

Feeding value of detoxified (ammonia treated and roasted) simaruba (*Simarouba glauca*) oilcake in broilers

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ABSTRACT

Simaruba (*Simarouba glauca*) oilcake (SOC) is very rich in crude protein (50–60% on DM). Presence of bitter toxic quassinoids makes it unsuitable for livestock and poultry feeding. Ammonia treatment followed by roasting is found to be a suitable method for partial detoxification of a oilcake. Two experiments were conducted in the present study to find out the ME of ammonia treated and roasted simaruba oilcake (DSOC) and ascertain the safe level of inclusion of SOC in the broiler diet. The apparent metabolizable energy (AME) and nitrogen corrected apparent metabolizable energy (AMEN) of DSOC were 1863 and 1771 kcal/kg in broilers. DSOC was fed to broilers at 2.5, 5, 7.5 and 10% level in the diet. The average sixth week body weight of birds in T₁ (control), T₂ (2.5% DSOC), T₃ (5% DSOC), T₄ (7.5% DSOC) and T₅ (10% DSOC) were 1959, 1845, 1833, 1836 and 1658 g, respectively. There was no significant difference in the sixth week body weight of the control, 2.5, 5 and 7.5% DSOC fed groups. The serum biochemical parameters such as serum protein, albumin, globulin, serum urea nitrogen as well as serum uric acid values were significantly lower at 10% DSOC level. There was gradual increase of ASAT activity, ALAT activity and ALP activity with the increase in DSOC level in the diet. The birds fed 10% DSOC showed marked degenerative changes in the liver, kidney and intestine, whereas such organs of birds fed low level of DSOC were apparently free from such degenerative changes. Feeding DSOC, which replaced traditional high cost protein supplements like GNOC and soyabean oil meal reduced the cost of broiler production. The cost of production for kg live weight was Rs 27.01, 26.82, 26.74, 26.27 and 28.98, respectively, for 0, 2.5, 5, 7.5 and 10% DSOC fed groups. There was a gradual reduction in cost of production with the increased level of inclusion of DSOC in the diets and the reduction in the cost of production over control was the highest (Rs 0.74/kg live weight) in 7.5% DSOC fed group. From the results of the present investigation it is concluded that ammonia treated and roasted SOC can be incorporated in the broiler diet up to a level of 7.5% without any harmful effect.

Key words: Broiler, Detoxification, Feeding value, Simaruba, *Simarouba glauca*

Simaruba (*Simarouba glauca*) a medium-sized ever green plant belonging to the family Simaroubaceae and Genus *Simarouba*, a native of El Salvador was introduced to India in 1960s by the ICAR. Though the plant was introduced in five states during 1960s, now it has spread to nearly all the states of India due to its wide adaptability to varied range of climatic conditions, drought hardiness and non browsing characters. The plant starts fruiting at the age of 5–6 years. An adult plant can yield 20–50 kg seeds and about 200 trees can be accommodated per hectare. About 1–2 tonnes of oil can be produced from 1 ha of wasteland under simaruba plantation. Besides, producing oil almost equal quantity of

oil cake can be produced as a by-product. The oilcake is very rich in protein (50–60%) and low in crude fibre. Therefore, simaruba oil and SOC could be very good energy and protein supplements for livestock and poultry diet. But, the oilcake contains bitter quassinoids to the extent of 5% by weight (Rao 2003), which is toxic to livestock and poultry. However, partial detoxification of simaruba oilcake was done successfully by treating with ammonia followed by roasting as reported by Behura (2007). The present study was designed to ascertain the exact level of the DSOC that could be safely incorporated in the ration of broilers.

