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The Effect of Dietary Supplementation of Fe-methionine Chelate and $FeSO_4$ on the Iron Content of Broiler Meat

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ABSTRACT : A broiler experiment was conducted to compare the effects of supplementary iron sources and levels on the iron content of broiler meat. Two hundred and fifty hatched Ross broiler chickens were randomly assigned to 5 dietary treatments. Each treatment had 5 replicates of 10 birds (5 males and 5 females). Birds were housed in raised floor batteries and fed traditional broiler diets *ad libitum* for 5 weeks. Dietary treatments were as follows: Control, Fe-Met 100 (100 ppm iron as Fe-methionine), Fe-Met 200, $FeSO_4$ 100 (100 ppm iron as $FeSO_4 \cdot 7H_2O$) and $FeSO_4$ 200. There were no significant differences among treatments in parameters related to production performance. Liver contained approximately 10 times more iron than the leg muscle which contained approximately 3 times more iron than either breast muscle or wing muscle. Significant differences in iron content in the broiler meat were observed. In the breast meat, Fe-Met treatments were significantly ($p<0.05$) higher than other treatments in iron content. In the leg meat, Fe-Met treatments and $FeSO_4$ 200 treatment were significantly higher than the control in iron content. In the wing muscle, Fe-Met 200 treatment was significantly higher than other treatments in iron content. Iron content in the liver was significantly influenced by source and supplementation level of iron. Fe-Met treatments were higher than $FeSO_4$ treatments and 200 ppm treatments were higher than 100 ppm treatments in iron content in the liver. It is concluded that iron-methionine chelate is more efficient than iron sulfate and 200 ppm iron supplementation as Fe-Met is recommended for maximum iron enrichment in broiler meat. (**Key Words :** Fe-methionine Chelate, Iron Sulfate, Iron Enrichment, Broiler)

INTRODUCTION

Iron (Fe) is an essential element for livestocks as well as human beings. NRC (1994) suggested that the Fe requirement should be 50-120 ppm for poultry, and Fe toxicity appears at a very high level over 2,000 ppm. It is well known that white meats, such as breast meat of broilers, is low in Fe content than red meats, such as beef. Extra supplementation of Fe in addition to meeting nutritional requirement would enable enrichment of Fe in white meat. Iron enriched broiler meat may meet the demand of niche market customers looking for such functional products.

Since a few years ago, researches on organic minerals have been undertaken actively because chelate minerals can be more effectively absorbed into the intestines than inorganic oxide and sulfate (Wedekind et al., 1992; Aoyagi and Baker, 1993). In the same way, Fe may have big difference in bioavailability according to the form of supply. Since it was found that chelate minerals which are new organic compounds of the metal enhanced the productivity of livestock because they have a higher bioavailability than inorganic minerals, an intensive research on this issue have been conducted (Kratzer and Vohra, 1986). Organic materials, in particular, amino acids and low molecule peptide (Miller et al., 1972; Mc Naughton et al., 1974; Zoubek et al., 1975; Spears, 1992) in the state of chelation with metal ions are more effectively absorbed into the body (Fouad, 1976; Ashmead, 1993). It is because chelation of metal ions with organic substances such as amino acids or low molecule peptide makes metal ions electrically neutral and chemically stable, thereby allowing easy passage through the small intestinal wall. Actually, 95% of them are absorbed (Kratzer and Vohra, 1986). Paik (2001) reported the results of application of chelated minerals in animal production. The results demonstrated that chelated minerals, e.g. Cu and Zn, are effective in improving the performance of animals at the lower supplementary level compared to inorganic minerals, especially those used at pharmacological levels. Park et al. (2004, 2005) used iron-methionine chelate to produce iron-enriched eggs. It was demonstrated that

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Table 1. Composition and nutrient content of broiler diet

Ingredients	------------- % --------------
Corn	51.580
SBM-44	27.324
Wheat flour	7.000
Corn gluten	4.000
Animal fat	3.123
Rice bran	3.000
Tri-calcium phosphate	2.017
Limestone	0.414
Salt	0.248
Lysine-HCl (99%)	0.270
Toxin binder	0.250
DL-methionine (88%)	0.203
Choline (75%)	0.126
Vitamin premix[1]	0.100
Mineral premix[2]	0.200
Colistin (1%)	0.100
Avilamycin (2%)	0.025
Ethoxyquin (66.6%)	0.020
Total	100.000
Calculated nutrient composition	
ME (kcal/kg)	3,020
Crude protein (%)	21.0
Lysine (%)	1.21
Met+cys (%)	0.91
Calcium (%)	0.95
Total P (%)	0.74
Iron (ppm)	130

[1] Provided per kg of diet: vitamin A, 10,000 IU; vitamin D_3, 2,500 IU; vitamin E, 25 mg; vitamin K_3, 1.7 mg; vitamin B_1, 2 mg; vitamin B_2, 5 mg; vitamin B_6, 3 mg; vitamin B_{12}, 16 μg; biotin, 84 μg; niacin, 34 mg; pantothenic acid, 9 mg; folic acid, 1 mg.

