World Journal of Agricultural Sciences 4 (5): 533-537, 2008
ISSN 1817-3047

Improving the Nutritive Value of Cottonseed Meal by Adding Iron on Growing Lambs Diets

Abou Ward, G.A. Tawila, M.A. Sawsan, M. Gad and M.M. El-Moniary

Department of Animal Production, National Research Center, Dokki, Giza, Egypt

Abstrac: Eighteen growing Barki male lambs (5-6 months old and weighed in average 25±2 Kg) were randomly assigned according to their body weight into three feeding groups (6 in each) to investigate the effect of adding ferrous sulfate on the performance of growing lambs fed undecorticated cottonseed meal (UCSM) compared with lambs fed UCSM or soybean meal (SBM) based diets without addition through growth trial for 150 days followed by digestibility trials. The experimental rations contained 13 % SBM for group I and 30 % UCSM (as a main source of protein) either, without addition as ration II or with ferrous sulfate addition (1 part iron: 1 part free gossypol), ration III. Animals in all groups were fed total mixed ration (concentrate and Berseem hay) *ad libtium*. The results showed that the addition of ferrous sulfate significantly (P<0.05) improved all nutrients digestibility and nutritive values as TDN and DCP compared with unsupplemented ration (II).Average daily gain was significantly (P<0.05) improved by adding ferrous sulfate. Animals in ration I had the lowest feeding cost being 7.3 followed by ration III which had 7.7 while ration II recorded the higher feeding cost being 8.2 L.E /Kg gain. It could be concluded that the addition of ferrous sulfate to UCSM might be improve the utilization of UCSM and alleviate the adverse effect of gossypol which reflected on the performance of growing lambs.

Key words: Undecorticated cottonseed meal · Soybean meal · Ferrous sulfate · Lambs

INTRODUCTION

The use of undecorticated cottonseed meal as an animal feed is limited by the presence of gossypol. Feeding diets containing gossypol can cause negative effects on growth, reproductive, performance, as well as intestinal and internal organ abnormalities [1- 4]. Gossypol in cotton seed exists in both the free and bound forms. Most gossypol found in whole cottonseed is in the free form but some becomes bound due to the heat, moisture and pressure associated with cottonseed meal extrusion and other types of cottonseed processing [5, 6]. The bound form of gossypol is generally considered to be nontoxic, although during digestion, some researchers suggested that more bound gossypol from processed whole cottonseed (WCS) or cotton seed meal (CSM) may be converted to free gossypol in the digestive tract [6-8]and the free form is potentially toxic [1, 3, 9]. Gossypol also exists as a mixture of (+) and (-) stereoisomers [10], the (-) isomer having the higher biological activity [11]. Adult cattle can tolerate much larger amounts of free gossypol but toxicity has been reported with levels 0.08 % of gossypol fed over a long period of time [9]. Gossypol toxicity in functioning ruminants depended on several factors, including the level of gossypol, the proportion of feeding gossypol in the free form, the relative proportion of the (+) and (-) isomers, the amount of cottonseed or cottonseed meal consumed and the efficiency of the detoxification action.

The objective of the present study is to improve the utilization of UCSM by adding ferrous sulfate which reduce the adverse effect of gossypol in UCSM and compare this with SBM diet on the performance of growing lambs.

MATERIALS AND METHODS

Feeding experiments including digestibility trials were carried out on growing Barki male lambs. Experimental rations were used to study the effect of gossypol in cottonseed meal without or with iron addition on daily gains, feed intakes, efficiency, nutrients digestibility and nitrogen balance of lambs given these rations. The current study was carried out on 18 Barki male lambs of about 25±2 live body weight and 6 month – old. Animals were randomly assigned to three experimental group 6 each. The three experimental rations were almost isocaloric, isonitrogenous and the control group (I) was based mainly on soybean meal as a source of protein. The other two rations were based mainly on undecorticated

Corresponding Author: Dr. Abou Ward, Department of Animal Production, National Research Center, Dokki, Giza, Egypt

