Feeding Management of Sheep in Semi-Arid Regions using Area Specific Crop Residue Based Total Mixed Ration (TMR)

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ABSTRACT: An experiment was conducted to determine the effect of feeding total mixed ration (TMR) as compared to separate ingredient feeding using sorghum straw, maize stover and red gram chunni in Nellore ram lamb for a period of 91 days. A total of 24 Nellore ram lambs of 3-4 m age were selected and divided into 4 treatment groups having 6 ram lambs in each randomly having similar average body weight (10.47±0.39 kg). Existing feeding practice at farmer's field as separate offering of greens, dry fodder and concentrate was considered as control group. In another three groups, animals were fed TMR based on maize stover, red gram chunni and sorghum straw, respectively as crop residue for the dry roughage component of TMR for TMR_1, TMR_2 and TMR_3. Fresh feed intakes were significantly ($p<0.05$) higher in control group (more than 30%) than those of animals in TMR_1,TMR_2 and TMR_3 groups. DM intake, CP/TDN intake was significantly higher in control group. Digestibility of feeds were significantly ($p<0.05$) superior when used in the form of total mixed ration than fed individually. Body weight gain of animals differ significantly ($p<0.05$) among the treatment groups. Finally, it may be concluded that chunni based TMR gives better results in terms of growth rate, and economic returns as compared to straw or stover based TMR, however, TMR based feeding was found to be beneficial than the separate feeding practices in Nellore sheep.

Key words: Crop residues, daily gain, economic efficiency, nitrogen utilization, nutrient digestibility

Introduction

Livestock plays a vital role in the natural resource-based livelihood of the majority of the population in semi-arid regions of India. However, most of these regions face the problem of acute shortage of feed resources especially during lean season. The pastures are degraded and poorly managed and the area under green forage crops as well as common resources is shrinking due to increase in human population and urbanization. As a result, the basal feeds available for ruminants in these regions are the crop residues which have low nutritional value and are bulky and fibrous. Due to lack of effective management of these resources, unfortunately they are being burnt in some areas, causing environmental pollution.

Crop residues represent one of the pillars of crop and livestock integration in mixed systems (McIntire *et al.,* 1992). The digestibility of crop residues and other low-quality forages can be increased through various methods, where complete feed mix is the way of strategically mixing suitable content to make it a complete diet. The increase in digestibility of crop residues and low-quality forages, in turn also increases their intake. Both these phenomena enhance the efficiency of nutrient utilization from these feed resources in animal food chains.

The Nellore breed of sheep is spread over the greater part of the central peninsular region, comprising the semi-arid areas of Maharashtra, Andhra Pradesh and Karnataka (Shinde and Singh, 1995). Nellore sheep breeds are well adapted to the extensive system of rearing and are well accepted by the locals in the region. Animals of the semi-arid regions mainly depend on rice straw for their nutrition and its contribution to livestock feeds is more than 90% of feed energy available in ruminant's diet (Tareque and Saadullah, 1988). Cereal crops (rice, wheat, maize, millets) contribute 70%, while rice crop alone contributes 34% to the crop residues in India (IARI, 2012). Of the total availability of 15 Mt of dry matter from crop residues in Telangana, paddy and maize straw represented almost 12.67 Mt (85% of total crop residues). Other than paddy and maize crop residues, straws from sorghum (0.29 Mt), green gram (0.07 Mt), Bengal gram (0.01 Mt), and ground nut (0.36 Mt) were important crop residues available in the state. Crop residues, green forage and concentrate contribute nearly 77%, 12% and 11% of the total DM availability for livestock of Telangana. The availability of green forages, dry forages and concentrates were 37, 118 and 51%, respectively in Telangana (ICAR-IGFRI, 2021) which suggests self-sufficiency of state in dry forages but facing severe scarcity of concentrates and green fodder. Apart from that these crop residues are sold at 20-60% of the grain price on an equal dry matter weight basis (Sharma *et al.,* 2010) which suggests that an opportunity exists for lowering of feed cost using these as major ingredients in the ration.

Straw based Total Mixed Ration (TMR) is a new concept of a complete balanced ration for feeding ruminants as well as a novel system of delivering nutrients to them. Each TMR is a total ration composed of both roughage and concentrates for a sheep for 24 hours and supplies all the major nutrients,

including micro nutrients required by the animals. The merits of complete rations are related to a stable environment for rumen fermentation, minimal fermentation losses and fluctuation in release of ammonia and enhancement in utilization of low-grade roughages (Venkanna *et al.,* 1997). Besides these complete rations facilitates control ratio of roughage to concentrate, provides uniform feed intake, reduces feed wastage, enhances nitrogen balance and milk production and reduces the cost of feeding (Hundal *et al.,* 2004; Lailer *et al.,* 2010). The roles of complete feed blocks are to increase productive and reproductive efficiency, enhance immuno-protective ability, reduce helminthic load and decrease ruminal methanogenesis of animals.