MATERIALS AND METHODS

In order to study the effects of feeding DSOC as a protein supplement in broilers, 2 experiments were conducted. In the first experiment the ME of the DSOC was determined and in the second experiment different levels of DSOC was fed to broilers to ascertain the safe level of inclusion and the

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economics. For energy bioassay, a practical type reference diet was formulated to contain adequate amount of nutrients required by the broilers (maize: 50 parts, soybean meal: 30 parts, DORB: 20 parts). Two test diets were prepared by incorporating SOC at 5% and 10% level replacing equal parts (w/w) of basal portion of the reference diet. Eighteen male Vencobb broiler chicks of 6 week of age were randomly distributed in 3 groups of similar group average body weight and housed in individual cages suitable for metabolic trial. The cages were placed in a well-ventilated and kept in lighted room. Each group was randomly assigned to one dietary treatment. The experimental diets were fed *ad lib.* as mash to the 3 groups of birds. A 12-day feeding period was followed by a 4-day recording of individual feed intake as well as faeces voided. The 4-day excreta of individual birds were pulled together, dried at 60°C in a forced draft hot air oven and absolute weight were recorded. The feed and excreta samples were assayed for total combustible energy with the help of Isothermal bomb calorimeter. The apparent metabolizable energy (AME) values of the test diets (Hill and Anderson 1958) and test material (Sibald and Slinger 1963) were determined.

The nitrogen corrected apparent metabolizable energy (AMEn) was calculated from the nitrogen balance by using nitrogen correction factor of 8.22 cal. per gram of nitrogen retained. The values were subtracted from the excreta energy for positive nitrogen balance and added to the excreta energy for negative nitrogen balance.

In the second experiment a feeding trial was conducted with day-old Vencob broilers (400) chicks. The chicks were distributed into 5 groups, having 4 replicates of 20 chicks each. Complete randomized design was followed. Five dietary treatments, viz. T₁ (control), T₂ (2.5% DSOC), T₃ (5% DSOC), T₄ (7.5% DSOC) and T₅ (10% DSOC) were tried. Separate isonitrogenous and isocaloric experimental diets for starter and finisher were prepared for each group as

per BIS (1992) specifications. One group of chick was assigned to each treatment. The experimental diets were analysed for their proximate compositions (AOAC 1975) and the values are presented in Table 1. The chicks were wing banded, weighed on the first day and reared in deep litter system. The chicks were vaccinated with RD F₁ and IBD intermediate on 7th and 14th day, respectively. Feed and water were offered *ad lib.* Weekly individual body weight and group wise feed consumption were recorded. At the end of sixth week, group-wise FCR was calculated. The experiment continued for a period of six weeks. At the end of sixth week, the feed conversion ratio (FCR) of chicks of individual groups was calculated. Six chicks were randomly picked up from each treatment for collection of blood at the end of sixth week. Blood was directly collected from the heart with a hypodermic needle. The serum was collected in separate vials and kept at -50°C in a deep freeze for estimation of total protein, albumin, globulin, urea nitrogen, uric acid, aspartate-aminotransferase activity, alanine-aminotransferase activity and alkaline phosphatase activity with the help of UV spectrophotometer ($\lambda=25$), using the reagent kits. At the end of sixth week, samples of tissues from visceral organs like liver, kidney, heart, intestine, pancreas, spleen and bursa of fabricius were collected from 6 birds, selected randomly from each group for histopathological examinations following Gridely (1960). Economics of broiler production was calculated taking into account the expenditure incurred on feed. The local rate of feed ingredients was taken in to account for calculation of feed cost. The cost of DSOC was calculated at Rs 5/kg taking into consideration the costs of seed, decortication, expelling and processing. Other expenditure such as labour, litter material, medicines, vaccines and electricity were considered same for all the groups. The sale price of broilers were calculated at Rs 36/kg live weight, the then prevailing market price. Data were analysed statistically (Snedecor and Cochran 1967).

