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Utilization of decorticated cottonseed meal with or without protease in diets of broiler chicken

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ABSTRACT

The present study was conducted to evaluate the feeding value of decorticated cottonseed meal (DCSM, non-detectable free-gossypol) with or without supplemental protease on the basis of growth performance, nutrient utilization and feed-cost of production in broiler chicken. Accordingly, a six weeks (0 to 6 weeks of age of broiler chickens) feeding trial was conducted following 5 × 2 factorial design involving five dietary levels (0, 5, 10, 15 and 20%) of DCSM, with (0.035%) or without protease in a standard broiler chicken diet. Day-old chicks (320) were divided into 40 groups of eight birds each (replicate) and each dietary treatment was offered to four replicated groups. There was no significant difference in body weight gain, feed intake and feed conversion ratio, protein and energy utilization efficiency due to levels of decorticated cottonseed meals in diets replacing soybean meal of control diet and protease supplementation. Nitrogen retention was not influenced either by cottonseed meal or by protease in diet. There was no adverse effect on cellular as well as humoral immunity on addition of cottonseed meal in diet. Addition of protease in diet did not improve the above mentioned performance parameters. Feed-cost of production decreased significantly and linearly on addition of cottonseed meal at graded levels. The present study revealed that incorporation of DCSM up to 20% level in diet, either with or without enzyme supplementation, did not affect growth performance of broiler chicken during 0–6 weeks of age. Therefore, decorticated cottonseed meal can safely and effectively be included up to 20% level without enzyme supplementation in maize-soybean based diets of broiler chickens replacing soybean meal for profitable broiler production.

Key words: Broiler, Decorticated cottonseed meal, Immunity, Performance, Protease

Feed is the major input (65 to 75%) in poultry production and ever increasing cost and scarcity of feedstuffs, especially proteinic ingredients are the major constraints in poultry production. It, therefore, becomes imperative for searching cheaper alternative feedstuffs without compromising quality of the mixed feed, to improve productive performance of the birds, nutrient utilization and profitability. Soybean meal is the major proteinic ingredient used in poultry diet. The estimated requirement for soybean meal will be 8.9 and 11.9 million tonnes in 2020 and 2025. Assuming diversion of 40% of soybean towards poultry, livestock and poultry feeding, there is net shortage of this commodity. Moreover, India's soybean extractions have high protein and fat contents (49% - 50% compared to 44–48% of China and America) and are very well accepted in international market, and thus are being exported (Chadha 2005). Therefore, to overcome the shortage of soybean meal, India has to rely on use of other protein supplements within their safe levels. The annual production of cotton oilseed has been 11.3 and 10.6, and that for cake 3.94 and 3.89 million tonnes in 2011 and 2012 (Mandal 2012). In addition, cotton meal constitutes the largest share in terms of total availability of meal, one third of total meal consumed. Despite the anti-nutritional factors and the low levels of available lysine associated with cottonseed meal, there has been a continuous interest in utilizing this feed ingredient in animal feeds due to the continual rise in cotton production around the world and to buffer the shortage of soybean meal (Anderson and Warnick 1966). Addition of protease to poultry diets is nutritionally, economically and environmentally justified. Proteases are added to feed with the purpose of increasing dietary protein hydrolysis and thus enabling improved nitrogen utilization. In view of the above, the proposed study was planned to evaluate the response of birds in terms of growth, nutrient utilization and carcass traits to diet containing cottonseed meal with or without enzyme supplementation.

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MATERIALS AND METHODS

Day-old chicks (320) from same hatch were divided into 40 groups of eight birds each (replicate). A feeding trial of six weeks duration (0 to 6 weeks of age) was conducted following 5 × 2 factorial CRD involving five dietary inclusion levels (0, 5,10,15 and 20%) of decorticated cottonseed meal-DCSM with and without protease in standard broiler chicken diets. Each dietary treatment was offered to four replicated groups having 8 chicks in each. The growth performance with respect to gain in body weight, feed intake, FCR, nitrogen utilization and cost of feeding were studied. The composition of feeds used in the present study is given in Tables 1 and 2. Growth performance of the experimental birds was recorded in terms of weight gain, feed consumption and feed conversion ratio starting from 0 to 42 days of age. Chicks were weighed individually at weekly intervals and the average gain in body weight under each dietary treatment was then calculated. Feed intake was also recorded weekly. Feed conversion ratio (FCR) was calculated.

