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Nutritional Evaluation of Cottonseed Meal with and Without Ferrous Sulfate for Broiler Chickens

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Abstract: This experiment was conducted to evaluate the using of different levels of cottonseed meal with and without ferrous sulfate in broiler diet. The performance of 42 old day straight Cobb (500) broiler chicks fed diets containing 5, 10, 15 and 20% Cottonseed Meal (CSM) was compared with that of control chicks fed corn and soybean meal based broiler rations. Four dietary treatments with Ferro sulfate, four dietary treatments without Ferro sulfate. The 1 treatment (control) 2-5 (without Ferro sulfate) and 6-9 (with Ferro sulfate). All diets were formulated to meet minimum NRC requirements. Lysine levels were adjusted by addition of synthetic lysine at rates of 0.5% of the protein in CSM and by addition of synthetic Ferro sulfate at rate of 0.04% of the protein in CSM.

Key words: Broiler chickens, cottonseed meal, ferro sulfate, nutrition, supplement, Iran

INTRODUCTION

Cottonseed Meal (CSM) is a byproduct of the process used to extract oil from cotton seeds arid contains 41 or 44% crude protein depending on the extent of hull separation prior to the oil extraction process. Although, CSM is high in protein, its utilization in poultry feed as a protein supplement is limited due to low lysine levels and by the presence of a toxic substance, gossypol. Problems related to lysine level and nutrient density are easily rectified by addition of synthetic lysine to poultry feed.

However, solutions to the problems related to gossypol in CSM have been elusive. Gossypol, a naturally occurring metabolite of cotton that is concentrated in the seeds is associated with reduced performance and increased mortality in chickens (Morgan, 2004). However, several feeding trails have shown that chick performance is not significantly affected when the dietary level of free gossypol is <250 mg kg^{-1} of feed (Gamboa *et al*., 2001).

Other studies have shown that several factors such as age, strain of chickens, dietary iron and dietary lysine may affect birds' tolerance of gossypol (Adeyemo and Longe, 2007; Clawson *et al*., 1975). The quantity of CSM that can be incorporated into the diet depends largely on the amount of gossypol in the meal. In order to utilize CSM in poultry rations great efforts have been devoted to devising practical methods to reduce and detoxify the free gossypol.

Extensive feeding studies have shown that addition of ferrous sulfate to rations containing CSM reduced the adverse effects of gossypol on swine and poultry (Adeyemo and Longe, 2007; Evans *et al*., 1961). Although, the addition of ferrous sulfate has reduced the adverse effects of gossypol, it is not widely accepted by the poultry industry. Free gossypol also binds to lysine under extreme temperatures and reduces the free gossypol available for absorption. However, extreme heat also reduces protein quality, thus limiting the usefulness of this method (Husby and Kroening, 1971; Randel *et al*., 1992). Several investigators have reported the anti fertility effect of gossypol in males and females of non-ruminant species (Adeyemo and Longe, 2007; Clawson *et al*., 1975; Gamboa *et al*., 2001). It was collectively indicated that gossypol acetic acid treatment of female rodents disrupts the normal pattern of estrous cycle through effect on pituitary and ovarian hormone secretion. It has been reported that at effective doses, gossypol causes males to be infertile because of sperm immotility and depressed sperm counts (Adeyemo and Longe, 2007).

MATERIALS AND METHODS

This experiment was carried out in the experimental farm of Zanjan University of Zanjan, Iran. The test material was analyzed in duplicate for dry matter, crude protein (N×6.25), crude fiber and crude fat by the procedures of the Association of Official Analytical

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Chemists (AOAC, 1995). Fat extracts were methylated in the presence of sulphuric acid for gas chromatographic identification of fatty acids (Sandler and Karo, 1992). Gross energy was determined using an adiabatic oxygen bomb calorimetric. CSM was included in grower diet with 5, 10, 15 and 20% of diet with and without ferrous sulfate. Four dietary treatment with Ferro sulfate and another four dietary treatment without Ferro sulfate and Lysine. We use in this experiment from Ferrous sulfate Heptahydrate. The metabolizable energy reported by National Research Council (1994) for CSM was 1.857 kcal kg^{-1} and this value was used in the formulation of the diets.

The 1 day old (Cobb500 strain) broiler chicks were used in all experiments. Chicks were housed in Petersime battery brooders with 24 h fluorescent light. Feed and water were provided *ad libitum* for the duration of the experiment (Table 1). A corn and soybean meal based starter ration was fed to chicks from 1-21 day of age. At 21 day, chicks were weighed. The average body weights on day 21 were 30.6, 29.8, 29.6, 28.3, 29.5, 28.9, 28.8, 29.7 and 29.8 g for experiment, respectively. Three hundred seventy eight 21 day old broiler chicks were distributed randomly to 9 treatments with 3 replicates (14 chicks in each replicate/pen) in each treatment.