Table 1. Proximate composition of experimental diets (per cent on DM basis)

Treatments	Crude protein	Crude fibre	Ether extract	Total ash	Acid insoluble	Nitrogen free	Calcium	Available phosphorus	ME* (kcal/kg)
<i>Starter diet</i>									
T ₁	23.10	4.62	2.65	9.60	2.23	60.03	1.451	0.45	2810
T ₂	23.00	4.53	2.37	9.863	2.48	60.237	1.48	0.47	2805
T ₃	23.08	4.26	2.75	10.11	2.17	59.8	1.67	0.44	2801
T ₄	23.17	3.87	2.58	9.54	2.678	60.84	1.68	0.40	2809
T ₅	22.08	3.65	3.02	10.02	2.59	60.23	1.70	0.45	2803
<i>Finisher diet</i>									
T ₁	20.08	4.14	2.89	8.55	2.45	64.34	1.37	0.48	2908
T ₂	20.09	3.91	2.95	9.00	2.19	64.05	1.31	0.40	2902
T ₃	20.23	3.61	2.62	9.51	2.55	64.03	1.49	0.45	2901
T ₄	20.10	3.26	2.90	9.47	2.39	64.27	1.476	0.49	2906
T ₅	20.39	3.14	3.28	10.02	2.54	63.17	1.51	0.43	2911

*Calculated values.

RESULTS AND DISCUSSION

The apparent metabolizable energy (AME) and apparent nitrogen corrected metabolizable energy (AMEn) of the test diets and test material are presented in Tables 2 and 3, respectively. The AME and AMEn values of the diets decreased with the increase in the level of DSOC in the diet. The AME value of DSOC decreased with inclusion of higher level in the diet. The average of both 5% and 10% levels was 1863 Kcal per kg. The AMEn values of the test material at 5 and 10% levels of feeding were 1788 and 1753 Kcal/kg, respectively, with the average values of 1771 Kcal/kg. The AME value of the DSOC obtained from the present experiment revealed that it is lower than ME value of conventional oilcakes like GN oilcake and soybean oil meal but well comparable with the ME value of sesame, fish meal, linseed meal and cotton seed meal.

The average weekly body weight of experimental broiler chicks up to sixth week of age is presented in Table 4. There was no significant ($P \geq 0.05$) difference in the sixth week body weight of the T_1 , T_2 , T_3 and T_4 groups. However the sixth

week body weight of the T_5 fed group differed significantly from all other groups. Statistical analysis of the weekly body weights of different groups showed that there was no significant ($P > 0.05$) difference between the groups up to fifth week of age. Similar findings were reported by Patro *et al.* (2002) that feeding of defatted methanol extracted SOC up to 7.5% level in the diet of broilers did not affect the growth of broilers but reduced the growth significantly ($P < 0.05$) at 10%. Further, the result indicated that the oilcake even at 10% level did not adversely affect the growth up to fourth week although there was a significant reduction in body weight gain at sixth week of age. This indicated that probably the toxin had a cumulative effect. However the severity of the cytotoxic quassinoids is less apparent at 7.5% inclusion of DSOC since, the body weight gain has not been adversely affected at this level. The feed conversion ratio (FCR) of the T_1 , T_2 , T_3 , T_4 and T_5 groups were 1.88, 1.89, 1.92, 1.95 and 2.06, respectively. The average feed consumption was almost unaffected by the dietary treatment. However there was a reduction in the body weight gain of broilers of T_5 group

Table 2. Estimation of apparent metabolizable energy of experimental diets containing different levels of DSOC*