In the recent years, the concept of feeding complete rations comprising of fibrous crop residues to dairy animals became popular among the farmers. The term total mixed ration (TMR) or complete ration (CR) is defined as a quantitative mixture of all dietary ingredients, blended thoroughly without giving any choice to the animal for selection of any specific ingredient. In general, it can be regarded as power foods for animals. The objective of complete rations is to provide a blend of all the feed ingredients including roughages without giving any choice to the animal for selection of specific ingredient (Khan *et al.,* 2010). In smallholder animal production system that is predominant in India, a crop residue based TMR (also referred to as 'dry TMR') is more apt as it can be transported easily and stored for at least 2-3 weeks unlike the conventional TMR. It has a benefit of saving labour, reducing cost of feeding, avoiding refusal, effective utilization of agricultural crop residues and steady nutrient supply. However, very less research work has been carried out in sheep using total mixed ration (TMR). Looking to the justifications, the present investigation has been carried out to prepare different iso-proteinous TMR using different crop residues to investigate the effect of feeding complete rations on nutrient utilization, nitrogen metabolism and profitability in Nellore ram lambs under intensive system of rearing.

Materials and Methods

Location and duration of experiment

The research was conducted at Livestock Farm, Hayathnagar Research Farm, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana, India for a period of 91 days from 31th May to 29thAugust, 2020.

Composition and preparation of feed

Maize stover, red gram chunni and sorghum straw was the crop residue chosen for the dry roughage component of TMR, respectively for TMR_1, TMR_2 and TMR_3 collected from farm produce and chopped by a chopper machine before preparation of TMR. The major concentrate ingredient in the TMR were maize grain, cotton seed cake, maize grain for control, TMR_1, TMR_2 and TMR_3, respectively.

These dry forages along with other concentrates were analyzed to determine the DM (91.8, 90.4, 90.0, 91.69, 91.55 and 90.01%, respectively for maize stover, red gram chunni, sorghum straw, maize grain, wheat bran and cotton seed cake) and CP (5.01, 15.3, 4.1, 9.4, 12.0 and 27.1%, respectively for the same ingredients). After nutritional evaluation, all the concentrate ingredients were well mixed manually and then those mixture were properly mixed with dry roughage so as to reach 12% CP and finally mixed with green fodder in the ratio of 50:50 on the day of offering to the animals (Table 1). In case of control group, all these ingredients were offered to the animals separately.

Table 1: Composition of different feeding materials used in the experiment

Ingredients	Control*	TMR_1	TMR_2	TMR_3
Maize stover		50		
Red gram chunni			45	
Sorghum straw				40
Maize grain	60	15	42	25
Wheat bran	22	10	10	10
Cotton seed cake	15	22	0	22
Mineral mixture	2	2	2	2
Salt	1	1	1	1
Total	100	100	100	100
Dry TMR to green fodder ratio	Fed separately#	50:50	50:50	50:50

*Under control group, dry fodder as maize stover was fed @ 0.5 kg per day, #1.5 kg chopped green fodder, Co-4 variety of hybrid napier grass was offered separately to individual sheep. Feed rejection was weighed and used for final calculation of dry matter intake.

Dietary treatments and layout of the experiment

A total of 24 Nellore ram lamb of 3-4 month age were selected and randomly divided into one control and 3 treatment groups each having 6 sheep almost similar average body weight (10.47±0.39 kg). The mean initial body weights (kg) of lambs in four treatments were10.42±0.35 (Control), 10.45±0.47 (TMR_1), 10.35±0.71 (TMR_2), and 10.65±0.61 (TMR_3), respectively.

Feeding and management of animals

The animals were housed according to groups in well-ventilated clean pens. All the experimental animals were stall fed with zero grazing. Every day required amount of green fodder was weighed chopped and mixed with dry TMR and provided twice daily (once in the morning at 8.00 AM and rest in the

afternoon at 4.00 PM) *ad libitum.* Left over feed was recorded for determining the feed intake daily. Always fresh, clean and safe drinking water was supplied to the animals. All lambs were treated for external and internal parasites before the beginning of the experiment.

Digestibility trial

To determine digestibility of supplied feed, a conventional digestibility trial was carried out at the end of the feeding trial having 7 days collection periods. During that period, daily feed intake, feces and urine voided were recorded and collected individually. At the end of the collection period the feces were composites together and then proximate components of each of the samples were analyzed in Animal Science Laboratory at ICAR-CRIDA, Hyderabad.

Collection of data

Weekly body weight of lamb was monitored using portable weighing balance. For economics, all the data pertaining to different inputs like concentrate, dry/green forage, veterinary cost, etc was collected. Prevailing price of all the inputs were taken for computation of economics.

Chemical analysis

The feed samples, leftover and faeces were analyzed by the method of AOAC (1995) for determination of DM, CP, OM and Ash, while, ADF and NDF by Van Soest *et al.,* (1991).All the samples were analyzed in triplicate and mean values were recorded.

