Indian J. Anim. Nutr. 2025. 42 (3): 329-336
doi: 10.56093/IJAN.v42i3.2

Indian Journal of Animal Nutrition

Nutrient Utilization and Energy Value of Maize Oil Cake in Ration of Goat Kids

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ABSTRACT

A study was conducted to assess the effects of dietary inclusion of maize oil cake on nutrient digestibility, nutrient intake, FCR and energy value of feeding maize oil cake in kids. Eighteen Beetal male kids were randomly divided into three groups of 6 animals each. The kids of group I were maintained on basal ration comprising of green fodder, gram straw and concentrate mixture. Maize oil cake was included in the ration of group II and group III @ 15% and 30% of concentrate mixture, respectively. The feeding trial lasted for a period of 120 days. Body weight changes and feed intake of animals were recorded at fortnightly intervals. Ether extract digestibility (%) was significantly (P<0.05) higher in T2 (78.45) and T3 (80.77) groups as compared to the control group (76.38) in both experiments. DM, OM, CP and NFE digestibility did not differ significantly among different treatment groups. Nutrients intake (g/day) in terms of DCP and TDN were found significantly (P<0.05) higher for maize oil cake added groups (T2 and T3) than control group. Nitrogen intake and nitrogen balance reported higher (p<0.05) in T2 and T3 groups than T1 group. Overall mean FCR of experimental kids was found similar among all dietary treatments. GE, ME, DE values were significantly (P<0.05) higher in maize oil cake added treatment groups. Results of the study showed that inclusion of maize oil cake improved ether extract digestibility and intake of total digestible nutrients as well as energy value of feed due to its high energy and protein content.

KEYWORDS: Beetal kids, Digestibility, FCR, TDN, Maize oil cake

Article received: 13 January 2025; Article accepted: 04 July 2025.

INTRODUCTION

Small ruminants comprise approximately 41.5% of the country's total livestock population, as reported in the 20th Livestock Census (BAHS, 2019). Goats are among the main meat-producing animals in India, whose meat (chevon) is one of the choicest meats and has huge domestic demand. It is a great source of nutrients, including protein, iron, vitamin B_{12}, zinc, potassium as well as low in total fat and saturated fat compared with other forms of red meat (Pophiwa et al., 2020). Due to its good economic prospects, goat rearing under intensive and semi-intensive system for commercial production has been gaining momentum for the past couple of years.

The unfortunate reality is that the availability of quality feed resources is increasingly over shadowing the genetic potential of livestock, as their production heavily relies on both the quality and quantity of feed and fodder. Currently, the country faces a net deficit of 61.1% in green fodder, 21.9% in dry crop residues, and 64% in concentrate feeds. There is also a deficiency of 26.5% in crude protein (CP) and 23.7% in total digestible nutrients (TDN) (Datta, 2013). The gap between feed requirements and available resources, along with the need for climate-smart farming, has compelled us to seek non-conventional feed sources that do not compete with human consumption, such as agricultural by-products that are available year-round but are underutilized.

Maize oil cake is a by-product derived from the extraction of maize oil from full-fat maize germ, which is a coproduct of the starch industry. It is nutrient-dense, containing high levels of protein and fat, and possesses excellent functional properties, making it a valuable concentrate source for livestock (Bakke and Vickers, 2007). It is highly digestible by the livestock. Maize oil cake improves production as it contains high amount of ether extract which provide energy to the animals. The fat stored in ruminant adipose tissue primarily consists of triglycerides, mainly saturated fatty acids, with low levels of polyunsaturated fatty acids. This lipid profile has contributed to a decline in the consumption of meat and meat products in some regions (Bas et al., 2007), due to the strong association between the quality of

dietary fats and human health. Corn germ meal has been shown to enhance the nutritional quality of the lipid fraction by enriching it with compounds that are beneficial to human health (Urbano et al., 2014).

Cheaper supplies of feed containing good amount of fat and protein would surely have a substantial impact on designing cost-effective meals, affecting chevon pricing. The product's ease of availability, reasonable market pricing, and high protein and oil necessitates a trial for goat feeding. Present research was thus undertaken to study the effects of dietary inclusion of maize oil cake nutrient digestibility, nutrient intake, FCR and energy value of feed.

