ISSN 1682-8356
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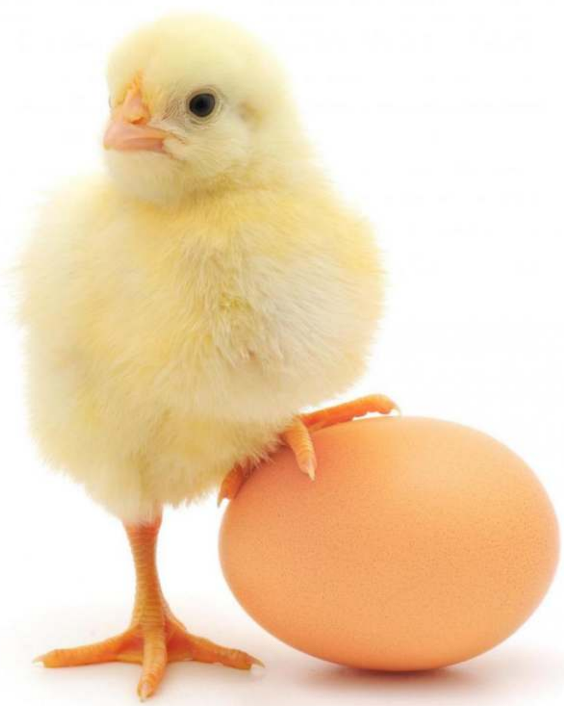

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 6 (7): 524-526, 2007
ISSN 1682-8356

Effects of Feeding High Tryptophan GM-Rice on Growth Performance of Chickens

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Abstract: Recently, high tryptophan genetically modified (GM)-rice has been newly developed and its tryptophan content was 50% higher than conventional rice. The goal of this experiment was to clarify the nutritive value of high tryptophan GM-rice on chicken growth performance. Experimental treatments were the following, 1) NB (control) group; brown rice (Nihonbare) based low protein diet in which all the deficient essential amino acids except tryptophan were added to meet the nutritional requirement, 2) NB+Trp group; control diet+crystalline tryptophan, 3) HW-1 (GM Trp) group; GM-brown rice (high tryptophan) based low protein diet in which all the deficient essential amino acids except tryptophan were added. Twenty one birds of Boris brown male chickens (7 days of age and 80±2 g of initial body weight) were used. They were assigned to three experimental groups, each of which contained 7 birds. The birds were individually housed in electrically heated battery cages maintained in temperature constant (24 degrees) room. They had free access to experimental diet and water during an experimental period of three weeks. Body weight gain in NB+Trp group and HW-1 group were significantly higher than that in control group. Similarly, higher feed intake in NB+Trp group and HW-1 group compared with control group were observed. Feed efficiency (gain/feed) in HW-1 group was significantly higher than in control group. These results show that the nutritional value of high tryptophan GM-Rice is similar to that of non-GM rice supplemented with crystalline tryptophan.

Key words: Chickens, GM-rice, growth performance, tryptophan

Introduction

Tryptophan is one of the essential amino acids and mainly used for protein synthesis as substrate in the body. Chickens essentially need to have tryptophan from feeds. Concomitantly with methionine, lysine and threonine, tryptophan is also deficient when the protein concentration in the diet is severely reduced compared with conventional diets. In general, cereal feedstuffs such as corn, wheat and barley are relatively low in tryptophan.

Recently, environmental pollution with nitrogen derived from animal excreta has been severe social problem in the world. To reduce the nitrogen excretion from animal, the application of low protein diet is effective. However, low protein diet requires the additions of essential amino acids such as methionine, lysine and threonine to meet the each requirement. When protein level in the diet is still more reduced, further addition of tryptophan to the diet is required.

Tryptophan is the primary precursor of serotonin. Serotonin has a sedative effect, such as inducing a sleep, suppressing pain sensitivity and aggressive behaviors. Because serotonin does not cross the blood-brain barriers, its effects within the central nervous system depend on the transfer of tryptophan across that barrier. When an animal fed a diet containing high levels of tryptophan, tryptophan concentration in brain would increase as well as in blood and lead to increase the related metabolites levels in brain. It could be, thus, expected that feeding tryptophan can alleviate the various stress and affects the animal behavior. Laycock and Ball (1990) studied the high levels of dietary tryptophan on hysteria and demonstrated that the incidence of episodes of hysteria declined by feeding a high tryptophan diet. Li *et al.* (2006) have reported that pigs fed the high tryptophan diet spent more time lying and less time eating than pigs fed the control diet. Thus, tryptophan is now expected for the feed additive which exerts the stress reducing effect in domestic animals.

