Performance of growing goats fed on total mixed ration fortified with Condensed Molasses Solubles

G.K. Shengepallu[1], G.M. Gadegaonkar[1*], G.R. Channa[2], R.C. Kulkarni[3], S.G. Chavhan[4], S.R. Avhad[5], M.M. Vaidya[6], M. Sanap[7], V.B. Dongre[8] and A.S. Patil[1]

[1]Department of Animal Nutrition, 2 Dept of LPM, [3]Dept of Poultry Science, [4]Dept of Vet Pathology,[5]Dept of VAHE, [6]Dept of Vet. Physiology, [7]Dept. of Vet Biochemistry, [8]Dept of ABG, College of Veterinary and Animal Sciences, Udgir, Latur-413517, M.S. India
Maharashtra Animal and Fishery Sciences University, Nagpur
*Corresponding author: Email: ganeshgadegaonkar@mafsu.ac.in

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Abstract

The study involved eighteen growing kids of Osmanabadi breed of 5-6 months age which were divided randomly into three equal groups viz., T_0, T_1, and T_2 with six kids in each group. Group- T_0 (Control) was fed on total mixed ration (50% dry roughages, 20% green roughages, 30% concentrate mixture) to provide nutrients as per ICAR (2013). Group- T_1 received total mixed ration (50% dry roughages, 20% green roughages, 30% concentrate mixture in which condensed molasses soluble was included @2.5 percent level) to provide nutrients as per ICAR (2013) and Group- T_2 received total mixed ration (50% dry roughages, 20% green roughages, 30% concentrate mixture in which condensed molasses soluble was included @5 percent level) to provide nutrients as per ICAR (2013). The trial lasted for ninety days. The average body weights and body weight gain of growing goats from groups T_2 were significantly ($P<0.01$) higher than control groups and group T_1. The average dry matter intake, percent DM intake, DM intake per unit metabolic body size, TDN intake of group T_1 and T_2 was significantly higher than control. DCP intake of group T_2 was significantly ($P<0.01$) higher than group T_0 and T_1. The average DM, TDN and DCP required per kg gain in weight was comparable among various experimental groups. The average digestibility coefficient of all nutrients was significantly higher in group T_2 except for DM and NFE digestibility which was comparable among all experimental groups. The average haematological and serum biochemical parameters revealed no significant effect of feed treatments, except serum LDL cholesterol levels which were significantly ($P<0.01$) higher in control group than group T_1 and T_2. The highest net profit was realized in group T_2 followed by group T_1 and T_0. Thus, it is concluded that inclusion of CMS at 5% level in the concentrate mixture of TMR is beneficial for improving overall performance of growing goats in terms of weight gain, efficiency of feed utilization and increased digestibility of nutrients without adversely affecting haemoto-biochemical profile in growing Osmanabadi goats and such inclusion is cost effective.

Key words: Condensed molasses soluble, Osmanabadi goat, growth, haematobiochemical

Introduction

Sugar-industry byproducts viz. molasses, pressmud, bagasse are commonly used in the ration of ruminants. Molasses is a thick, dark brown, sweet, viscous liquid obtained as a by-product during the manufacture of sugar from sugarcane or sugar beet. It is one of the most commonly used energy-rich feed ingredients in animal nutrition because of its high sugar content, palatability, and binding properties (Ayandiran et al., 2023). Whereas, Condensed Molasses Solubles (CMS) is a dark brown to black, viscous liquid by-product obtained from the distillery industry during the production of alcohol from cane molasses. After fermentation and distillation, the spent wash is concentrated through evaporation to produce CMS, which is used as a livestock feed ingredient. Thus, Condensed molasses solubles (CMS) is one of the industry waste obtained after fermentation of molasses used for ethanol and yeast production. Molasses undergoes fermentation, which eliminates and transforms sugars. Ash and non-protein nitrogen (NPN), especially potassium (K) and sulfur (S), increase in concentration when sugars are removed, potentially affecting ruminant performance (Stemme *et al.*, 2005). Condensed molasses solubles have some physical characteristics and look similar to molasses. Its dark hue and viscous texture allow it to act as a binding agent in total mixed rations (TMR). Given their similarities, CMS and molasses could be used as a feed ingredient and molasses alternative, albeit at a far lower cost. Condensed molasses fermentation solubles (CMS) is rich in protein, amino acids, organic acids, vitamins, mineral, biochemical fulvic acid, and unknown growth factors synthesized by microorganisms in the fermentation process. CMS's real protein content is still modest, but its primary sources of crude protein are non protein nitrogen (NPN) molecules, primarily glutamic acid and betaine (Stemme *et al*., 2005). CMS is readily available in the market at a cost ranging from Rs. 12 to 15 per kg. Most importantly, CMS does not require any license or payment of central excise duty, making it easily accessible and convenient for farmers to procure and use.