Table 1: Ingredient composition

Item	I	II	III
Corn	35.5	30.0	30.0
Soybean meal	13.0	----	----
Cottonseed meal	----	30.0	30.0*
Wheat bran	16.7	----	----
Wheat straw	6.5	11.2	11.2
Berseem hay	25.0	25.0	25.0
Minerals	0.2	0.2	0.2
Vitamins	0.1	0.1	0.1
Salt	1.0	1.0	1.0
Limeston	2.0	2.5	2.5

*cottonseed meal supplemented by 15 gm ferrous sulfate/ 1 kg.

cottonseed meal as main protein source calculated to supply an amount of protein equivalent to the soybean meal in the control group. A supplement of ferrous sulfate was given for rations III (1 part iron: 1 part free gossypol). The total and free gossypol were determined and found to be 1.6% total and 0.24% free gossypol. The three experimental rations are presented in Table 1.

Each group had received one of the three experimental rations, for 150 days, which were given *ad-lib* and the residuals were daily weighed to determine the free choice intake of each. Animals were allowed free access to clean water. Changes in body weight were recorded bi-weekly. During the last month of the experiment, four animals of each group were used in a metabolic trial. Preliminary period is 15 days, followed by 7 days collection period. Diets were offered twice daily and water was freely available. Faeces and urine collected every 24 hours for 7 consecutive days. Samples of both faeces and urine were take (10%) for each animal and kept frozen until chemical analysis.

Chemical Analysis: A proximate chemical analysis was carried out according to the standard methods of A.O.A.C [12] on representative samples of the essential nutrients in feeds, faeces, residuals and nitrogen of urine. Total gossypol and free gossypol determined according to A.O.C.S [13].

Statistical Analysis: Data collected were statistically analyzed using the general liner model of SAS [14]. Significant differences between means were tested by Duncan's multiple range tests [15]. One way analysis of variance was adopted using the following equation:

$$Yij = u + Ti + Eij$$

Where:

Yij = The observations of the parameter measured.

U = Overall means

Ti = The effect of replication

Eij = The random error term.

RESULTS AND DISCUSSION

Chemical composition of the experimental rations which are presented in Table 2 showed that all the tested rations in the current experiment were almost similar in their chemical composition.

Nutrients Digestibility: The results of nutrients digestibility in Table 3 clearly showed that lambs fed ration (I) which including soybean meal (SBM) and ration of undecorticated cottonseed meal supplemented with iron(III) had significantly (P<0.05) higher nutrients digestibility compared with feeding undecorticated cottonseed meal without iron (II). This is in agreement with El Hag and El Hag [16] who reported that sheep fed cottonseed cake depressed DM and OM digestibilities and with Abou Donia [17], which reported that protein digestibility depression related to gossypol toxicity. Gossypol is combined with ϵ-amino groups in the digestive tract and then be excreted by facilitating catabolism and detoxification of the absorbed gossypol. On the other hand, the depression of nutrients digestibility of lambs fed UCSM may be due to the effect of gossypol on digestive enzymes [18]. Adding iron sulfate to cottonseed meal improved significantly (P<0.05) all nutrients digestibility as compared with those fed ration containing UCSM. This may be due to the effective of iron on alleviating gossypol toxicity by binding it and partially inhibit the adverse effect of gossypol on digestive enzyme [19, 20].

The TDN value of rations I and III had no significant differences between them but they were significantly higher than ration II. TDN is a reflection of higher nutrient digestibility coefficients value of the different nutrients. As regards to DCP, values recorded for rations I and III were significantly higher than those obtained for ration II.