The blood samples were collected from eight birds per treatment (two birds from each replication) at 35th day (5 days after SRBC immunization) for HA titre estimation against SRBC for humoral immune response (Siegel and Gross 1980). For cell mediated immune response, at 22nd day post-hatch 0.1 ml of PHA-P was injected and after 24 h of injection the foot web index (mm) was calculated (Corrier and Deloach 1990). In order to study the retention of nitrogen, a metabolism trial of four days duration was conducted at 4th week of age (24th to 27th day) during which the net feed consumed by each bird in the respective dietary group was recorded and the dropping voided over same period were collected quantitatively. Feeding cost of broilers in terms of weight gain and meat production based on the prevailing market prices of the feed ingredients was calculated. The cost of reference and test diets was calculated taking into consideration the prevailing price of individual feed ingredients, supplements and enzyme.

Table 1. Ingredients and nutrient composition of experimental diets for starter phase (0–3 weeks)

	DCSM (%)				
Nutrient composition%	0	5	10	15	20
Maize, yellow	55.40	55.15	54.91	54.67	54.32
Soybean meal (solv. ext.)	41.00	36.20	31.40	26.60	21.90
DCSM	0.00	5.00	10.00	15.00	20.00
Limestone	1.00	1.00	1.00	1.00	1.00
DCP	1.75	1.75	1.75	1.75	1.75
Salt	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.16	0.16	0.15	0.15	0.15
L-lysine hydrochloride	0.00	0.05	0.10	0.14	0.19
TM. Premix1*	0.10	0.10	0.10	0.10	0.10
Vit. Premix2**	0.15	0.15	0.15	0.15	0.15
Vitamin B complex**	0.02	0.02	0.02	0.02	0.02
Ch. Chloride, 60%	0.08	0.08	0.08	0.08	0.08
Toxin binder	0.05	0.05	0.05	0.05	0.05
Enzyme	±	±	±	±	±
Total	100.00	100.00	100.00	100.00	100.00
Nutrient composition					
Crude Protein,%***	22.14	22.15	22.16	22.16	22.21
ME, kcal/kg)****	2831	2837	2844	2852	2858
Lysine,%****	1.25	1.25	1.25	1.25	1.25
DL-methionine****	0.54	0.54	0.54	0.54	0.54
Calcium,%***	1.06	1.06	1.07	1.08	1.09
Av. P,%****	0.45	0.45	0.44	0.44	0.43
Cost, Rs./kg****	25.5	24.91	24.28	23.67	23.11

Trace mineral premix supplied mg / kg diet: Mg, 300; Mn, 55; I, 0.4; Fe, 56; Zn, 30; Cu, 4. The vitamin premix supplied per kg diet: Vit A, 8250 IU; Vit D_3, 1200 ICU; Vit K 1mg; Vit E, 40 IU; Vit B_1, 2 mg; Vit B_2, 4 mg; Vit B_{12} , 10 mcg; niacin, 60 mg; pantothenic acid, 10 mg; choline, 500 mg. * Analysed values, ****Calculated.

Table 2. Ingredients and nutrient composition of experimental diets for finisher phase (3–6 weeks)

Ingredient composition%	0	5	10	15	20
Maize, yellow	64.93	64.69	64.45	64.11	63.87
Soybean meal (solv. ext.)	31.80	27.00	22.20	17.50	12.70
DCSM	0.00	5.00	10.00	15.00	20.00
Limestone	1.00	1.00	1.00	1.00	1.00
DCP	1.50	1.50	1.50	1.50	1.50
Salt	0.30	0.30	0.30	0.30	0.30
DL- Methionine	0.11	0.11	0.10	0.10	0.09
L-lysine hydrochloride	0.00	0.04	0.09	0.13	0.18
TM. Premix1*	0.10	0.10	0.10	0.10	0.10
Vit Premix2**	0.15	0.15	0.15	0.15	0.15
Vitamin B complex**	0.02	0.02	0.02	0.02	0.02
Ch. Chloride, 60%	0.05	0.05	0.05	0.05	0.05
Toxine binder	0.05	0.05	0.05	0.05	0.05
Enzyme	±	±	±	±	±
Total	100.00	100.00	100.00	100.00	100.00
Nutrient composition					
Crude Protein,%***	19.03	19.04	19.05	19.10	19.11
ME, kcal/kg)****	2919.00	2926.00	2933.00	2940.00	2948.00
Lysine,%****	1.02	1.02	1.02	1.02	1.02
DL-methionine****	0.45	0.45	0.45	0.45	0.45
Calcium,%***	0.97	0.98	0.98	0.99	1.00
Av. P,%****	0.39	0.39	0.38	0.38	0.38
Cost, Rs./kg****	23.06	22.46	21.83	21.25	20.62