MATERIALS AND METHODS

The experimental work of the study was carried out at the Animal farm, Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana). Eighteen Beetal kids of comparable body weight were randomly divided into three groups of 6 in each. The animal experiment was conducted in accordance with guidelines approved by the Institutional Animal Ethics Committee, 12/CPCSEA Dated 29.10..2022 via protocol number IAEC.LUVAS.26/10 in the Department of Animal Nutrition, Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar.

They were housed in semi covered sheds. An adjustment period of fifteen days was given before the start of experiment. All the kids were maintained on basal ration comprising green fodder, gram straw and concentrate mixture (Maize grain, groundnut cake, barley, mineral mixture and common salt in the ratio of 35: 35: 27: 2: 1). The experimental diet of group G - II was included with maize oil cake @15% of the concentrate mixture while maize oil cake was included @ 30% of the concentrate mixture in the diet of group - III. Feed ingredients used for ration formulation were evaluated for various proximate nutrients viz. dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and total ash (TA). Table 1 depicts the chemical composition of different feedstuffs used in preparing the experimental diets. Feeding trial lasted for a period of 120 days and kids were fed as per ICAR (2013). Feed intake was calculated at fortnightly interval by subtracting residue from the offered amount of feed throughout the experiment. The kids were weighed individually at fortnightly intervals before feeding and the body weights were recorded to calculate body weight gain up to 120 days of the experimental period. The gross energy (GE) of oven dried feed and excreta samples was determined by standard procedures using Bomb Calorimeter. The gross heat of combustion in calories per gram of the material was computed by substituting values in the following equation.

At the end of the feeding trial, a metabolism trial of 5 days duration was conducted to assess the effects of dietary inclusion of maize oil cake on growth performance in kids. A preliminary period of 3 days was given for adaptation of the lambs to new system of housing and management, followed by a collection period of 5 days. The proximate composition of feeds and faecal samples was determined (AOAC, 2013). The digestibility coefficient of any given nutrient was calculated as the difference in its intake and its output through faeces and expressed as the proportion of intake. The total digestible nutrients (TDN) and digestible crude protein (DCP) content of any particular diet was calculated by taking into account of all the prevailing digestible nutrients in the diet.

Statistical analysis

Data were analyzed statistically using general linear model procedure of operational statistics, Statistical Package for Agricultural Scientists (OPSTAT) and comparison of means tested using Duncan's multiple range test (DMRT) and significance was considered at $P< 0.05$ (Snedecor and Cochran, 1994).

Table 1. Chemical composition of feeds offered to experimental kids offered (%DM basis) of experimental diet

Feed offered	DM	CP	EE	CF	Total Ash	NFE
Green fodder	17.42	7.97	2.65	26.31	9.53	53.54
Gram straw	91.27	5.52	1.59	38.41	7.67	46.81
Conc. Mix. T1	90.55	20.07	4.16	5.84	6.52	65.40
Conc. Mix. T2	90.63	20.20	5.32	6.14	6.11	64.22
Conc. Mix. T3	92.75	20.16	6.56	6.56	5.81	62.89

RESULTS AND DISCUSSION

Nutrient digestibility

Digestibility forms the single most important parameter to determine the nutritive values of ration. The data pertaining to nutrient digestibility under different dietary treatments are summarized in Table 2. Among all dietary treatment groups, there was no significant effect on dry matter and organic matter digestibility. Crude protein digestibility ranged from 70.64 to 71.92 % and had no statistically significant difference on crude protein digestibility amongst different dietary treatment groups having maize oil cake inclusion as compared to control group. It can be inferred from the result that maize oil had no negative impact on digestibility of feed and can be used for formulating ration upto 30% of the concentrate in ruminants.