[2] Provided per kg of diet: Zn, 75 mg; Mn, 75 mg; Fe, 50 mg; Cu, 7.5 mg; I, 1.65 mg; Se, 0.45 mg.

enrichment of Fe in egg could be effectively achieved by supplementation of 100 ppm of Fe as Fe-methionine chelate.

The experiment in this paper is to examine the productivity of broiler meat according to the form and level of Fe supplementation, to find out the extent of Fe accumulation within broiler meat and ultimately to develop effective means to produce Fe-enriched broiler meat.

MATERIAL AND METHOD

Experimental diet

The composition of the basal diet used as the control is shown in Table 1. Control diet as the basal diet contained 50 mg of supplementary Fe from $FeSO_4 \cdot 7H_2O$ per kg diet: Fe-Met 100 diet and Fe-Met 200 diet contained additional 100 mg and 200 mg of Fe from Fe-methionine chelate (Fe-Met) per kg diet; $FeSO_4$ 100 diet and $FeSO_4$ 200 diet contained additional 100 mg and 200 mg of Fe from $FeSO_4 \cdot 7H_2O$ per kg diet, respectively. Fe-Met was made in the laboratory following the principle of Cu-methionine chelate manufacturing (Kim et al., 1997; Lim and Paik, 2003). $FeSO_4 \cdot 7H_2O$ and methionine were reacted at 1:2 molar ratio. About 50% of Fe-Met was dissolved at pH 2. A quarter of dissolved Fe-Met was dissociated to ionic form (Fe^{++}) and remaining three quarters of dissolved Fe-Met was in a stable form which is considered to be chelated.

Experimental design and feeding

Two hundred fifty hatched Ross broiler chickens (125 males and 125 females) were randomly assigned to the 5 dietary treatments. Each treatment had 5 replicates of 10 birds (5 males and 5 females) each. Birds were housed in raised floor batteries (width: 76 cm, length: 76 cm, height: 50 cm) and fed traditional broiler diets *ad libitum* for 5 weeks. The weekly weight gain and feed intake were measured by pen.

Analysis of Fe content in muscles and liver

On the termination of feeding, 10 birds (5 males and 5 females) from each treatment were randomly chosen for liver and muscles (breast, leg and wing) analysis. For the analysis of Fe in the liver and muscle samples were ashed with HNO_3 and HCl (AOAC, 1990) and assayed with flame atomic absorption spectrophotometry.

Chemical and statistical analysis

General compositions of feeds were analyzed by AOAC (1990) procedures. The data were analyzed by ANOVA using General Linear Models (GLM) procedure of SAS (1995). Significant differences between treatment means were determined at $p<0.05$ using Duncan's new multiple range test (Duncan, 1995).

RESULTS AND DISCUSSION

Weight gains, feed intake, feed/gain ratio and mortality for the period of experiment are shown in Table 2. There were no significant differences among treatments in weight gains and feed intake over the whole period of experiment. The feed/gain ratio was higher in the Fe-met 100 treatment group than in the Fe-Met 200 treatment group significantly in the starter period of experiment but there was no significant difference between the treatment groups over the whole period of experiment. There was no significant difference in the mortality over the whole period of experiment. Paik (2001) reported that growth performances of broilers and pigs were improved by supplementation of chelated Cu and Zn at pharmacological level. The findings were supported in the subsequent experiments (Lim et al., 2006; Lim and Paik, 2006). However, there is no available information on the effect of Fe-methionine chelate on the growth performance of broilers when supplemented at

Table 2. Effects of supplementation of Fe-Met and $FeSO_4$ on weight gain, feed intake, feed/gain and mortality in broiler chickens

Item	Week	Treatments[1]					SEM
		Control	Fe-Met 100	Fe-Met 200	$FeSO_4$ 100	$FeSO_4$ 200	
Weight	0-3	717.21	720.52	735.40	718.20	716.06	12.26
Gain	4-5	1,141.20	1,097.70	1,108.20	1,111.10	1,143.34	25.57
(g/bird)	0-5	1,858.41	1,818.22	1,843.60	1,829.30	1,859.40	31.00
Feed	0-3	997.99	1,027.72	1,003.60	992.20	999.37	16.45
Intake	4-5	1,876.69	1,815.16	1,797.90	1,817.30	1,854.98	53.00
(g/bird)	0-5	2,874.68	2,842.87	2,801.50	2,809.50	2,854.34	60.32
Feed/gain	0-3	1.39^{ab}	1.43^{a}	1.37^{b}	1.38^{ab}	1.40^{ab}	0.02
(g/g)	4-5	1.65	1.65	1.62	1.64	1.62	0.05
	0-5	1.55	1.56	1.52	1.54	1.53	0.03
Mortality	0-3	2.00	2.00	0.00	0.00	2.00	1.55
(%)	4-5	0.00	0.00	0.00	0.00	0.00	0.00
	0-5	2.00	2.00	0.00	0.00	2.00	1.55