Trace mineral premix supplied mg / kg diet: Mg, 300; Mn, 55; I, 0.4; Fe, 56; Zn, 30; Cu, 4. The vitamin premix supplied per kg diet: Vit A, 8250 IU; Vit D_3, 1200 ICU; Vit K 1mg; Vit E, 40 IU; Vit B_1, 2 mg; Vit B_2 4 mg; Vit B_{12}, 10 mcg; niacin, 60 mg; pantothenic acid, 10 mg; choline, 500 mg. * Analysed values, ****Calculated.

RESULTS AND DISCUSSION

The chemical composition of DCSM used in this study contained (on % dry matter basis) , 91.69 dry matter , 44 crude protein, 1.96% lysine, 0.73 methionine, 2.9 ether extract, 10.57 crude fiber, 5.9 total ash, 36.63 nitrogen free extract, 3.20 acid insoluble ash, 0.21 calcium, and 1.13

Table 3. Effect of different levels of DCSM with or without protease on body weight gain and feed intake

Interaction effect		Body wt. gain			Feed intake		
DCSM level	Enzyme	0–3wk	3–6wk	0–6wk	0–3wk	3–6wk	0–6wk
0	-	477.2[ab]	1022.2	1499.4	841.3	2322.9	3164.2
0	+	429.5[a]	1018.9	1448.4	808.1	2306.5	3114.6
5	-	463.7[ab]	1041.8	1505.5	874.6	2368.2	3242.8
5	+	489.2[b]	1066.4	1555.6	838.0	2394.8	3232.8
10	-	466.5[ab]	987.4	1453.9	754.4	2253.2	3007.6
10	+	473.9[ab]	1042.8	1516.7	825.5	2355.4	3180.9
15	-	479.4[ab]	985.6	1465.0	823.5	2257.4	3080.9
15	+	452.1[ab]	663.5	1410.3	791.2	2198.8	2989.9
20	-	434.9[ab]	1006.2	1441.0	763.1	2218.2	2981.3
20	+	472.9[ab]	1115.2	1588.0	807.7	2327.3	3134.9
Pooled SEm		3.90	13.40	14.60	10.60	14.90	23.80
DCSM level							
0		453.3	1020.5	1473.9	824.7	2314.7[pq]	3139.4[pq]
5		476.5	1054.1	1530.6	856.3	2381.5[q]	3237.8[q]
10		470.2	1015.1	1485.3	789.9	2304.3[pq]	3094.2[pq]
15		465.8	971.9	1437.7	807.3	2228.1[p]	3035.4[p]
20		454.2	1061.5	1514.9	785.4	2272.8[pq]	3058.1[pq]
Enzyme							
-		464.5	1008.6	1473.2	811.4	2283.9	3095.3
+		463.5	1040.3	1503.5	814.1	2316.6	3130.6
Significance							
Interaction		P<0.01	NS	NS	NS	NS	NS
DCSM level		NS	NS	NS	NS	P<0.01	P<0.01
Enzyme		NS	NS	NS	NS	NS	NS

Values bearing different superscripts [abc] (interaction) and [pqr] (DCSM level) within a column differ significantly (P<0.05); NS, nonsignificant.

