RESEARCH ARTICLE
Open Access

Journal of Veterinary and Animal Sciences
ISSN (Print): 0971-0701, (Online): 2582-0605
https://doi.org/10.51966/jvas.2023.54.2.388-395

Effect of fermented cottonseed meal on growth performance and carcass traits in broiler chicken#

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Citation: Arundhathi, U., Anitha, P., Sankaralingam, S., Shamna, T.P. and Priya, P.M. 2023. Effect of fermented cottonseed meal on growth performance and carcass traits in broiler chicken. *J. Vet. Anim. Sci.* **54**(2):388-395
DOI: https://doi.org/10.51966/jvas.2023.54.2.388-395

Received: 08.11.2022 *Accepted: 20.01.2023* *Published: 30.06.2023*

Abstract

An experiment was conducted to study the effect of dietary inclusion of fermented cottonseed meal (FCSM) on growth performance and carcass traits in broiler chicken up to 42 days of age. A total of 160, day-old broiler chicks were randomly allotted into five dietary treatment groups, viz. T1, T2, T3, T4 and T5 with four replicates having eight bird each, in a completely randomised design. The birds in the control group (T1) were fed with standard broiler ration formulated as per BIS (2007). The diets in groups T2 to T5 were formulated by inclusion of five per cent cottonseed meal (CSM), five per cent FCSM (T3), 10 per cent FCSM (T4) and 15 per cent FCSM (T5), respectively. All the experimental diets were isocaloric and isonitrogenous. Fermentation of CSM significantly ($p<0.05$) increased its moisture, crude protein and total ash content and reduced dry matter and crude fibre content. The mean body weight, feed consumption and feed conversion ratio of broilers in different treatment groups at sixth week of age did not differ significantly. The carcass characteristics at sixth week also did not differ significantly among treatments, except ready to cook yield per cent which was significantly ($p<0.05$) higher in FCSM groups. The highest net profit per kilogram body weight was obtained in 10 per cent FCSM group (T4 group), followed by T3, T5, T2 and T1.

Keywords: *Cottonseed meal, fermented cottonseed meal, free gossypol, ready to cook yield*

#*Part of MVSc thesis submitted to Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala*

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Feed is the major component in the poultry production, which accounts about 70 per cent of the total cost of production. The global demand for the major poultry feed ingredients increased, which in turn led to the higher cost of poultry production. In poultry feed formulation, protein sources constitute the next biggest component after the energy yielding sources, which primarily determine the feed cost. Soybean meal is the commonly used plant protein source in poultry industry (Sun *et al*., 2012). As there is a tremendous increase observed in the price in the soybean meal in recent years, there is a need to search for alternative protein sources in poultry feeds to reduce the feed cost. Hence, alternative cheap protein sources have to be evaluated and included in the broiler diet which should safeguard the health of the birds and support highest performance efficiency.

Cottonseed meal (CSM) is a locally available protein source that can partly replace soybean meal but its use in poultry feeds is limited due to the presence of anti-nutritional factors like free gossypol (FG), cyclopropenoid fatty acids and high fibre content (Tang *et al*., 2012). Fermentation of feeds has been introduced as an effective and biosafe nutritional method for improving the nutritive value of feed and to reduce the anti-nutritional factors. Fermentation of feeds has significant effect on growth of birds (Nie *et al*., 2015). Microbial fermentation had a positive effect on the chemical composition of feed (Supriya *et al*., 2022). In the present scenario of the increased cost of soybean meal, it can be replaced with alternative protein sources by improving its nutritive value after fermentation. Thus, the present study was conducted by fermenting the cottonseed meal using different microorganisms and including it in the broiler chicken diet at different inclusion levels to assess the growth performance and carcass traits.

Materials and methods

The experiment was conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy, using 160, day-old commercial broiler chicks (Vencobb-430Y). All chicks were wing banded, weighed individually and randomly allotted to five dietary treatment groups, each group consisting of four replicates of eight birds each, in a completely randomised design. Diets were formulated as per BIS (2007), isocaloric and isonitrogenous and fed from 0-42 days of age.