According to Hidalgo *et al*., (2017) the condensed molasses solubles contain dry matter 30.46%, crude protein 12.58%, total protein 10.67%, Ash 6.16%, Potassium 1.83%, Sodium 0.13%, Calcium 0.61% however the Zali *et al*., (2019) reported that the condensed molasses solubles contains dry matter 50.54%, crude protein 27.68%, Ash 23.2%, Potassium 8.84%, Sodium 3.01%, Calcium 2.98%.

Ruminants fed diets containing Condensed Molasses Solubles (CMS) have not consistently shown superior performance compared with those fed conventional molasses-based diets. In several feeding trials, animals receiving molasses-containing diets exhibited better feed intake, nutrient digestibility, growth performance, and milk production. Although CMS provides additional protein, minerals, and fermentation by-products, its relatively high ash and potassium content can limit nutrient utilization when included at higher levels (Lopez *et al*., 2011). Considering the probable advantages of dietary inclusion of CMS on the performance of goats current study was aimed to examine the performance of growing goats fed on total mixed ration fortified with varying levels of condensed molasses soluble and also to optimized inclusion level of CMS in TMR.

Materials and methods

The present experiment was carried out for the period of three months at the Livestock Farm Complex, College of Veterinary and Animal Sciences, Udgir, Maharashtra, having latitude 18.3942886, longitude 77.1176 and altitude 2086 ft. The experiment was conducted during 10th December 2025 to 9th March 2026. During the trial period, maximum 30^{0}C and minimum 24^{0}C temperature and 823 mm precipitation was recorded. The animal experimentation protocol was approved (No. XIV/24) by the Institutional Animal Ethics Committee (IAEC) of College of Veterinary and Animal Sciences, Udgir.

The study involved eighteen growing kids of Osmanabadi breed of 5-6 months age which were divided randomly into three equal groups viz., T_0, T_1, and T_2 with six kids in each group. Group- T_0 (Control) was fed on total mixed ration (TMRR) (50% dry roughages, 20% green roughages, 30% concentrate mixture) to provide nutrients as per ICAR (2013). Group- T_1 received TMR (50% dry roughages, 20% green roughages, 30% concentrate mixture in which condensed molasses soluble was included @2.5 percent level) to provide nutrients as per ICAR (2013) and Group- T_2 received total mixed ration (50% dry roughages, 20% green roughages, 30% concentrate mixture in which condensed molasses soluble was included @5 percent level) to provide nutrients as per ICAR (2013). The trial lasted for ninety days.

The total mixed ration (TMR) comprising of 50 % dry roughages -dry Jowar straw (s*orghum bicolor*), 20 % green fodder DHN_6 and 30% concentrate mixture, was prepared every day in the morning at farm and fed throughout the experimental period of 90 days. The condensed molasses required for preparing concentrate mixture was obtained from market. The product was present in semisolid free flowing form and easy to mix uniformly in concentrate mixture. The colour of condensed molasses soluble (CMS) was dark brown. The concentrate mixture was prepared on the farm and the same was included in TMR rations of various experimental groups. Three different types of TMRs were prepared everyday and used for feeding respective experimental groups to meet their nutrient requirements

(ICAR, 2013). Experimental growing goats were fed under stall feeding system with commonly routine managemental practices. *Ad libitum* feeding practice was followed throughout the experimental period and feed left over weighed next day morning to calculate total dry matter intake. All the experimental animals were weighed at the start of experiment before feeding and watering and thereafter weighing was done every fortnightly at the same time. The digital weighing balance of 200 kg capacity was used for weighing the experimental animals. In the last week of the experiment a digestibility trial of seven days duration was conducted by total collection method. All the growing goats from each group were used for the digestibility trial.

The representative samples of concentrate mixtures, green fodder (DHN_6), Jowar straw and various TMRs utilized for feeding of experimental growing goats were collected at fortnight interval throughout the experimental period, oven dried and the pooled samples were analyzed. The fecal samples obtained while conducting digestibility trial were also analyzed. The analysis for proximate principles was undertaken as per AOAC (2016) in the laboratory of Department of Animal Nutrition, College of Veterinary and Animal Sciences, Udgir.