Body weights were measured at 21 and 42 day, residual feed was measured at 21 and 42 day and Feed Conversion Ratio (FCR) was calculated. At termination, chicks were killed by cervical dislocation. Hearts, livers, Testes and abdominal fat pads were removed and weighed. Control and experimental diets formulated and fed to chicks in experiment are shown in Table 1.

Statistical analysis: The experimental design was a completely random arrangement of nine treatments with tree replications. The general linear models procedure of SAS Institute (1992) was used to analyze the data. Duncan (1955) means separation test was used to test for differences between means when the F test for treat means was significant ($p<0.05$).

RESULTS AND DISCUSSION

The increase of the cottonseed meal resulted to decrease significant difference in mortality that contrast with other researchers (Boatner *et al*., 1949; Eagle, 1949). The inclusion of CSM (with and without Ferro sulfate) in the diets resulted in higher carcass fat as indicated by fat pad as a percentage of body weight (Table 2). The liver, heart, testes, Gizzard, values were not significantly affected by the use CSM (with and without Ferro sulfate) in the diets (Table 2). There were no differences in body weight gain of chicks fed CSM (with and without Lysine and Ferro sulfate) and those fed corn and soybean meal based control diet. In the present study (Table 3), feed formulated with 5, 10, 15 and 20% CSM (with and without Ferro sulfate) to meet the National Research Council (1994) recommended level for all nutrients. The free and total gossypol which was determined using a HPLC procedure, remained about the same in all treatments. Even with this dramatic decrease in free gossypol in the CSM, the performance of chicks fed CSM were not equivalent those fed corn and soybean meal based diets.

Although, supplemental Lysine and Ferro sulfate both significantly improved weight gain and feed efficiency, they were not able to prevent the increase in carcass fat associated with the use of CSM as the major protein source. The increase in carcass fat in chicks fed rations formulated with CSM as the major protein source may be attributed to the protein quality. Diets formulated with high ratios of calorie to protein resulted in high

Table 1: Feed formulation and nutrient composition in control and experiment rations

	Treatments								
Ingredient (%)	1	2	3	4	5	6	7	8	9
Corn	59.50	56.95	54.29	51.51	48.82	56.69	54.00	51.17	48.50
Soybean meal, 48% CP	26.70	24.11	21.50	19.00	16.40	24.10	21.50	19.03	16.40
Cottonseed meal	0.00	5.00	10.00	15.00	20.00	5.00	10.00	15.00	20.00
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	1.16	1.13	1.14	1.14	1.15	1.13	1.13	1.14	1.15
Limestone	1.26	1.28	1.27	1.27	1.26	1.28	1.28	1.27	1.26
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin+Mineral mix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.22	0.17	0.18	0.20	0.20	0.17	0.18	0.20	0.21
Lysine	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Soybean oil	5.35	6.50	6.20	5.90	5.60	6.40	6.10	5.80	5.50
Ferro sulfate	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Calculated analysis									
ME (kcal kg^{-1})	2950.00	3232.00	3232.00	3232.00	3232.00	3232.00	3232.00	3232.00	3232.00
CP (%)	21.20	20.20	20.20	20.20	20.20	20.20	20.20	20.20	20.20
Crud fiber (%)	3.20	4.10	4.90	5.80	6.60	4.10	4.90	5.80	6.60
Lysine	1.20	1.20	1.10	1.20	1.20	1.20	1.10	1.20	1.20

Provides the following per kilogram of diet: Vit. A (8000 IU); Vit.D3 (3000 IU); Vit. E (25 IU); Vit. B12 (4.5 mg); Biotin (0.2 mg); Folacin (1 mg); Niacin (50 mg); Pantothenic acid (15 mg); Pyrodoxin (4 mg); Riboflavin (10 mg) and Thiamin (3 mg); Provides the following per kilogram of diet: Copper (Cupric sulfate pentahydrate) (7 mg); Iodine (Calcium iodate) (1 mg); Iron (Ferrous sulfate monohydrate) (50 mg); Manganese (Manganese sulfate monohydrate) (100 mg); Selenium (Sodium selenite) (0.15 mg) and Zinc (Zinc sulfate monohydrate) (75 mg)

Table 2: Effect of cottonseed meal with and without ferrous sulfate on weight of some organs determined at 42 days of age (percentage of live body weight)

Diets	Heart	Liver	Testes	Gizzard	Abdominal fat
1	0.51	1.90	0.22^{abc}	2.10	0.95^{b}
2	0.57	2.10	0.17^{c}	2.10	1.80^{ab}
3	0.63	2.20	0.25^{abc}	2.30	2.40^{b}
4	0.61	2.20	0.32^{a}	2.40	1.80^{ab}
5	0.62	2.20	0.21^{bc}	2.10	1.80^{ab}
6	0.57	2.10	0.31^{ab}	2.30	2.10^{a}
7	0.63	2.30	0.31^{ab}	2.70	1.70^{ab}
8	0.58	2.30	0.32^{ab}	2.70	1.50^{ab}
9	0.58	2.30	0.32^{ab}	2.70	1.50^{ab}
SEM	0.04	0.16	0.03	0.21	0.29