Fermentation of cottonseed meal

The freeze-dried cultures of *Bacillus subtilis* (MTCC441) and *Aspergillus oryzae var. brunneus* (MTCC8846) in the form of ampoules were purchased from Microbial Type Culture Collection and Gene Bank, CSIR - Institute of Microbial Technology, Sector- 39A, Chandigarh - 160036, India. The culture of *Aspergillus niger* was obtained from the Department of Veterinary Microbiology, College of Veterinary and Animal Sciences, Mannuthy, Thrissur. Each kilogram of CSM was mixed with 1.2 litre of distilled water containing approximately 10^5 CFU/mL of *B. subtilis* and 10^5 spores/mL of *A. oryzae and A. niger* then incubated at 30°C for seven days in fermentation tank equipped with a one-way valve. Fermented product was dried at 50°C for three days, ground and kept at room temperature until it was mixed with the experimental diet (Jazi *et al*., 2017).

Experimental diets

The five dietary treatments in the trial are given below:

T1- Standard broiler ration (Control diet)

T2- Diet with 5 per cent CSM replacing SBM

T3- Diet with 5 per cent FCSM replacing SBM

T4- Diet with 10 per cent FCSM replacing SBM

T5- Diet with 15 per cent FCSM replacing SBM

Standard management practices were followed throughout the experiment. The birds were given *ad libitum* feed and water. The feed ingredients and the feed samples were subjected to proximate analysis as per AOAC (2016). The chemical composition of cottonseed meal before and after fermentation are presented in Table 1.

Table 1. Chemical composition of cottonseed meal (on DM basis) before and after fermentation, per cent

Item	Cottonseed meal	Fermented cottonseed meal	p-value
Moisture	6.85^{b}±0.07	10.80^{a}±0.08	0.001
Dry matter	93.15^{a}±0.09	89.20^{b}±0.06	0.001
Crude protein	37.00^{b}±0.34	39.17^{a}±0.43	0.04
Crude fibre	15.03^{a}±0.09	12.18^{b}±0.35	0.01
Total ash	7.22^{b}±0.02	8.63^{a}±0.05	0.001

Mean values bearing different superscripts within a row differ significantly ($p<0.05$)

The body weight (g) of individual birds were recorded at weekly intervals from day-old to six weeks of age was calculated. Feed consumed (g) by birds in each replicate was recorded at weekly intervals up to six weeks of age and from this data cumulative feed consumption for the entire period was calculated. Feed conversion ratio (kg of feed consumed per kg weight gain) was calculated replicate wise, based on the data on body weight gain and feed consumption. At the end of the experiment (42 days of age), four birds from each treatment (one bird per replicate) were randomly selected and slaughtered humanely to study the carcass characteristics. Data on pre-slaughter weight, carcass weight, giblet weight, abdominal fat and ready to cook yield were recorded.

Results and discussion

Microbial fermentation of cottonseed meal using organism *B. subtilis*, *A. oryzae* and *A. niger* resulted a positive effect on the chemical composition of cottonseed meal and significantly ($p<0.01$) increased the moisture, crude protein and total ash content and decreased the dry matter and crude fibre content of FCSM. The decrease in crude fibre and pH and increase in crude protein and LAB count after fermentation is in agreement with Supriya *et al*. (2022) who studied the effect of fermented soybean meal (FSBM) in broilers. The decrease in the dry matter per cent is due to the utilisation of carbohydrate compounds in the cottonseed meal for the growth of microorganisms (Chiang *et al*., 2010). The decrease in crude fibre per cent may be due to the production of microbial enzymes that helps to degrade the fibre and increase in crude protein content is due to the production of microbial proteins during the fermentation by the microorganisms (Tang *et al*., 2012).

Body weight

The effects of experimental treatments on body weight of broilers are presented in Table 2. The body weight of broilers at weekly intervals in different dietary treatment groups (T1 to T5) did not show any significant difference between the groups except for the first week. There was no significant effect on the body weight of broilers fed with diet containing FCSM over the experimental period, which is in harmony with the findings of Jazi *et al*. (2017) and Niu *et al*. (2021) who evaluated the effect of FCSM, while Guo *et al*. (2020) and Supriya (2022) observed no significant effect on body weight of broilers fed diet with FSBM.