In agreement to our study, Albuquerque et al., 2014 reported that the control diet, CGM 20% and CGM 30% diets had no effect on coefficients of apparent metabolizability of dry matter (CAMDM) in the layers during 8 days experimental period. Kelzer et al., 2009 reported that OM digestibility and NDF digestibility was similar across experimental groups. i.e. control, dried distillers grains plus soluble, dehydrated corn germ meal and high-protein dried distillers grains in Holstein cows. Kaur (2017) also found that the NFE digestibility (%) in control (90.04), T1 (91.17) and T2 (90.21) group varied non significantly. Detray (2016) also reported that the digestibility of ADF was not affected by CGM and DDG (P e"0.18) diets fed to the calves.

In contrary to our results, Kaur (2017) reported that DM digestibility (%), OM digestibility (%), CP digestibility (%) and NDF digestibility (%) was higher ($P<0.05$) in control and T1 groups than T2 group. Lopez et al. (2003) also reported that apparent DM digestibility decreased ($P<0.05$) from 90.8 to 85.5%, when the corn was replaced by defatted corn germ meal at 0, 10, 20, 30 and 40% level in the diets of growing pigs. They also reported that CP digestibility decreased ($P<0.05$) and NFE digestibility decreased ($P<0.05$) from 93.37 to 86.85% by replacing the corn with increasing levels of defatted corn germ meal in the diets of growing pigs. Zhang et al. (2018) also reported that the ATTD (apparent total tract digestibility) of DM, OM and CP linearly decreased ($P<0.01$) as dietary CGM increased in the diet of growing pigs.

However, Kumar et al. (2018) who reported that DM digestibility in group I (58.34) was lower ($P<0.05$) than group II (59.99) and group III (62.37) and also digestibility of OM , CP, ADF and NDF varied significantly ($P<0.05$) and increased when the calves were fed maize germ oil cake (MGOC) at increasing level of 1.3, 1.7 and 2.1 kg/d.

It was observed that ether extract (EE) digestibility of T3 group was maximum and significantly ($P<0.05$) higher followed by T2 group and the control group T1. Increased ether extract digestibility may be due to high ether extract content of maize oil cake as well as high unsaturated fatty acids which increase formation of micelle formation.

Similar to our findings, Kumar et al. (2018) reported that digestibility of EE increased significantly ($P<0.05$) between the groups when the calves were fed maize germ oil cake at 1.3, 1.7 and 2.1 kg/d.

However, Kaur (2017) found that the EE digestibility (%) in control (79.60), T1 (77.82) and T2 (79.52) groups was similar and there was no significant ($P>0.05$) difference in the EE digestibility among the groups. Similarly, Kelzer et al. (2009) reported that digestibility of ether extract was similar and averaged 85.1±1.9 across experimental treatments i.e. control, dried distillers grains plus soluble, dehydrated corn germ meal and high-protein dried distillers grains fed to lactating Holstein cattle.

Table 2. Nutrient digestibility (%) of growing kids under different dietary treatments

Attributes	Treatments		
	T1	T2	T3
DM%	71.50±0.65	72.50±0.67	72.96±0.87
OM %	72.84±0.44	73.29±0.48	74.30±0.59
CP%	71.04±0.56	71.72±0.28	72.81±0.58
EE%*	76.38^{a}±1.05	78.45^{b}±0.67	80.77^{c}±0.68
CF%	66.20±0.45	66.62±0.41	66.98±0.36
NFE%	75.20±0.30	75.61±0.34	76.68±0.36

*Mean bearing different super scripts in arrow differ significantly (P<0.05)

Nutritive value of different experimental rations

Statistical analysis of the data revealed that TDN% differ significantly (P<0.05) between different dietary treatments as compared to the control group was recorded higher in T2 and T3 groups than control group. Similarly, DCP % in groups fed maize oil cake significantly as compared to the control group (Table 3). Increased nutrient intake in kids fed maize oil cake was may be due to improved ether digestibility as well as high energy content of these rations as compared to control group. Hence, it can be concluded that maize oil cake has improved the nutritive value of feed.

