}	2.4
Liver	425.3	444.9	433.8	48.1

$^{a, b}$ Means within the same row without the same superscript letters are significantly different ($p<0.05$).
* Means viscera without heart and liver.

Table 6. Effect of tryptophan level of feed on performance (Trial 2)

Week/ treatment	Tryptophan level (%)		SE
	0.167	0.198	
	Feed intake (g/day/chicken)		
1	115.1	113.6	12.6
1-2	124.2	123.5	11.9
3-4	138.7^{b}	145.4^{a}	13.7
1-4	131.4	134.5	11.5
	Weight gain (g/day/chicken)		
1	55.1^{b}	59.8^{a}	9.7
1-2	62.5^{b}	66.9^{a}	8.2
3-4	56.7^{b}	62.2^{a}	9.4
1-4	59.6^{b}	64.6^{a}	6.3
	Feed efficiency (g/g)		
1	2.1^{a}	1.9^{b}	0.2
1-2	2.0^{a}	1.9^{b}	0.1
3-4	2.5	2.4	0.4
1-4	2.2^{a}	2.1^{b}	0.2

$^{a, b}$ Means within the same row without the same superscript letters are significantly different ($p<0.05$).
Week 1=3 weeks old chicken.

Trial 2

There was no significant difference ($p>0.05$) on feed intake when tryptophan content in diet was either at 0.167% or 0.198%. However, weight gain, feed efficiency (Table 6), and most broiler carcass (Table 7) characteristics in the

Table 7. Effect of tryptophan level of feed on carcass characteristics of broiler

Carcass	Tryptophan level (%)		SE
	0.167	0.198	
Head	72.9	80.3	12.0
Neck	134.4[a]	113.3[b]	23.8
Wing	60.7[b]	69.7[a]	7.9
Breastbone	162.1	162.1	21.7
Breast	469.6[b]	497.3[a]	33.4
Thigh	401.5[b]	433.4[a]	28.7
Leg	338.4[b]	403.4[a]	41.2
Back	228.2	220.1	58.9
Leaf fat	534.1	547.9	120.8
Viscera*	109.1[b]	122.9[a]	17.3
Blood	75.4	70.7	34.4
Feather	189.9	215.6	35.3
Heart	30.1[b]	38.7[a]	7.0
Liver	13.7	12.9	4.5

[a, b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

* Means viscera without heart and liver.

Table 8. Effect of tryptophan level of feed on performance of broiler (Trial 3)

Week / treatment	Tryptophan level (%)			SE
	0.136	0.167	0.198	
	Feed intake (g/day/chicken)			
1	103.5	105.3	109.9	14.0
2	133.5	133.9	132.5	13.5
3	141.4	141.3	144.8	14.1
4	144.5	144.9	152.1	14.2
1-4	130.4	131.3	134.8	11.4
	Weight gain (g/day/chicken)			
1	55.5[b]	61.2[a]	63.2[a]	10.2
2	59.1[b]	69.7[a]	66.1[a]	11.0
3	59.2[b]	69.5[a]	66.7[a]	9.6
4	56.3[b]	60.7[ab]	64.7[a]	12.1
1-4	57.1[b]	65.3[a]	65.2[a]	6.2
	Feed efficiency (g/g)			
1	2.0[a]	1.8[b]	1.7[b]	0.2
2	2.5[a]	1.9[b]	2.0[b]	0.7
3	2.5[a]	2.0[b]	2.2[b]	0.5
4	2.7[a]	2.4[b]	2.4[b]	0.4
1-4	2.3[a]	2.0[b]	2.1[b]	0.1

[a, b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

Week 1=14 days old chicken.

0.198% treatment were significantly better ($p<0.05$) than those in the 0.167% treatment. This result could be explained by the fact that 0.167% tryptophan content may be enough for control of feed intake but not enough for amino acid balance. Consequently, the 0.167% level caused lower weight gain and carcass weight. This result was different from the results of Hewitt and Lewis (1972) and Smith and Waldroup (1987), who showed that the tryptophan requirements of broiler are less than 0.17% and 0.16%, respectively.

Table 9. Effect of tryptophan level of feed on broiler carcass characteristics

Carcass / treatment	Tryptophan level (%)			SE
	0.136	0.167	0.198	
Head	77.7	83.8	73.2	13.7
Neck	121.2	119.7	128.7	15.8
Wing	53.8	58.0	56.8	6.1
Breastbone	137.1	133.8	139.1	18.0
Breast	428.6[b]	468.7[a]	469.8[a]	33.5
Thigh	380.2[b]	415.2[a]	411.9[a]	32.8
Leg	343.9	367.9	360.8	32.2
Back	183.6[b]	196.0[a]	202.1[a]	12.4
Leaf fat	490.8[b]	532.0[a]	534.9[a]	29.1
Viscera*	98.7	101.8	97.8	7.3
Blood	70.4	79.0	70.5	16.9
Feather	198.0[b]	211.3[a]	207.3[ab]	12.1
Heart	31.8[b]	34.8[a]	34.8[a]	3.4
Liver	11.5	12.8	12.6	2.9

[a, b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

* Means viscera without heart and liver.