Feed consumption

The mean feed consumption of birds at weekly intervals is presented in Table 3. The dietary treatment groups had no significant effect on mean feed consumption of birds throughout the experiment except on the first week. This finding is in agreement with Nie *et al*. (2015) who reported that average daily feed intake of broilers did not differ in FCSM (with *C. tropicalis* plus *Saccharomyces cerevisiae*) fed group than control group, also Jazi *et al*. (2017) and Niu *et al*. (2021) who studied the effect of fermentation in CSM at 10 and 20 per cent levels and 3, 6 and 9 per cent levels, respectively. This result also agrees with the findings Li *et al*. (2020) and Supriya (2022) who studied the effect of feed containing FSBM.

Contrary to this finding, Niu *et al*. (2021) observed significantly ($p<0.05$) lower

Table 2. Mean (±SE) body weight of broilers in different dietary treatments at weekly Intervals (g)

Age in weeks	Treatments					p value
	T1 Control	T2 Diet with 5% CSM	T3 Diet with 5% FCSM	T4 Diet with 10% FCSM	T5 Diet with 15% FCSM	
Day-old	45.56 ±0.19	45.75 ±0.68	45.32 ±0.39	46.02 ±0.78	45.12 ±0.97	0.89
1	167.37^{b} ±4.55	176.19^{b} ±3.40	166.68^{b} ±3.52	188.33^{a} ±3.95	174.18^{b} ±3.27	0.007
2	395.78 ±5.53	413.50 ±17.87	384.39 ±7.99	427.59 ±3.67	409.56 ±6.96	0.06
3	775.25 ±4.15	810.93 ±21.44	756.38 ±17.01	818.98 ±16.67	775.61 ±18.24	0.08
4	1219.54 ±16.91	1264.12 ±33.68	1220.66 ±34.64	1285.95 ±31.76	1213.94 ±34.07	0.40
5	1774.64 ±25.05	1838.24 ±40.90	1775.82 ±19.62	1835.43 ±43.55	1778.18 ±31.18	0.49
6	2227.20 ±20.98	2252.69 ±39.77	2228.36 ±26.20	2272.84 ±22.57	2216.06 ±35.90	0.68

Mean values bearing different superscripts within a row differ significantly ($p<0.01$)

Table 3. Mean (±SE) feed consumption of broilers at weekly intervals in different dietary treatments (g)

Age in weeks	Treatments					p-value
	T1 CONTROL	T2 Diet with 5% CSM	T3 Diet with 5% FCSM	T4 Diet with 10% FCSM	T5 Diet with 15% FCSM	
1	136.62^{bc} ±3.28	144.87^{ab} ±4.19	129.86^{c} ±4.90	149.92^{a} ±4.13	144.99^{ab} ±2.91	0.02
2	298.56 ±4.01	330.00 ±13.76	295.82 ±10.36	309.71 ±4.44	317.81 ±6.53	0.07
3	511.74 ±11.23	563.36 ±20.63	510.91 ±18.65	536.15 ±21.28	542.89 ±6.23	0.19
4	752.18 ±20.02	771.82 ±24.34	749.34 ±29.92	739.65 ±21.13	762.32 ±22.68	0.89
5	974.15 ±19.75	990.52 ±25.03	974.43 ±26.83	994.68 ±28.29	1003.81 ±39.24	0.93
6	946.51 ±8.15	910.22 ±23.44	951.74 ±10.57	930.23 ±53.45	907.42 ±21.03	0.73
Cumulative feed consumption (Day-old to 6 weeks)	3619.77 ±41.57	3710.80 ±85.07	3612.14 ±37.16	3660.34 ±91.25	3679.24 ±65.88	0.83

Mean values bearing different superscripts within a row differ significantly ($p<0.05$)

average daily feed intake in nine per cent FCSM diet compared to three per cent FCSM diet over 29 to 35 days of age. On the other hand, Tang *et al*. (2012) observed significantly ($p<0.05$) higher feed consumption with eight per cent FCSM diet from 22 to 42 days of age than control group.