The results of the present study are in agreement with Silva et al. (2023), who reported that cows fed corn germ quadratically increased (p< 0.05) intake of dry matter, crude protein, and total digestible nutrients. Nagpur (2011) reported that the per cent total digestible nutrients (TDN) values of diets were 62.36 ± 1.5 for T1 ,72.99 ± 2.0 for T2 and 86.88 ± 1.8 for T3 diets. Significant (P d" 0.05) difference was recorded among the three experimental diets, which may be due to the varying levels of GNC, CGM and other ingredients in different diets.

However, Kumar et al. (2018), who reported that CP intake did not vary significantly among the different groups of crossbred calves fed maize germ oil cake at 1.3, 1.7 and 2.1 kg/d levels for 28 days. Kaur (2017) also determined that the overall mean CP intake(kg/animal/d) was similar in control, T1 and T2 groups and ranged between 0.570 to 0.588. The CP intake did not vary significantly among the groups.

Table 3. Mean nutritive values of experimental rations under different dietary treatments

Attributes	Treatments		
	T1	T2	T3
DCP%	9.00^{a}±0.20	9.42^{b}±0.11	9.59^{c}±0.09
TDN%	70.73^{a}±0.37	71.97^{b}±0.52	73.50^{c}±0.55

*Mean bearing different super scripts in arrow differ significantly (P<0.05)

Nitrogen balance under different dietary treatments

Statistical analysis showed significant (P<0.05) increase in N intake in groups T2 and T3 than the control group. Both the faecal and urinary outgo were found non-significant among different dietary treatment groups. Nitrogen balance values were maximum for group supplemented with 30% maize oil cake i.e. T3 followed by T2 and T1. Nitrogen balance amongst different treatment groups was observed to be significant (P<0.05). Significant

increase in nitrogen intake and nitrogen balance was may be due to increased percent of digestible crude protein in kids fed maize oil cake.

The results of the present study were in contrary with Li et al. (2018), who reported that nitrogen retention did not differ between corn germ meal, corn gluten feed, peanut meal, dehulled sunflower meal and full-fat rice bran and averaged 25.4 g/d whereas the urinary nitrogen output was the highest (P<0.01) in the peanut meal diet as compared to the corn germ meal, corn gluten feed and full-fat rice bran when fed to the growing pigs. Nascimento et al. (2022) also reported that the inclusion of WCG in the diet did not influence N recycling, and retained N remained similar between the treatment groups. Netto et al. (2023), reported that the nitrogen intake and daily excretion in urine and feces decreased, while nitrogen use efficiency increased linearly by replacing ground corn (GC) with full-fat corn germ (FFCG) in cows. There was no significant effect of diets on nitrogen balance or microbial protein synthesis and efficiency. Silva et al. (2023) reported that cows fed corn germ reduced ($p < 0.05$) the excretion of urea-N in milk and N excretion via urine. Bakshi et al. (2023), determined that animals fed diet containing MPIBs based concentrate mixture as compared to those fed control diet showed comparable urinary excretion of purine derivatives and N-retention in both the groups.

Table 4. Mean values of Nitrogen balance (g/day) under different dietary treatments

Attributes	Treatments		
	T1	T2	T3
N_2 intake(g)*	18.13± 0.30	19.28± 0.39	19.94± 0.35
N_2 faecal outgo(g)*	4.99 ± 0.10	5.15 ± 0.06	5.24 ± 0.11
Urinary outgo (g)*	1.64 ± 0.07	1.71 ± 0.15	1.95 ± 0.09
N_2 balance (g)*	11.49 ± 0.30	12.42 ± 0.25	12.75 ± 0.24

*Mean bearing different super scripts in arrow differ significantly (P<0.05)

Feed conversion ratio (FCR)

FCR reflects the efficiency with which animal convert feed into body weight gain. The analysis of data of this study represents that the overall mean values of FCR did not differed significantly (P<0.05) as compared to the control group. However, the overall mean of FCR of maize oil cake fed groups T2 and T3 were numerically improved as compared with control group with no maize oil cake supplementation. No significant effect observed may be due to numerical increase in feed intake in kids along with increased body weight gain. During different fortnight periods also there was no significant difference between the treatments except during 5th fortnight in which FCR was significantly improved for group T3 as compared to the control group with no supplementation. The high nutrient content of maize oil cake likely, enabled the kids to convert feed more efficiently into body weight gain. Qi et al.(2022), fed Cherry Valley ducks diets containing 0, 3, 6, 9, or 12% CGM and results showed that compared with other groups, ducks fed 12% CGM significantly increased ($P < 0.05$) the feed to gain ratio.