Nitrogen Balance: Data of nitrogen balance (NB) are presented in Table 3. All rations showed positive nitrogen balance. The values of NB ranged between 4.1 and 6.4 g/h/d. Lambs fed rations I and III retained highest

Table 2: Chemical composition of experimental rations

Item	I	II	III
Moisture	8.74	8.29	7.96
Chemical composition, (%DM basis)			
DM	91.26	91.71	92.04
OM	91.36	91.64	91.31
CP	14.32	14.69	14.85
EE	2.20	2.67	2.57
CF	13.12	14.18	14.12
NFE	61.72	60.10	59.77
Ash	8.64	8.36	8.69

Table 3: Nutrient Digestibility, nutritive value and nitrogen balance of lambs fed rations

	Tested rations		
Item	I	II	III
A) Nutrient digestibility, % ± SE			
DM	75.7±0.88[a]	65.3±0.88[b]	71.7±2.73[a]
OM	80.0±1.73[a]	68.3±1.20[b]	75.0±2.08[a]
CP	73.0±1.73[a]	60.0±1.15[b]	70.3±2.40[a]
EE	74.7±1.20[a]	62.7±1.45[b]	70.7±1.20[a]
CF	53.3±0.88[a]	44.3±1.21[b]	53.0±1.53[a]
NFE	86.0±1.15[a]	74.7±0.90[b]	83.3±0.88[a]
B) Nutritive value% ± SE			
TDN	74.2±1.69[a]	63.8±1.63[b]	71.8±1.89[a]
DCP	10.5±1.73[a]	8.8±1.15[b]	10.4±2.4[a]
Nitrogen balance			
Nitrogen intake g/h/d	22.9	25.9	26.4
Faecal nitrogen g/h/d	6.2	10.4	7.8
Urinary nitrogen g/h/d	10.3	11.4	12.4
Nitrogen balance g/h/d	6.4±0.71[a]	4.1±0.95[b]	6.2±1.2[a]

a and b different letters indicate significant difference (P = 0.05)

Table 4: Feed intake, live weight gain and feed conversion of lambs fed tested rations

Item	I	II	III
A) Live body weight:			
Initial body weight,Kg	25	23	27
Final body weight,Kg	55	48.5	55.5
Total body weight gain,Kg	30	25.5	28.5
Daily body weight gain, g±SE	200±4.65[a]	170±2.89[b]	190±2.89[a]
B) Feed intake			
Total DMI g/h/d	1000	1100	1110
TDN Intake g/h/d	742	702	797
C) Feed conversion, g feed/g gain			
DMI	5.00	6.47	5.84
TDN	3.71	4.13	4.19

a and b different letters indicate significant difference (P = 0.05)

(p<0.05) values of NB compared with lambs fed ration II. While there were no significant difference (P<0.05) between rations I and III.

Table 5: Economical evaluation of tested ration

Item	I	II	III
Price of one ton feed	1460.00	1310.00	1325.00
Price of feed intake h/d. L.E.	1.46	1.44	1.47
Feed cost/Kg gain L.E.	7.30	8.20	7.70
Feed efficiency Kg Feed /Kg gain	5.00	6.50	5.80

*Based on market prices at the beginning of experiment as DM basis

The results obtained indicated that NB of lambs fed rations I and III were nearly similar. Therefore it is suggested that protein of cottonseed meal could be more efficiently utilized with iron supplement than unsupplemented CSM.

Growth Performance: Data presented in Table 4 showed that lambs received ration I and III had significant (P<0.05) higher average daily gain (ADG) being 200 g and 190 g respectively, while lambs fed ration II recorded lower value being 170 g. Better performance with lambs fed ration I may be related to the higher nutrients digestibility, [21] and also may be due to the effect of protein source on lambs performance. Several investigators reported that at the equal protein level the source of protein showed better growth rate than other protein sources such as urea, corn gluten meal, sunflower meal, soybean meal and cottonseed meal [22-24].

On the other hand cottonseed meal has gossypol which appears a toxic effect [6]. Poor body weight gain for lambs fed ration II may be due to the lower of protein digestibility related to gossypol toxicity [17], also, may be due to the effect of gossypol on digestive enzymes [18]. Gossypol in UCSM and WCS is considered anti-nutritional factor when used in high percentage in dairy cows [20, 25], calves [26], sheep [27, 28] and goats [29]. Velasquez-Pereira *et al.* [30] found that using UDCSM in Holstein bulls diet recorded lower daily gain compared with SBM diet. Feeding lambs on ration III which including UDCSM with iron resulted a significant (P< 0.05) increase in ADG compared with lambs fed UCSM. This improvement may has been related to the higher nutrients digestibility compared with ration II and may also be due to the effective of iron on alleviating gossypol toxicity by binding with free gossypol (FG) which is a toxic form of gossypol [20]. Dry matter intake (DMI) was similar for all treatments while diet containing SBM recorded lower DMI. The corresponding values were 1000, 1100 and 1110 for the three diets respectively.