Feed conversion ratio (FCR)

The mean feed conversion ratio of broilers in the five dietary treatment groups at weekly intervals and cumulative period (Day-old to 6 weeks) are presented in Table 4. The mean weekly FCR did not show any significant

Table 4. Mean (±SE) feed conversion ratio of broilers at weekly intervals in different dietary treatments

Age in weeks	Treatments					p-value
	T1 CONTROL	T2 Diet with 5% CSM	T3 Diet with 5% FCSM	T4 Diet with 10% FCSM	T5 Diet with 15% FCSM	
1	1.12±0.04	1.11±0.01	1.07±0.02	1.05±0.01	1.12±0.01	0.10
2	1.31±0.03	1.40±0.03	1.36±0.02	1.29±0.02	1.35±0.02	0.82
3	1.37±0.05	1.44±0.01	1.37±0.02	1.40±0.01	1.48±0.03	0.54
4	1.70±0.04	1.71±0.03	1.61±0.03	1.66±0.02	1.66±0.05	0.37
5	1.75±0.03	1.73±0.05	1.76±0.04	1.83±0.08	1.77±0.3	0.79
6	2.09±0.06	2.20±0.02	2.10±0.04	2.13±0.04	2.23±0.09	0.41
Cumulative FCR (Day-old to 6 weeks)	1.66±0.02	1.69±0.02	1.66±0.02	1.64±0.02	1.70±0.01	0.53

difference between the treatment groups throughout the experimental period. Similar to the current findings of FCSM inclusion in diet, Tang *et al*. (2012), Jazi *et al*. (2017) and Niu *et al*. (2021) observed non-significant effect on FCR in FCSM diet groups compared to the control group from 1 to 42 days of age. On contrary, Nie *et al*. (2015) observed poor FCR in six per cent FCSM included diet group compared to control diet over entire experimental period and Wang *et al*. (2017) observed significantly poor FCR in 15.1 per cent FCSM diet group than soybean meal diet group.

The production performances of broiler chicken such as body weight, feed consumption and feed conversion ratio were not adversely affected with the inclusion of fermented cottonseed meal in diet.

Carcass characteristics

The different dietary treatments did not significantly influence the carcass characteristics of birds except for ready to cook yield in broiler chicken (Table 5). The broilers fed with FCSM diets (T3 to T5 groups) were having significantly ($p<0.05$) higher ready to cook yield (per cent) than those fed with SBM based diet (control) and five per cent CSM included diet group (T2). Supporting to the present findings of FCSM inclusion in broiler diets, Niu *et al*. (2021) reported higher eviscerated yield in diet with three per cent FCSM and Chachaj *et al*. (2019) reported higher carcass yield in three and six per cent FSBM group. However, Supriya (2022) reported no significant effect on mean carcass yield and ready to cook yield of broilers when fed with diet having fermented soybean meal.

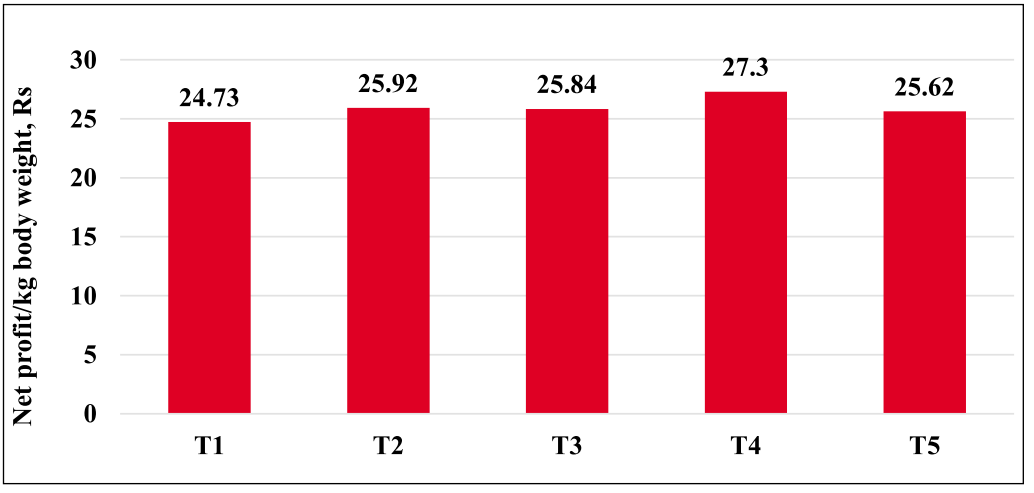

Fig. 1. Net profit per kilogram body weight of broilers in different dietary treatments, Rs