Group	Bird no.						Average
	1	2	3	4	5	6	
Reference diet group							
Feed consumed (g)	725.00	695.00	700.00	720.00	760.00	725.00	720.83±9.43
GE intake (Kcal)	3070.37	2943.00	2964.50	3049.20	3218.60	3070.4	305.82±39.96
Excreta voided (g)	300.00	270.00	285.00	270.00	305.00	295.00	287.50±6.16
GE of excreta (Kcal/kg)	3887.00	3920.00	3778.00	3986.00	4000	3955.00	3921.00±33.28
GE out go (Kcal)	11.66.10	1058.00	1076.70	1076.22	1220	1166.73	1127.36±26.81
GE metabolized (Kcal)	1904.27	1885.00	1887.80	1972.98	1998.6	1903.65	1925.36±19.66
AME of diet (Kcal/kg)	2626.58	2712.00	2696.80	2740.25	2629.7	2625.72	2671.87±20.72
N retained/g faeces	0.0150	0.0153	0.0122	0.0135	0.0103	0.0133	0.01303±0.001
AMEn of diet (Kcal/kg)	2580.50	2663.00	2655.90	2698.64	2595.80	2581.13	2629.21±20.41
5% DSOC fed group							
Feed consumed (g)	650.00	680.00	705.00	710.00	695.00	635.00	679.17±12.48
GE intake (Kcal/kg)	2700.10	2825.00	2928.60	2949.34	2887.00	2637.79	2821.26±51.83
Excreta voided (g)	265.00	270.00	275.00	270.00	280.00	260.00	270.00±2.89
GE of excreta (Kcal/kg)	3840.00	3750.00	3824.00	3850.00	3900.00	3835.00	3833.16±19.83
GE out go (Kcal)	1017.60	1013.00	1051.60	1039.50	1092.00	997.10	1035.05±13.89
GE metabolized (Kcal)	1682.50	1812.00	1877.00	1909.84	1795.00	1640.69	1786.21±43.29
AME of diet (Kcal/kg)	2588.462	2665.00	2662.40	2689.92	2582.8	2583.76	2628.72±19.96
N retained/g faeces	0.0144	0.0150	0.0152	0.0141	0.0109	0.0138	0.0139±0.0007
AMEn of diet (Kcal/kg)	2540.19	2615.00	2613.70	2645.83	2546.60	2537.34	2583.07±19.28
10% DSOC fed group							
Feed consumed (g)	660.00	595.00	710.00	690.00	615.00	635.00	650.83±18.05
GE intake (Kcal/kg)	2760.78	2489.00	2969.90	2886.27	2572.50	2656.21	2722.44±75.49
Excreta voided (g)	255.00	235.00	265.00	260.00	245.00	245.00	250.83±4.55
GE of excreta (Kcal/kg)	4250.00	3990.00	4260.00	4100.00	4130.00	4200.00	4155.00±42.01
GE out go (Kcal)	1083.75	937.70	1128.90	1066.00	1011.90	1029.00	1042.86±26.98
GE metabolized (Kcal)	1677.03	1551.00	1841.00	1820.27	1560.70	1627.21	1679.58±51.39
AME of diet (Kcal/kg)	2540.96	2607.00	2593.00	2638.07	2537.70	2562.53	2579.89±16.22
N retained/g faeces	0.15	0.016	0.014	0.015	0.012	0.016	0.015±0.006
AMEn of diet (Kcal/kg)	2492.27	2556.00	2549.30	2591.23	2498.90	2512.84	2533.47±15.73

*Detoxified (NH_3 treated and roasted) *Simaruba* oilcake.

Table 3. AME and AMEn of the test material (DSOC)

	Reference diet	Test diet-1	Test diet-2	DSOC (5%)	DSOC (10%)	Average*
AME						
1	2626.59	2588.46	2540.96	1945.33	1851.50	
2	2712.12	2665.03	2607.12	1854.15	1745.96	
3	2696.81	2662.37	2593.00	2091.31	1742.08	
4	2740.25	2689.92	2638.07	1818.31	1803.23	
5	2629.74	2582.78	2537.72	1771.87	1790.86	
6	2625.72	2583.77	2562.53	1867.73	2074.97	
Average	2671.87	2628.72	2579.90	1891.45	1834.76	1863.11
±SE	±20.71	±19.96	±16.22	±46.35	±50.79	
AMEn						
1	2580.50	2540.19	2492.27	1854.00	1778.00	
2	2663.34	2614.85	2556.36	1776.00	1676.00	
3	2655.86	2613.66	2549.26	1894.00	1672.00	
4	2698.64	2645.83	2591.23	1726.00	1708.00	
5	2595.77	2546.57	2498.87	1692.00	1707.00	
6	2581.13	2537.34	2512.83	1785.00	1978.00	
Average	2629.21	2583.07	2533.47	1787.83	1753.167	1770.5
±SE	±20.41	±19.28	±15.74	±30.99	±47.567	

*Average of 5 and 10% level.