[a-c]Within the same column, means with different letters are significantly different ($p<0.05$)

Table 3: Effect of cottonseed meal with and without ferrous sulfate on performance parameters of broiler (21-42 days of age)

Diets	Weight gain (g/b/day) 21-42 days	Feed intake (g/b/day) 21-42 days	Feed conversion ratio 21-42 days
1	76.2	136.7^{a}	1.80^{ab}
2	69.1	137.2^{a}	2.10^{a}
3	74.2	139.2^{a}	1.80^{ab}
4	67.2	120.4^{c}	1.60^{bc}
5	68.8	129.2^{b}	1.70^{bc}
6	76.3	122.6^{c}	1.50^{c}
7	69.2	114.1^{d}	1.50^{c}
8	71.2	128.5^{b}	1.70^{bc}
9	67.9	129.6^{c}	1.60^{bc}
SEM	2.9	1.8	0.04

[a-c]Within the same column, means with different letters are significantly different ($p<0.05$)

carcass fat on chickens. The CSM metabolizable energy used in diet formulation was taken from National Research Council (1994) publication and thus the ME level of the diets with CSM may be greater than calculated. High energy: protein ratio increases carcass fat. Although, the use of iron to detoxify gossypol may be more economical, it does not result in improved feed utilization. The use of iron may also affect the utilization of other trace minerals and thus is not widely accepted by the poultry industry.

CONCLUSION

In all experiments, weight gain, feed intake and Feed Conversion Ratio (FCR) of broilers at 21-42 day were significantly affected by the diets. Feeding CSM resulted in decreased body weight gain, increased feed intake and inefficient feed utilization. When 0.04% Ferro sulfate were added to feed, the body weight gains and feed conversion ratio of chicks were not significantly different from those fed the control diet. The FCR of chicks fed CSM plus 0.04% Ferro sulfate at 21-42 days was significantly better than that of chicks fed CSM without Ferro sulfate. Abdominal fat pads (as a percentage of body weight) were significantly increased by the inclusion of CSM with or without the addition of Ferro sulfate ($p<0.05$). Liver and heart weights were not affected by the presence of CSM in the diet. However, this study shows that with adequate supplemental Ferro sulfate, CSM can be used in broiler diets without a reduction in performance.

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REFERENCES

AOAC, 1995. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

Adeyemo, O.G. and D.O. Longe, 2007. The reproductive performance of breeder cocks fed cottonseed meal cake-based diets. J. Poult. Sci., 2: 140-144.

Boatner, C.H., L.E. Castillon, C.M. Hall and J.W. Neely, 1949. Gossypol and gossypurpurin in cottonseed of different varieties of *G. barbadense* and *G. hirsutum* and variation of the pigments during storage of the seed. J. Am. Oil Chem. Soc., 26: 19-25.

Clawson, A.J., J.H. Maner, G. Gomez, O. Mejia, Z. Flores and J. Buitrago, 1975. Unextracted cottonseed in diets for monogastric animals. I. The effect of ferrous sulfate and calcium hydroxide in reducing gossypol toxicity. J. Anim. Sci., 40: 640-647.

Duncan, D.B., 1955. Multiple range and multiple F-test. Biometrics, 11: 1-42.

Eagle, E., 1949. Detoxification of cottonseed pigment glands with ferrous sulfate. Proc. Soc. Biol. Med., 72: 444-446.

Evans, R.J., J.A. Davidson and S.L. Bandemer, 1961. Fatty acid and lipid distribution in egg yolks from hens fed cottonseed oil or *Sterculia foetida* seeds. J. Nutr., 73: 282-290.

Gamboa, D.A., M.C. Calhoun, S.W. Kuhlmann, A.U. Haq and C.A. Bailey, 2001. Tissue distribution of gossypol enantiomers in broiler fed various cottonseed meals. Poult. Sci., 80: 920-925.

Husby, F.M. and G.H. Kroening, 1971. Energy value of cottonseed meal for swine. J. Anim. Sci., 33: 592-603.

Morgan, S., 2004. Gossypol toxicity in livestock. Division of Agricultural Sciences and Natural Resources, Oklahoma State University. http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1952/VTMD-9116.pdf.

National Research Council, 1994. Nutrient Requirements of Poultry. 9th Rev. Edn., National Academy Press, Washington, DC. USA., ISBN-10: 0-309-04892-3, pp: 176.

Randel, R.D., C.C. Jr. Chase and S.J. Wyse, 1992. Effects of gossypol and cottonseed products on reproduction of mammals. J. Anim. Sci., 70: 1628-1638.

SAS Institute, 1992. SAS-User's Guide, Statistics. Version 8, SAS Institute Inc., Cary, NC. USA.

Sandler, S.R. and W. Karo, 1992. Source Book of Advances Organic Laboratory Preparations. Academic Press, San Diego, pp: 332.