[1] Fe-Met 100: 100 ppm Fe as Fe-methionine; Fe-Met 200: 200 ppm Fe as Fe-methionine; $FeSO_4$ 100: 100 ppm Fe as $FeSO_4 \cdot 7H_2O$; $FeSO_4$ 200: 200 ppm Fe as $FeSO_4 \cdot 7H_2O$.

[a, b] Values with different superscripts in the same row are different ($p<0.05$).

Table 3. Effects of Fe-Met and $FeSO_4$ supplementation on the content of Fe in breast , leg and wing muscle and liver of broiler chickens

Item	Treatments[1]					SEM
	Control	Fe-Met 100	Fe-Met 200	$FeSO_4$ 100	$FeSO_4$ 200	
	mg/kg					
Breast	12.27^{b}	16.96^{a}	17.20^{a}	12.67^{b}	12.79^{b}	0.90
Leg	41.16^{c}	48.93^{b}	54.34^{a}	40.88^{c}	46.43^{b}	1.61
Wing	12.81^{b}	14.04^{b}	22.31^{a}	12.23^{b}	14.46^{b}	1.06
Liver	363.23^{d}	441.77^{b}	519.36^{a}	400.17^{cd}	426.36^{bc}	26.25

[1] Fe-Met 100: 100 ppm Fe as Fe-methionine; Fe-Met 200: 200 ppm Fe as Fe-methionine; $FeSO_4$ 100: 100 ppm Fe as $FeSO_4 \cdot 7H_2O$; $FeSO_4$ 200: 200 ppm Fe as $FeSO_4 \cdot 7H_2O$.

[a, b, c, d] Values with different superscripts in the same row are different ($p<0.05$).

pharmacological level. In the present study, basal diet contained 130 ppm Fe which is well over NRC (1994) requirement for broilers. It was found that the supplementation of Fe-methionine chelate and $FeSO_4 \cdot 7H_2O$ at 100 ppm or 200 ppm as Fe does not have adverse or positive effect on the production performance.

The Fe contents in the muscles and livers by treatment group are shown in Table 3. The Fe content was highest in the liver (363 mg/kg) followed by leg (41 mg/kg), wing (13 mg/kg) and breast muscle (12 mg/kg) in the control group. Iron content in the breast muscle was significantly higher in the Fe-Met treatment groups than in other treatment groups but there were no significant differences between the control group and $FeSO_4$ treatment groups. The Fe content in the leg muscle was significantly higher in the Fe-Met treatment groups and $FeSO_4$ 200 treatment group than in the control group but there was no significant difference between the $FeSO_4$ 100 treatment group and the control group. The Fe content in the wing muscle was significantly higher in the Fe-Met 200 treatment group than in other treatment groups but there were no significant differences among the rest treatment groups. The Fe content in the liver was significantly influenced by the supplementaion source and level of iron. The iron content was higher in the Fe-Met treatment groups than the $FeSO_4$ treatment groups and 200 ppm treatment groups were higher than 100 ppm groups in the treatments of the same supplementary source. Park et al. (2006) reported that Fe-methionine chelate is much more effective than $FeSO_4 \cdot 7H_2O$ in enriching Fe content of eggs. Bioavailability of iron from amino acid complex (Availa-Fe®) may also be higher than that of $FeSO_4 \cdot 7H_2O$ in piglets (Wei et al., 2005). Supplementing Fe-methionine at the level of 100 ppm Fe for 15 days resulted in satisfactory iron enrichment and increasing the supplementary Fe level to 200 or 300 ppm did not show any further response in iron enrichment. In the present broiler study, however, supplementation of 200 ppm Fe as Fe-methionine resulted in better response than 100 ppm Fe in iron enrichment of broiler meat.

In summary, liver contained approximately 10 times more iron than the leg muscle which contained approximately 3 times more iron than either breast muscle or wing muscle. Maximum iron enrichment was shown in Fe-Met 200 treatment in which increase of iron content was 40.2% in the breast muscle, 32.0% in the leg muscle, 74.2% in the wing muscle and 43.0% in the liver, respectively. It was concluded that the bioavailability of Fe in broiler chickens was higher in organic Fe sources (Fe-Met) than in inorganic Fe sources ($FeSO_4 \cdot 7H_2O$) and it was found that Fe is effectively accumulated in the muscle when 200 ppm

Fe was supplied in the form of Fe-Met.

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