phosphorus. The gossypol content in DCSM used in the present study was at non-detectable level. The body weight gain (Table 3) during 0–3 weeks of age differed significantly due to interaction, while the major effects had no influence on this parameter. The highest body weight gain was observed in diet containing 5% DCSM with supplemental protease. However, body weight gain emanated in all the dietary treatments (with 5, 10, 15 and 20% DCSM with or without supplemental protease) was similar to control diet. The body weight gain during 3–6 or 0–6 weeks of age did not differed significantly (P>0.05) due to interaction, DCSM levels or protease supplementation. Although, several workers have reported detrimental effects of cottonseed meal in poultry diets (Sterling *et al*. 2002, Henry *et al*. 2001) but the results obtained in the present study were in line with Watkins *et al.* (1994) and Fernandez *et al.* (1995), who reported that adequate growth was observed at 20% inclusion level of cottonseed meal. In an earlier experiment conducted in this laboratory (Elangovan *et al.* 2003, Mandal *et al*. 2004), it was found that commercially produced solvent-extracted CSM with low free gossypol levels (<0.02% in meal) can be included at 10% level (maximum level studied) in a SBM based broiler diet replacing SBM and rice bran without additional iron. The differences in observations are attributed to type of cottonseed meal (corticated vs. un-decorticated) and free gossypol. Henry *et al.* (2001) reported that dietary incorporation of commercial cottonseed meal (75 mg free gossypol /kg) at 20% in the diet of broiler chicken resulted in decreased body weight gain. However, the decorticated cottonseed meals (DCSM) used in this study was devoid of free-gossypol.

The feed intake (Table 3) at any growth phase did not differ significantly (P>0.05) due to interaction or protease supplementation. However, significant (P<0.01) difference in feed intake was obtained during 3–6 and 0–6 wks of age due to dietary inclusion levels of DCSM. Higher feed intake was observed at 5% level and thereafter there was decrease in feed intake, though the values obtained in any test group did not differ with control group fed maize-soybean meal devoid of cottonseed meal. Results of this study are in line with Henry *et al.* (2001) who did not report significant decrease in feed intake when they fed broilers diets containing 800 and 1600 mg gossypol/kg of diet. Feed intake also did not differ when solvent extracted commercial variety of cottonseed meal was fed. These results indicate that palatability of feed was not altered due to inclusion of commercial CSM in diet.

Feed conversion ratio (feed: gain), calculated for starter phase (0–3 weeks) or overall growth phase (0–6 wk.), did

Table 4. Effect of different levels of DCSM with or without protease on feed conversion ratio

Interaction effect				
DCSM level	Enzyme	0–3 wk.	3–6 wk.	0–6 wk.
0	-	1.77	2.31[a]	2.14
0	+	1.98	2.31[a]	2.18
5	-	1.89	2.28[a]	2.16
5	+	1.68	2.28	2.10
10	-	1.78	2.33[a]	2.15
10	+	1.75	2.31[a]	2.13
15	-	1.73	2.33[a]	2.12
15	+	1.78	2.37[b]	2.17
20	-	2.14	2.25[a]	2.10
20	+	1.73	2.28[a]	2.09
Pooled SEm		0.04	0.02	0.01
DCSM level				
0		1.88	2.32[p]	2.16
5		1.79	2.28[p]	2.13
10		1.77	2.33[p]	2.14
15		1.76	2.35[q]	2.15
20		1.94	2.27[p]	2.10
Enzyme				
-		1.87	2.31	2.14
+		1.79	2.31	2.14
Significance				
Interaction		NS	P<0.05	NS
DCSM level		NS	P<0.05	NS
Enzyme		NS	NS	NS

Values bearing different superscripts [abc] (interaction) and [pq](DCSM level) within a column differ significantly (P<0.05); NS, nonsignificant.

Table 5. Effect of different levels of DCSM with or without protease on immunity, nitrogen retention and feed cost /kg gain