The results of the present study are in consistence with Ezequiel et al. (2006), also reported that no significant differences were observed for feed conversion (7.88 kg of DMI/kg of weight gain) and carcass dressing (54.52%) across treatments in Nellore steers. Similarly, Moreira et al. (2002) reported no influence of defatted corn germ meal at increasing levels (0, 15, 30 and 45%) on the average feed conversion in the crossbred pigs. Leeuw et al. (2009) also reported no significant difference in feed conversion ratio when the steers were fed defatted maize germ meal at 0, 25, 50, 75 and 100% levels, replacing hominy chop for 124 days. Likewise, Lakshmi et al. (2015) investigated that replacing maize and soybean meal with CGM (at 0, 15, 20 and 25%) had no significant effect on FCR in the coloured broilers.

Table 5. Mean values of FCR (Fortnightly) of growing kids under different dietary treatments

Period (Fortnight)	Treatments		
	T1	T2	T3
1st	7.09±0.16	7.25±0.33	6.62±0.21
2nd	7.78±0.22	6.68±0.41	6.59±0.40
3rd	7.75±0.28	6.95±0.24	6.80±0.30
4th	7.77±0.42	8.14±0.25	7.85±0.45
5th	7.71±0.36	6.94±0.41	5.84±0.27
6th	7.70±0.45	7.17±0.47	6.72±0.52
7th	8.22±0.40	7.82±0.38	8.57±0.60
8th	8.52±0.26	8.25±0.26	7.56±0.26
Overall mean FCR	7.82±0.17	7.40±0.18	7.07±0.26

*Mean bearing different super scripts in arrow differ significantly (P<0.05)

Energy values and efficiency ratios

Statistical analysis of GE showed significant (P<0.05) difference between different dietary treatments T2 and T3, as compared to control group. Mean values of digestible energy (DE) of dietary treatment group T1, T2, and T3 having maize oil cake inclusion were significantly (P<0.05) higher than the control group having no maize oil cake inclusion in the diet. Similarly ME of various dietary treatments T2 and T3 also showed significant (P<0.05) higher values as compared to the control group. Gross energy of the corn co-products ranged from 4,397 to 5,811 kcal/kg of DM and GE of corn germ meal was found 4767 kcal/kg (Rochell et al. (2011). GE value of MOC used in our experiment was reported 4900 kcal/kg. Due to high GE of this ingredient it increased (P<0.05) GE values of diets offered to kids in the group T_2, and T_3. Likewise, mean values of DE and ME also found significantly increase in the group in which maize oil cake was added @ 15% and 30% . According to Li et al. (2018), the ME and NE contents also increased (p<0.05) as the BW of pigs increased but without significant changes in energy digestibility and ME/DE and NE/ME ratios. Kim et al. (2008) determined significantly higher true metabolizable energy (TMEn) and amino acid digestibility in corn germ meal compared to high protein DDGS, while 'Phosphorus' bioavailability was significantly less for CGM (25 %) when compared to high protein-DDGS (60 % vs. 58 %, respectively).

Table 6. Energy values of feed and efficiency ratios under different dietary treatments

Attributes	T1	T2	T3
GE(kcal)	3064.04^{a}±65.75	3227.47^{ab}±73.44	3459.56^{bc}±83.88
DE(kcal)	2198.82^{a}±42.50	2332.83^{bc}±48.91	2526.92^{b}±35.98
ME(kcal)	1803.03^{a}±34.85	1912.92^{b}±40.10	2072.07^{b}±29.50

*Mean bearing different super scripts in arrow differ significantly (P<0.05)

CONCLUSION

Inclusion of maize oil cake did not have negative impact on FCR. It improved ether extract digestibility and nutritive value of feed in terms of DCP and TDN % in kids. Energy value of feed was also improved due to addition of maize oil cake.

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