Concerning feed conversion as g DM and TDN intake / g gain, lambs fed ration I markedly performed better compared with other groups, the corresponding values were 5, 6.47 and 5.8 for rations I, II and III, respectively, this superiority in feed conversion might be due to lower feed intake relative to the highest body weight gain recorded by lambs.

Economic Evaluation: The feed cost /kg in L.E were 7.3, 8.2 and 7.7 for rations I, II and III, respectively. Data presented in Table 5 showed that lambs fed ration I which including SBM had the best economic efficiency followed by lambs fed rations III, while the poor economic efficiency was found with ration II.

REFERENCES

1. Beradi, L.C. and L.A. Goldblatt, 1980. Gossypol. In: Liener, I. E. (Ed), Toxic Constituents of Plant Foodstuffs, 2nd ed. Academic press, NY, USA., pp: 183.
2. Francis, G., H.P.S. Makkar and K. Becker, 2001. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture. 199: 197.
3. Robinson, P.H., G. Getachew, E.J. DePeters and M.C. Calhoun, 2001. Influence of varity and storage for up to 22 days on nutrient composition and gossypol level of Pima cottonseed (*Gossypium* spp). Anim. Feed Sci. and Technol., 91: 149.
4. Santos, J.E.P., M. Villasenor, P.H. Robinson, E.J. Depeters and C.A. Holmberg, 2003. Type of cottonseed and level of gossypol in diets of lactating dairy cows: plasma gossypol, health and reproductive performance. J. Dairy Sci., 86: 892.
5. Calhoun, M.C., S.W. Kuhlmann and B.C. Baldwin, 1995. Assessing the gossypol status of cattle fed cottonseed products. Pages 147A-157A. In: Proceedings of the Pacific Northwest Anim. Nutr. Conf., Portland, OR. C.F. Mena *et al* 2004. J. Dairy Sci., 87: 2506.
6. Mena, H., J.E.P. Santos, J.T. Huber, J.M. Simas, M. Tarazon and M.C. Calhoun, 2001. The effect of feeding varying amounts of gossypol from whole cottonseed and cottonseed meal in lactating dairy cows. J. Dairy Sci., 84: 2231.
7. Blauwiekel, R., S. Xu, J.H. Harrison, K.S. Loney, R.E. Riley and M.C. Calhoun, 1997. Effect of whole cottonseed, gossypol and ruminary protected lysine supplementation on milk yield and composition. J. Dairy Sci., 80: 1358.
8. Noftsger, S.M., B.A. Hupkins, D.E. Diaz, C. Brownie and L.W. Whitlow, 2000. Effect of whole and expended-expelled cottonseed on milk yield and blood gossypol. J. Dairy Sci., 83: 2539.
9. Morgan, S.E., 1989. Gossypol as a toxicant in livestock. In Burrows GE (ed): The Veterinary Clinics of North America: Food Animal Practice. Philadelphia. W. B. Saunders, pp: 251-263.
10. Huang, L., D.K. Zheng and Y.D. Si, 1987. Resolution of racemic gossypol. J. Ethnopharmacol., 20: 13.
11. Joseph, A.E.A., S.A. Matlin and P. Knox, 1986. Cytotoxicity of enantiomers of gossypol. Br. J. Cancer, 54: 511.
12. A.O.A.C. 1990. Official Methods of Analysis. (15th Ed.). Association of Official Analytical Chemists, Arlington, VA., USA.
13. A.O.C.S. 1984. Sampling and analysis of oilseed by-products. Official Methods Ba 8-55. In: Official and Tentative Methods of Analysis. 3rd ed. Chicago.
14. S.A.S. User's Guide, Statistics 1982. SAS Inst. Cary. NC.
15. Duncan, D.B., 1955. Multiple Range and Multiple F Test. Biometrics, 11: 1.
16. El Hag, M.G. and G.A. El Hag,1981. Further studies on effect of supplementing groundnut hulls with dried poultry excreta or cottonseed cake on performance of Suden desert sheep. World Rev. Anim. Prod., 17: 9-14.
17. Abou-Donia, M.B., 1989. Gossypol. In: P. R. Cheeke (Ed.) Toxicants of Plant Origin. Vol. IV: Phenolics. pp: 122. CRC Press, Boca.
18. Chase, J.R., C.C.J. Bastidas, L. Ruttle, C.R. Long and R.D. Randel, 1994. Growth and reproductive development in Brah-man bulls fed diets containing gossypol. J. Anim. Sci., 72: 445.
19. Jarquin, R., R. Bressani, L.G. Elias, C. Tejada, M. Gonzalez and J.E. Braham, 1966. Effect of cooking and calcium and iron supplementation on gossypol toxicity in swine. J. Agric. Food Chem., 14: 275.
20. Barraza, M.L., C.E. Coppock, K.N. Brooks, D.L. Wilks, R.G. Saunders and G.W. Latimer, 1991. Iron sulfate and feed pelleting to detoxify free gossypol in cottonseed diets for dairy cattle. J. Dairy Sci., 74: 3457.
21. Haddad, S.G. and S.N. Goussous, 2005. Effect of yeast culture supplementation on nutrient intake, digestibility and growth performance of Awassi Lambs. Anim. Feed Sci. and Tech., V. 118 Iss. 3-4, 4 Feb. 343-348.