(1.605 kg/bird) in comparison to T₁ (1.807 kg/bird). The reduction in growth of T₅ group could be the major cause of widening of the FCR. However, Patro *et al.* (2002) reported and PCR value of 2.593 in broilers fed defatted and methanol extracted SOC. During the experimental period of 6 weeks, there was no mortality in T₁, T₂, T₃ and T₄ groups. Mortality in T₅ (10% DSOC) group was 5% and the mortality occurred during the first week, which could not be connected to toxicity. Patro *et al.* (2002), on feeding defatted and methanol extracted SOC to broilers observed a higher mortality (20%) at 10% level of inclusion in the chick diet.

The serum biochemical parameters and enzyme activities of the experimental broiler have been presented in Table 5. The total serum protein, albumin, globulin, serum urea nitrogen and serum uric acid of the group T₅ was significantly

lower ($P < 0.05$) than other groups. Quassinoids have irreversible inhibitory effect on protein synthesis and they also affect the synthesis of RNA (Kupchan *et al.* 1976). Plasma protein synthesis is markedly reduced in severe liver damage (Swenson 1990). The low total serum protein, albumin, globulin, serum urea nitrogen and serum uric acid of the group T₅ could be due to presence of higher level of quassinoids in the cake resulting in liver damage. A gradual increase of ASAT activity, ALAT activity and ALP activity with the increase in DSOC level in the diet was indicative of presence of remnants of the toxin in the DSOC. The increase in the serum enzyme activities could be attributed to the degenerative effects of quassinoids on hepatocytes. Overall observation of health, activity and growth of the experimental birds of DSOC fed groups failed to show any notable difference. However the birds of T₅ group showed ruffled feathers.

Feeding DSOC at lower rate failed to cause any observable alteration and was comparable with that of control birds. The birds of T₄ group revealed moderate to marked congestion of the liver but no necrotic pale spots could be detected. The liver of the T₅ was markedly congested and in several cases few small pale areas were observed in both surface and parenchyma. The kidneys, in several cases of group T₅ revealed slight enlargement, mild to moderate congestion and enlarged ureter suggestive of moderate nephrosis. The intestine, particularly the large intestine, was severely congested and necrotic in many instances in T₅ group, while in T₄ group birds, although showed moderate to marked congestion, the luminal surface contained mucinous exudates indicating catarrhal enteritis. In the present study, chicks fed with lower percentage of DSOC, viz. 2.5, 5 and 7.5% were free of any gross and microscopic lesions of significance. On the other hand the chicks fed with the higher rates, i.e. 10% of the DSOC showed moderate to marked changes in liver, kidneys and intestine. Other organs such as heart, lungs and spleen were apparently normal. In T₄, however, the lesions were inconsistent while in T₅ a majority of the cases revealed presence of pathological alterations including

Table 4. Average weekly body weight of broilers fed diets containing different levels of DSOC

Treatments	Average weekly body weight (g)						
	Day-old	1st week	2st week	3st week	4st week	5st week	6st week
T ₁	52.20 ±0.39	180.97 ±4.043	369.13 ±11.95	636.25 ±16.822	944.55 ±23.781	1466.61 ±21.56	1859.34 ^a ±33.868
T ₂	52.85 ±0.76	182.96 ±4.65	362.97 ±16.33	637.27 ±15.92	956.53 ±30.82	1459.97 ±29.85	1845.37 ^a ±26.92
T ₃	52.91 ±0.83	172.77 ±4.97	356.98 ±18.38	629.46 ±17.41	944.45 ±26.43	1486.23 ±27.94	1833.98 ^a ±33.46
T ₄	52.39 ±0.58	174.59 ±4.26	347.23 ±12.63	616.79 ±17.77	938.60 ±32.67	1469.33 ±24.79	1836.90 ^a ±29.99
T ₅	52.91 ±0.72	161.13 ±3.16	325.14 ±9.62	602.38 ±18.74	905.89 ±28.61	1390.66 ±28.01	1658.18 ^b ±26.34

Means with the different superscripts differ significantly from each other ($P < 0.05$).