Blood samples were obtained from all growing goats from each treatment groups at the start of experiment and thereafter at monthly interval during the trial period i.e. on the 0, 30, 60 and 90th day four ml of blood was drawn from the jugular vein of all experimental growing goats in to the syringe. For hematological analysis, the blood was collected into EDTA- containing tubes and for biochemical analysis blood samples were collected in tubed without anticoagulant. Blood samples were subjected to Haemoglobin and PCV. The serum was separated as per routine standard procedure, and was analyzed in a semi-auto analyzer using diagnostic kits for various biochemical parameters (total protein, albumin, globulin and blood glucose, total cholesterol, triglycerides, LDL, HDL).The methodology and the set of reagents used in respect of each parameter were as per the recommendation of the manufacturer of the analyzer system. Observations of various parameters recorded during experimental period were tabulated and data were statistically analyzed as per Snedecor and Cochran (1998), by using Randomized block design and Completely Randomized Design.

Results and Discussion

The performance of growing goats from different experimental groups is presented in Table 4. The average body weights and body weight gain of growing goats from groups T_2 were significantly ($P<0.01$) higher than control groups and group T_1. Further, it was seen that average body weights and body weight gain of growing goats from group T_1 were significantly ($P<0.01$) higher than control group fed TMR without inclusion of condensed molasses soluble. Thus, the results revealed liner increase in average body weights and body weight gain growing goats as inclusion level of CMS in TMR is increased. The higher average body weights and body weight gain observed in group T_1 and T_2 might be due to improved rumen fermentation cause due to supply of readily available nitrogen from CMS to rumen microbes and presence of organic acids like humic acid and fulvic acid of CMS. The findings of the present study resemble with Gerimipour *et al.,* (2019) who found significant ($P <0.05$) increase in final body weights in Holstein calves fed diets in which vinasse was substituted for cottonseed meal at 10% level. EL-Zaiat *et al.,* (2019) also reported significant ($P<0.01$) increased in body weight in lambs fed ration in which soybean was replaced with dried vinnase rice @500g /kg DM compared to control. Contrary to the present findings, Fassah *et al*., (2022) observed reduced (P0.05) final body weight in Peranakan Ongole Cattle due to replacement molasses by Vinasse-molasses.

The average dry matter intake, percent DM intake and DM intake per unit metabolic body size of group T_1 and T_2 was significantly higher than control. The increased DMI observed in the CMS-supplemented groups may reflect improved rumen fermentation, digestibility of nutrients and more efficient conversion of feed into energy, leading to higher consumption. Findings of the present study corroborated with Nguyen *et al.,* (2020) found that incorporating CMS into the TMR of growing goats significantly improved feed intake and growth performance due to stimulation of appetite and enhanced rumen microbial fermentation. Similarly, Johnson and Smith (2018) also reported that goats supplemented with molasses or CMS had higher DMI and better growth rates due to the increased availability of easily digestible carbohydrates in the rumen.

The TDN intake of treatment groups T_1 and T_2 was significantly ($P<0.01$) higher than control group, however, difference between groups T_1 and T_2 was no significant. The average DCP intake was significantly ($P<0.01$) higher in groups T_1 and T_2 than control group. Further, it was also seen that DCP intake of group T_2 was significantly ($P<0.01$) higher than groupT_1. The higher TDN and DCP intake in treatment groups might be due to higher digestibility of all the nutrients of TMR fed to treatment groups which was also reflected from the results of the digestibility trial conducted at the last week of experiment.

The average DM, TDN and DCP required per kg gain in weight was comparable among various experimental groups. The results from this study are consistent with other research on CMS supplementation in ruminants, which often shows an increase in total nutrient intake, however, no significant changes in feed conversion efficiency. Nguyen *et al.,* (2020) and Williams *et al.,* (2017) found that while dietary CMS inclusion level increased total nutrient intake, it did not lead to a significant improvement in feed conversion efficiency or the amount of protein required per unit of weight gain in goats.

The average percent digestibility coefficients, TDN and DCP percentage for experimental TMRs is presented in Table 5. The average digestibility coefficient of all nutrients was significantly higher in group T_2 except for DM and NFE digestibility which was comparable among all experimental groups. The digestibility coefficient of organic matter and crude protein were significantly higher in group T_2 than group control and group T_1, however, difference between control and group T_1 was comparable. The digestibility coefficient of ether extract and crude fibre was significantly higher in group T_1 and T_2 than control group, however, it was comparable between group T_1 and T_2. The average digestibility coefficient for DM and NFE was comparable among all experimental groups. The average TDN and DCP % of various experimental TMR revealed non-significant effect of feed treatments. The higher digestibility of all the nutrients observed in treatment group $T_1$and T_2 fed on diet containing CMS might be due to availability of nitrogen and readily available source of energy in the form of soluble sugars obtained from CMS to rumen microbes which must have resulted in enhance rumen fermentation and nutrient digestibility. Findings of the present study are matching with Gerimipour *et al.,* (2019) who found significant increased in OM and CP digestibility in Holstein calves fed diets in which vinasse was substituted for cottonseed meal at 10 and 15 % level.