Recently, high tryptophan genetically modified (GM)-rice, in which tryptophan contents was 50% higher than that in conventional rice, has been newly developed (Wakasa *et al.*, 2006. Thus, it could be expected that high tryptophan GM-rice based low protein diet without adding crystalline tryptophan has similar nutritive value to non-GM rice based low protein diet with adding crystalline tryptophan. The goal of this experiment is to clarify the nutritive value of high tryptophan GM-rice compared with that of conventional rice with or without adding crystalline tryptophan.

Materials and Methods

One-d-old male layer chickens (boris brown) obtained from a local hatchery were housed in an electrically heated battery cages and had free access to water and a commercial starter diet for 7 days. They were then assigned to three groups with 7 chickens each according to body weight equalize the mean body weight

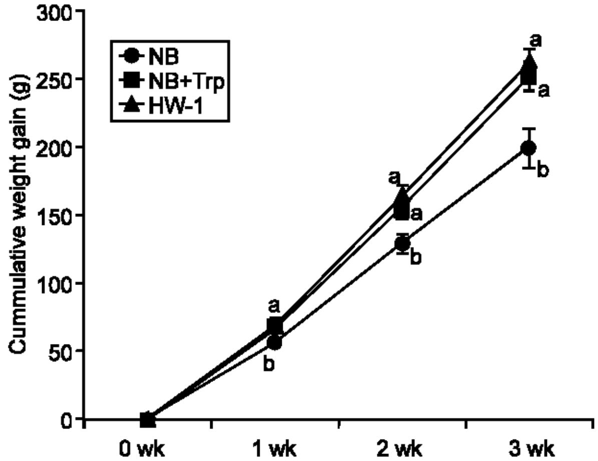

Fig. 1: Cumulative weight gain of chickens fed high tryptophan GM-rice, Different superscripts within a same week mean significant ($p<0.05$), NB, HW-1: see the footnote of Table 1

in each group. They were housed individually in wire cages and given the experimental diets for 3 weeks. Body weight gain and feed intake were recorded weekly. All experiments employed in this study followed the recommendations within the Guide for the Care and Use of Agricultural Animals in Agricultural Research of the National Institute of Livestock and Grassland Science (Tsukuba, Japan).

Table 1 shows the composition of experimental diets. The protein contents of all three diets were severely low to formulate the tryptophan deficient diets. Control diet (NB diet) was based on rice (non GM-rice, Nihonbare) and soybean meal. NB diet was supplemented with lysine, methionine, threonine to meet the nutritional requirement of laying chickens (NRC, 1994). Because tryptophan was not added to the control diet, this was tryptophan deficient diet. NB+Trp diet was constituted of control diet plus crystalline tryptophan, so this was tryptophan sufficient diet. In HW-1 diet, non GM-rice was completely replaced with high tryptophan GM-rice and other ingredients were same to the control diet.

Tryptophan contents in non GM-rice and high tryptophan GM-rice were 0.076% and 0.183%, respectively (Wakasa *et al.*, 2006).

The data were analyzed statistically by one-way analysis of variance, followed by Turkey's multiple range test (Yoshida, 1978). Differences were considered significant at $p<0.05$.

Results and Discussion

Table 2 shows the results of growth performance and Fig. 1 indicates the change of cumulative weight gain. Through the total experimental period, body weight gains in NB+Trp group and HW-1 group were significantly higher than that in the control group. There was no significant difference in body weight gain between NB+Trp group and HW-1 group. At the end of experiment, body weights in NB+Trp group and HW-1 group were 334±15 g, 345±13 g, respectively. NRC (1994) demonstrates that standard body weight of 4 weeks old in Brown-Egg-Laying Strain is 325 g. Although there are no growth data related to male laying strain, it appears that the growth rate of these two groups are normal and that of control group is inferior to standard growth. From the data of NRC (1994), body weight of male broiler chickens (4 week old) are about 12 percent heavier than that of female broiler chickens. In this experiment, body weights of male laying strain in NB+Trp group and HW-1 group were 3 and 6 percent heavier than female standard weight, respectively. The extent of higher body weight in male compared with female is a little lower in laying strain than in broiler strain. This may be attributed to different type of chicks. Although NB+Trp diet was supplemented with tryptophan to meet its requirement and HW-1 diet was not, the body weight gains of two groups were similar. Thus, it seems that the nutritional value of tryptophan in HW-1 diet was similar to that in NB+Trp diet.