Table 5. Serum biochemical values and serum enzyme activities of the experimental broilers fed different levels of DSOC at the end of sixth week

Parameters	D ₁	D ₂	D ₃	D ₄	D ₅
Total serum protein	3.162 ^a ±0.078	3.198 ^a ±0.100	3.045 ^a ±0.149	3.098 ^a ±0.150	2.693 ^b ±0.151
Serum albumin (g/dl)	1.20 ^a ±0.030	1.22 ^a ±0.038	1.16 ^a ±0.057	1.18 ^a ±0.057	0.96 ^b ±0.035
Serum globulin (g/dl)	1.90 ^a ±0.11	1.92 ^a ±0.15	1.83 ^a ±0.22	1.86 ^a ±0.22	1.52 ^b ±0.13
Serum urea nitrogen (mg/dl)	2.28 ^a ±0.08	2.20 ^a ±0.05	2.22 ^a ±0.07	2.27 ^a ±0.07	1.96 ^b ±0.09
Serum uric acid (mg/dl)	65.78 ^a ±3.55	5.03 ^a ±0.09	4.97 ^a ±0.06	4.85 ^a ±0.09	4.03 ^b ±0.16
ASAT activity (IU/L)	65.03±3.19	69.59 ^a ±2.49+	68.97 ^a ±4.64	71.05 ^a ±3.02	80.78 ^b ±2.87
ALAT activity (IU/L)	12.06 ^a ±1.51	11.92 ^a ±1.13	12.74 ^a ±1.47	14.81 ^a ±1.53	17.37 ^b ±.62
ALP activity (IU/L)	1.33.33 ^a ±3.54	134.67 ^a ±3.15	136.67 ^a ±4.72	133.83 ^a ±4.50	143.17 ^b ±3.97

Means with different superscripts differ significantly from each other (P<0.05).

Table 6. Cost benefit analysis of broiler production feeding diets containing different levels of DSOC

Head of expenditure	Dietary treatments				
	D ₁	D ₂	D ₃	D ₄	D ₅
Cumulative feed consumption per bird up to 6 weeks of age (kg)	3.46	3.41	3.39	3.34	3.36
Cost of feed consumed per bird up to 6 weeks of age (Rs)	27.75	27.08	26.65	25.92	25.69
Cost of day-old chicks (Rs)	14	14	14	14	14
Other expenses per bird (Rs)	5	5	5	5	5
Cost of production per bird (Rs)	55.87	54.74	54.23	53.36	53.22
Average bodyweight at the end of 6th week (kg)	1.86	1.85	1.83	1.84	1.66
Cost of production per kg live weight (Rs)	27.01	26.82	26.74	26.27	28.98
Net Profit/kg live weight*	8.99	9.18	9.26	9.73	7.02
Reduction in cost of production over control (Rs/kg)	—	0.19	0.27	0.74	−1.97

*Sale price of broilers: Rs 36/kg live weight.

degenerative changes in liver, kidney and intestine. The findings are indicative of cytotoxic effects of quassinoids present in the DSOC. As no macro and microscopic lesions of significance was observed up to 7.5% DSOC feeding in the diet, it may be assumed that the concentration of the toxin in that level was tolerable by the birds.

The economics of broiler production under feeding different levels of DSOC has been presented in Table 6. There was a gradual reduction in cost of production with the increased level of inclusion of DSOC in diets and the reduction in the cost of production over control was the highest (Rs 0.74/kg live weight) in T₄ group. The cost of production of T₅ group was Rs 1.97 more than the T₁ group

per kg live weight, despite the fact that the diet at 10% DSOC level was the cheapest. This is obviously due to low production performance of that group.

The findings of the present experiment suggested that inclusion of the DSOC (NH₃-treated and roasted SOC) could be used in the ration of broilers up to a level of 7.5% without any deleterious effect. With the increase in the level of this oilcake in the diet (up to a maximum 7.5%) the cost of production decreases as it replaces costly protein supplements.

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