Table 10. Effect of sex on broiler performance

Week	Sex	
	Male	Female
	Feed intake (g/day/chicken)	
1	109.1[a]	101.6[b]
2	135.6[a]	129.5[b]
3	146.0[a]	136.7[b]
4	151.5[a]	140.0[b]
1-4	135.6[a]	126.7[b]
	Weight gain (g/day/chicken)	
1	63.0[a]	55.1[b]
2	67.4[a]	61.5[b]
3	67.8[a]	61.2[b]
4	65.5[a]	52.6[b]
1-4	65.9[a]	57.2[b]
	Feed efficiency (g/g)	
1	1.8[b]	1.9[a]
2	2.1	2.1
3	2.2	2.2
4	2.4[b]	2.7[a]
1-4	2.1[b]	2.2[a]

[a, b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

Trial 3

There was a trend that feed intake increased with an increase in the level of tryptophan, but without any significant difference ($p>0.05$). The weight gain and feed conversion rate were significantly worse for the broiler in the 0.136% treatment ($p<0.05$) (Table 8). The 0.136% tryptophan treatment showed significantly lower ($p<0.05$) weight on the following carcass characteristics, breast, thigh, back, leaf fat, feather and heart (Table 9). There was a very clear result that feed intake, weight gain, feed conversion rate (Table 10) and some parts of carcass (Table 11) were significantly better ($p<0.05$) for male broilers than for

Table 11. Effect of sex on broiler carcass characteristics

Carcass	Sex	
	Male	Female
Head	84.0[a]	72.4[b]
Neck	122.7	123.7
Wing	61.9[a]	50.4[b]
Breastbone	140.9	132.4
Breast	464.6	446.8
Thigh	407.4	397.4
Leg	372.9[a]	342.2[b]
Back	202.8[a]	185.7[b]
Leaf fat	542.8[a]	495.6[b]
Viscera*	110.2[a]	88.6[b]
Blood	68.7	77.9
Feather	208.4	202.6
Heart	34.4	33.3
Liver	11.9	12.7

[a, b] Means within the same row without the same superscript letters are significantly different ($p<0.05$).

* Means viscera without heart and liver.

female broilers.

The results of these three trials showed that the broilers feed intake was not significantly influenced by the levels of tryptophan which between 0.136% and 0.258%. However, the weight gain, feed conversion rate, and carcass characteristics were influenced by the level of tryptophan which below 0.167%. The present results agreed with the other report (Tabiri et al., 2002) when tryptophan level in chicken diet was high, although their report showed a dramatically reduction of feed intake when tryptophan level dropped to half of NRC requirement. The present experiment did not have such a low level of tryptophan treatment. These results indicated that the level of tryptophan might not play an important role on feed intake when the level was not too low. However, tryptophan level in the experiment plays an important role on weight gain and carcass characteristics. The phenomenon may be due to imbalance of amino acids in diet when broilers age about 3 to 8 weeks old.

REFERENCES

Henry, Y. and B. Seve. 1993. Feed intake and dietary amino acid balance in growing pigs with special reference to lysine, tryptophan and threonine. Pig News and Information 14(1):35-43.

Hewitt, D. and D. Lewis. 1972. The amino acid requirement of the growing chick. Poult. Sci. 13:449-463.

National Research Council. 1971. Nutrient Requirements of Poultry. 6th ed. National Academy Press. Washington, DC.

National Research Council. 1977. Nutrient Requirements of Poultry. 7th ed. National Academy Press. Washington, DC.

National Research Council. 1984. Nutrient Requirements of Poultry. 8th ed. National Academy Press. Washington, DC.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th ed. National Academy Press. Washington, DC.

Smith, N. K, Jr. and P. W. Waldroup. 1987. Estimation of tryptophan requirement of male broiler chickens. Poult. Sci. 67:1174-1177.

Tabiri, H. Y., K. Sato, K. Takahashi, M. Toyomizu and Y. Akiba. 2002. Effects of heat stress and dietary tryptophan on performance and plasma amino acid concentrations of broiler chickens. Asian-Aust. J. Anim. Sci. 15(2):247-253.

Voet, D and J. G. Voet. 1995. Biochemistry (2nd Edition). John Wiley & Sons, Inc. New York.