Table 1: Composition of experimental diets

Ingredients (%)	NB	NB+Trp	HW - 1
Corn	23.98	23.91	23.98
Brown rice (NB[1])	55	55	-
Brown rice (HW-1[2])	-	-	55
Corn gluten meal	2	2	2
Defatted rice bran	4	4	4
Soybean meal	10	10	10
Soybean oil	1	1	1
Dicalcium phosphate	1.6	1.6	1.6
Calcium carbonate	1.1	1.1	1.1
NaCl	0.3	0.3	0.3
Vitamin Mix.[3]	0.1	0.1	0.1
Mineral Mix.[4]	0.05	0.05	0.05
L-Lysine·HCl	0.44	0.44	0.44
DL-Methionine	0.16	0.16	0.16
L-Threonine	0.27	0.27	0.27
L-Tryptophan	-	0.07	-
Caluculated composition			
ME, kcal/g	2.92	2.92	2.92
CP, %	13.7	13.7	13.7
Ca, %	0.84	0.84	0.84
npP, %	0.42	0.42	0.42
Lys, %	0.92	0.92	0.92
Met+Cys, %	0.67	0.67	0.67
Thr, %	0.74	0.74	0.74
Trp, %	0.13	0.21	0.19

[1]NB = Standard rice (Nihonbare), [2]HW- 1 = High tryptophan GM-rice, [3]Provided per kg diet: riboflavin 3.3mg, thiamine-HNO_3 1.7mg, pyridoxine·HCl 2mg, cyanocobalamin 20μg, D-calcium pantothenate 13.3mg, nicotinic acid 33.3mg, menadione sodium bisulfate 1.0mg, folic acid 1.3mg, choline chloride 200mg, D-biotin 0.2mg, DL-α-tocopheryl acetate 10mg, *trans*-retinol 2667IU, cholecalciferol 400IU, [4]Provided per kg of diet: $MnSO_4$ 73.3mg, $FeSO_4$ 5.4mg, $CuSO_4$ 2.5mg, $ZnCO_3$ 16.7mg and Ca $(IO_3)_2$ 0.5mg

Table 2: Effect of dietary high tryptophan GM-rice on the growth performance of chickens

	Control (NB)[1]	NB+Trp	HW- 1[2]
Weight gain (g)			
0-1wk	57±2[b]	67±2[ab]	69±3[a]
1-2wk	72±5[b]	90±5[a]	96±4[a]
2-3wk	69±9[b]	95±5[a]	97±5[a]
0-3wk	199±14[b]	252±11[a]	262±10[a]
Feed intake (g)			
0-1wk	114±4[b]	130±3[a]	129±3[a]
1-2wk	158±7[b]	183±6[a]	188±5[a]
2-3wk	168±12[b]	226±11[a]	218±8[a]
0-3wk	440±19[b]	538±14[a]	535±14[a]
Feed efficiency (gain/feed intake)			
0-1wk	0.506±0.026	0.514±0.009	0.531±0.019
1-2wk	0.455±0.014[b]	0.489±0.011[ab]	0.517±0.008[a]
2-3wk	0.400±0.026	0.422±0.003	0.445±0.007
0-3wk	0.448±0.014[b]	0.467±0.007[ab]	0.489±0.008[a]

Initial body weight was 80±2 g, Values were means±SE, n = 7, [1,2] = see the footnote of Table 1, Different superscripts within a same row means significant ($p<0.05$)

It is widely accepted that birds fed amino acid imbalance diet show less feed intake compared with that of birds fed nutritionally complete diet. Table 1 shows that the control diet is deficient in tryptophan. In this experiment, feed intake in control group was 18 percent less than in NB+Trp group and HW-1 group. This response of feed intake and the change of body weight gain suggest that the control diet is amino acid imbalance diet and the other two diets are amino acid sufficient diet.

Feed efficiency of HW-1 group was significantly higher than that of control group, as well as the changes of body weight gain and feed intake. In the NB+Trp group, the changes of body weight gain and feed intake were significantly higher than in control group, whereas feed efficiency was not significant. The reason for the different fashion of feed efficiency between NB+Trp group and HW-1 group is unclear. In general, the response of feed efficiency is more sensitive for nutritive value than that of body weight gain. Thus, the amounts of some nutrient may be different between GM-rice and non GM-rice. In addition, there are some possibilities of the different availability of amino acids.

On the basis of the changes of body weight gain, feed intake and feed efficiency, we infer that the nutritive value of high tryptophan GM-rice is similar to that of non GM-rice supplemented with crystalline tryptophan.

Acknowledgements

This work was supported by Multi disciplinary Research of the National Agriculture and Bio-oriented Research Organization (NARO).

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