The average haematological and serum biochemical parameters revealed no significant effect of feed treatments, except serum LDL cholesterol levels which were significantly ($P<0.01$) higher in control group than group T_1 and T_2. All the rumen parameters were comparable among different groups except rumen total nitrogen and NPN which was significantly ($P<0.01$) higher in group T_2 than control group. The highest net profit was realized in group T_2 followed by group T_1 and T_0. The findings of this study are in line Singh *et al.,* (2019) who observed not significantly effect of CMS supplementation on blood profiles, of goats fed a total mixed ration.

Table 4. Performance of growing goats from different experimental groups

Parameters	GroupT_0	GroupT_1	GroupT_2	P Value
Initial average body wt.(kg)	9.15±0.09	9.21±0.08	9.18±0.07	NS
Final average body wt. (kg)	16.62±0.10	17.24±0.09	17.63±0.07	NS
Total gain in weight (kg)	7.47	8.03	8.45	-
Fortnightly avg. body wt (kg)	12.78^c± 1.02	13.12^b± 1.10	13.33^a± 1.15	P<0.01
Fortnightly avg. gain in wt (g)	1.25^c± 0.03	1.34^b± 0.05	1.41^a± 0.03	P<0.01
Avg. daily gain in wt(g)	83.00± 0.12	89.22±0.008	93.89 ± 0.11	-
Avg. daily DM intake(kg)	0.523^b ± 0.04	0.558^a ± 0.04	0.572^a ±0.04	P<0.01
DM intake (%)	3.90^b ± 0.06	4.04^a ± 0.03	4.07^a ± 0.06	P<0.05
DMI/metabolic body size ($W^{0.75}$kg)	74.39^b ± 2.13	77.64^a ± 2.12	78.64^a ±2.17	P<0.01
Average daily TDN intake(kg)	0.342^b ± 0.02	0.368^a ± 0.03	0.379^a ±0.03	P<0.01
Average daily DCP intake(kg)	0.040^c ± 0.003	0.043^b ± 0.003	0.045^a ±0.003	P<0.01
DM required (kg)/kg gain in wt.	6.26±0.35	6.24±0.42	6.06±0.39	NS
TDN required (kg)/kg gain in wt.	4.09±0.23	4.12±0.28	4.02±0.26	NS
DCP required (kg)/kg gain in wt.	0.479±0.02	0.481±0.03	0.474±0.03	NS

Note: The means having common superscript in the same row do not differ significantly NS: Non-significant

Table 5. Average percent digestibility coefficients, TDN and DCP percentage for experimental TMR

Nutrient	Digestibility coefficients%			P Value
	GroupT_0 (TMRT_0)	GroupT_1 (TMRT_1)	GroupT_2 (TMRT_2)	
Dry matter	66.55 ±0.20	67.12 ±0.51	67.85 ±0.31	**NS**
Organic matter	68.84^b ±0.16	69.62^{ab}±0.43	70.14^a ±0.14	P<0.05
Crude protein	73.88^b ±0.28	74.35^{ab} ±0.35	75.11^a ±0.28	P<0.05
Ether extract	77.12^b±0.18	78.64^a ±0.20	78.95^a ±0.03	P<0.01
Crude fibre	57.85^b ±0.17	58.24^b ±0.26	59.12^a ±0.17	P<0.01
Nitrogen free extract	72.25 ±0.40	73.13 ±0.40	73.64 ±0.32	**NS**
TDN%	65.35 ±0.54	65.97 ±0.24	66.32 ±0.20	**NS**
DCP%	7.64 ±0.2	7.71 ±0.19	7.81 ±0.01	**NS**

Note: The means having common superscript in the same row do not differ significantly NS: Non-significant

Conclusion

From overall results of the study, it is concluded that the inclusion of CMS at 5% level in the concentrate mixture of TMR is beneficial for improving performance of growing Osmanabadi goats in terms of weight gain, efficiency of feed utilization and nutrient digestibility without any adversely affecting haemoto-biochemical profile and such inclusion was found cost effective.

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