Interaction effect		PHAP	SRBC Titre	N-retention %	Feed cost/ kg gain
DCSM level	Enzyme				
0	-	0.74	11.25	56.20	71.78
0	+	1.10	10.25	54.51	71.26
5	-	0.86	10.00	56.50	72.05
5	+	1.08	10.25	54.01	72.44
10	-	0.89	10.50	56.31	65.12
10	+	1.34	10.75	54.81	69.60
15	-	1.12	9.50	56.37	65.33
15	+	1.10	11.00	54.96	64.02
20	-	0.83	9.00	57.85	61.60
20	+	0.94	10.25	55.70	65.45
Pooled SEm		0.06	0.20	0.53	0.74
DCSM level					
0		0.92	10.75	55.35	71.52[qr]
5		0.98	10.13	55.25	72.24[r]
10		1.12	10.63	55.56	67.36[pq]
15		1.11	10.25	55.67	64.68[p]
20		0.88	9.63	56.77	63.52[p]
Enzyme					
-		0.89	10.05	56.65	67.18
+		1.11	10.50	54.80	68.55
Significance					
Interaction		NS	NS	NS	NS
DCSM level		NS	NS	NS	P<0.01
Enzyme		NS	NS	NS	NS

Values bearing different superscripts [pqr] (DCSM level) within a column differ significantly (p<0.01); NS, non-significant.

not differ significantly due to dietary levels of DCSM, interaction or protease supplementation. However, during 3–6 weeks of age DCSM level as well as interactions of DCSM and enzyme significantly (P<0.05) affected the FCR of broiler chicken (Table 4). The highest values were found in D8 (15% DCSM with enzyme) and at 15% DCSM during this period. However, protease did not affect significantly FCR during this period. No significant differences in feed conversion efficiency was obtained in earlier studies (Elangovan *et al.* 2003, Mandal *et al.* 2004) on feeding diet with 10% solvent-extracted commercial cotton seed meal. Reports indicate depressed weight gains and/or feed intakes when free gossypol levels fed to poultry were between 140 and 756 mg/kg (Milligan and Bird 1951), 200 and 400ppm (Richardson and Blaylock 1950), 240 and 360 mg/kg (Heywang *et al*. 1952), or greater than 480 mg/kg (Lipstein and Bornstein 1964) or 600 mg/kg (Couch *et al.* 1955). Therefore, in the present experiment, in which all the dietary treatments had similar concentrations of nutrients to meet the requirements of birds and non-detectable level of gossypol did not exert any deleterious effect on feed conversion efficiency or nutrient utilization.

Nitrogen retention (Table 5) was not influenced either by cottonseed meal, protease in diet or their interaction. The results of our study are in consonance with the findings of Abdur rashid *et al*. (2013) who suggested efficient utilization of the feed with 10%, 20% or 30% cottonseed meal in broilers. Similarly the differences in nitrogen retention (expressed as% of N intake) in diets with 10% cottonseed meal were non-significant (Mandal *et al.* 2004). In contrast, Heidarinia and Malakian (2011) found feeding dietary cottonseed meal resulted in increased feed intake, but with decreased body weight and inefficient utilization.

Results pertaining to haemagglutination assay (HA), which measures serum antibody against SRBC, as influenced by DCSM inclusion levels in diets of broiler chicken (Table 5) revealed that DCSM levels, protease or their interaction did not differ significantly. Similarly, mitogenic response to PHA-P measured in terms of foot pad index, an index of cell mediated immunity was not influenced significantly by DCSM levels, protease or their interaction. Mandal *et al.*(2004) also did not observe differences in PHA-P response.

Feed-cost estimated as Indian rupees per kg live weight gain did not vary significantly due to interaction of DCSM and enzyme (Table 5). However, it differed significantly due to DCSM levels. Feed-cost per unit gain decreased when DCSM was used beyond 10% level in the diet of broiler chickens and lowest feed cost was calculated in diet containing 20% followed by 15% DCSM level. The cost of cottonseed meal generally remains lesser than that of soybean meal. Moreover, due to decortications the protein value has been improved with concomitant decrease in fiber. Thus, inclusion of DCSM has potential for profitable broiler production besides bridging gap of shortage of conventional soya bean meal in India.

The overall results on growth performance, immune response, nitrogen utilization and feed-cost of production of the present study demonstrated that DCSM can effectively and economically be incorporated up to 20% level replacing soybean meal in diet of broiler chicken during their 0–6 weeks of age provided the critical amino acids are properly balanced. Moreover, protease supplementation did not provide additional advantage in terms of growth performance and protein utilization. Again, India is scarce in proteinic ingredients; high protein decorticated cottonseed meal, devoid or with traces of free gossypol, would be a potential alternate to soybean meal.

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