22. Merchen, N.R., D.E. Darden, L.L. Berger, G.C. Fahay, E.C. Titgemeyer and R.L. Fernando, 1987. Effects of dietary energy level and supplemental protein source on performance of growing steers and nutrient digestibility and nitrogen balance in lambs. J. Anim. Sci., 65: 658.
23. Douff, G.C., A.L. Goetsch, K.M. Landis, A.C. Hardin, S.R. Stokes, Z.B. Johnson and K.L. Hall, 1988. Mixing or alternating dietary crude protein source and performance of wether lambs. Canadian J. Anim. Sci., 68(2): 569-572.
24. Ludden, P.A., J.M. Jones, M.J. Cecava and K.S. Hendrix, 1995. Supplemental protein source for steers fed corn-based diets: II. Growth and estimated metabolizable amino acid supply. J. Anim. Sci., 73: 1476-1486.
25. Lindsey, T.O., G.E. Hawkins and L.D. Guthrie, 1980. Physiological responses of lactating cows to gossypol from cottonseed meal rations. J. Dairy Sci., 63: 562.
26. Rogers, P.A.M., T.D. Henaghem and B. Sheeler, 1975. Gossypol poisoning in young calves. Irish Vet. J., 29: 9-13.
27. Danke, R.G., R.J. Paniciera and A.D. Tillman, 1965. Gossypol toxicity studies with sheep. J. Anim. Sci., 24: 1199-1201.
28. Morgan, S., E.L. Stair, T. Martin, W.C. Edwards and G.L. Morgan, 1988. Clinical, Clinicopathologic, pathologic and toxilogical alterations associations with gossypol toxicosis in feeder lambs. Am. J. Vet. Res., 49: 493-499.
29. East, N.E., M. Anderson and L.J. Lowenstine, 1994. Apparent gossypol induced toxicosis in adult dairy goats. J. Am. Vet. Mad. Assoc., 204: 642-643.
30. Velasquez-Pereira, J., D. Prichard, L.R. Mcdowell, P.J. Chenoweth, C.A. Risco, C.R. Staples, F.J. Martin, M.C. Calhoun, L.X. Rojas, S.N. Williams and N.S. Wilkinson, 1998. Long term effects of gossypol and vitamin E in the diets of dairy bulls. J. Dairy Sci., 81: 2475.