Table 5. Mean (±SE) carcass characteristics of broilers in different dietary treatments at six weeks of age

Parameters	Treatments					p- value
	T1 CONTROL	T2 5% CSM	T3 5% FCSM	T4 10% FCSM	T5 15% FCSM	
Pre-slaughter body weight, g	2438.00 ±53.68	2468.25 ±29.26	2425.00 ±45.48	2548.75 ±28.37	2514.25 ±68.31	0.73
Eviscerated yield (%)	72.97 ±0.76	73.96 ±0.39	76.57 ±0.70	75.86 ±0.43	74.85 ±1.56	0.07
Heart (%)	0.46 ±0.05	0.52 ±0.01	0.51 ±0.08	0.45 ±0.03	0.43 ±0.01	0.59
Liver (%)	1.80 ±0.09	1.70 ±0.11	1.75 ±0.04	1.97 ±0.13	2.12 ±0.19	0.13
Gizzard (%)	1.88 ±0.05	1.81 ±0.10	1.91 ±0.12	1.93 ±0.13	1.99 ±0.13	0.84
Abdominal fat (%)	0.79 ±0.11	0.75 ±0.05	0.51 ±0.05	0.91 ±0.14	0.71 ±0.06	0.09
Breast (%)	22.61 ±0.77	24.52 ±1.73	27.91 ±0.92	25.36 ±1.12	26.17 ±1.06	0.06
Wings (%)	7.50 ±0.32	6.30 ±0.14	6.45 ±0.21	6.62 ±0.30	6.91 ±0.42	0.08
Thighs (%)	10.60 ±0.49	10.93 ±0.46	10.25 ±0.61	10.27 ±0.31	10.34 ±0.54	0.84
Drumstick (%)	10.04 ±0.10	9.64 ±0.26	9.76 ±0.10	9.34 ±0.50	10.13 ±0.35	0.40
Ready to cook yield (%)	77.12^{c} ±0.73	77.99^{c} ±0.59	80.74^{a} ±0.67	80.22^{ab} ±0.36	79.40^{b} ±1.41	0.04

Mean values bearing different superscripts within a row differ significantly ($p<0.05$)

The lower abdominal fat recorded in broiler fed with diet containing five per cent FCSM in the present study is in accordance with the findings of Niu *et al*. (2019) who reported lower abdominal fat content and subcutaneous fat thickness in broiler chicken fed with six per cent FCSM.

Even though non-significant higher eviscerated yield and breast yield were observed in birds from the FCSM groups, which resulted in significantly ($p<0.05$) higher ready to cook yield (79 to 80 per cent) in these groups compared to control and five per cent CSM group (77 to 78 per cent).

The cost benefit analysis of the treatment groups (Fig. 1) indicated that highest net profit per kilogram body weight was obtained in 10 per cent FCSM (T4) group followed by T3, T5, T2 and T1.

Conclusion

The dietary inclusion of fermented cottonseed meal at different levels by replacing soybean meal resulted in similar growth performance as that of the control group with the soybean meal diet. Therefore, FCSM in broiler diet up to 15 per cent inclusion can be recommended as an alternative protein to soybean meal without affecting the performance of the birds. Among the different levels of inclusion studied, 10 per cent level was found to be more beneficial with respect to net profit per kilogram body weight.

Acknowledgments

The authors are very thankful to the Dean of College of Veterinary and Animal Sciences, Kerala Veterinary and Animal Sciences University, Mannuthy, Thrissur,

Kerala for providing all necessary facilities and financial support for the research.

Conflict of interest

The authors report no conflict of interest.

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