Statistical analysis

Means and standard errors of various production and quality traits were calculated using standard statistical procedures (Snedecor and Cochran, 1989). Analysis of data was done by using IBM SPSS Statistics (Ver. 21.0) software. Duncan's Multiple Range Test (DMRT) which is a post-hoc test to measure the specific differences between pairs of means was also done to compare between two different treatment means for various parameters. Economic efficiency of the feeding system was calculated using the equation (i).

$$\text{Economic efficiency} = \frac{\text{Price of grain (Rs.)}}{\text{GST of average daily feed (Rs.)}} \quad \text{(i)}$$

Results and Discussion

Chemical composition of TMRs

Dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fibre (CF), nitrogen free extract (NFE) and total ash content of all the rations did not vary significantly from each other (Table 2), however, cell wall constituents had some difference in different rations.

Table 2: Chemical composition (g/kg DM) of TMRs

Nutrient	Control	TMR_1	TMR_2	TMR_3
Dry matter	932.2	928.4	926.6	930.1
Organic matter	896.3	895.1	894.2	896.2
Crude protein	111.2	111.2	110.1	111.4
Ether extract	22.3	23.4	26.1	23.1
Crude fibre	238.2	224.4	228.3	239.3
Nitrogen-free extract	532.3	535.3	543.8	547.5
Total ash	110.5	105.1	107.1	109.3
Cell wall constituents				
Neutral detergent fibre	735.2	614.2	624.2	715.1
Acid detergent fibre	412.4	295.6	302.3	401.7
Hemi-cellulose	278.3	256.5	274.4	264.3
Cellulose	314.7	211.4	194.6	321.2
Lignin	94.9	52.1	56.2	87.3

Each value is the average of triplicate analysis, on DM basis, except for dry matter (DM)

Nutrient digestibility

Digestibility of nutrients in feed supplied to ram lamb of different groups is illustrated in Table 3, which shows to have significant ($p<0.05$) differences of DM, OM, CP, ash and NDF digestibility among treatment groups. In all cases, digestibility of the said components in supplied feed was significantly higher in TMR_2 than those of other three groups. The digestibility of different nutrients in TMR_1 and TMR_3 were similar, however, it was least in control group. Thus, it is presumed that digestibility of nutrients will play major role in getting benefits of TMR in the experiment. Similar findings were observed by Jadhav and Deshmukh (2001) and Dhuria *et al.,* 2007 in sheep.

Table 3: Digestibility (%) of DM, CP, OM, Ash, ADF and NDF for different TMRs

Nutrient digestibility (%)	Treatment			
	Control	TMR_1	TMR_2	TMR_3
Dry matter (DM)	45.12^a	60.34^b	64.36^c	59.81^b
Crude protein	52.49^a	59.20^b	63.22^c	60.04^b
Organic matter	54.01^a	64.41^b	67.17^c	64.11^b
Ash	41.22^a	51.21^b	52.15^b	50.85^b
Acid detergent fibre	51.41^a	55.17^b	59.16^c	55.03^b
Neutral detergent fibre	51.24^a	55.11^b	58.12^c	54.83^b

Different superscripts in a row vary significantly at 5% level of significance

The result is comparable with the findings of Konka *et al.,* 2015 who conducted an experiment with three different crop residues based complete rations (crop residue and concentrate with ratio of 60:40 in buffalo at India) and found significant difference of

in vitro DM digestibility. It was also reported that digestibility of complete feeds can be enhanced by the additions of relatively small quantities of specific nutrients such as protein or soluble carbohydrates (Khan *et al.,* 2010).

Feed intake

The key to formulating TMR is maximized dry matter intake (DMI), which should be consistent because of improvement in palatability of certain feed ingredients. The fresh feed intakes of animals of different groups are shown in Table 4. Total DM intake, CP intake, and TDN intake per ram lamb was significantly higher in control group as compared to TMR groups. The results of the present study are in corroboration with the findings of Verma *et al.* (1996), Nagpal *et al.* (2005), Gupta *et al.* (2006), Lade *et al.* (2007) and Sharma *et al.* (2010). Fresh feed intake / DM intake was significantly higher in control as different feed ingredients were given at different time period, which was reflected in higher CP/TDN intake. Though, animals of all treatment groups were supplied diet containing same % of CP/ TDN but variation of CP/TDN intake could be due to variation of DM intake from diet.

Table 4: Feed intake of animal for different treatment groups

Parameters	Treatment group			
	Control	TMR_1	TMR_2	TMR_3
Fresh feed intake (kg/day)	15.6^{b}±1.01	11.04^{a}±0 .91	11.46^{a}±0 .60	10.68^{a}±0 .72
DM intake per animal (kg/day)	1.22^{b}±0.11	1.01^{a}±0.09	1.05^{a}±0.04	0.98^{a}±0.01
CP intake per animal (kg/day)	0.17±0.001	0.14±0.001	0.15±0.001	0.14±0.001
TDN intake per animal (kg/day)	1.05^{c}±0.09	0.57^{a}±0.01	0.69^{b}±0.02	0.61^{ab}±0.03

DM-Dry matter; CP-Crude protein; TDN-Total digestible nutrients; Different superscripts in a row vary significantly at 5% level of significance.

Body weight changes

Initially the mean body weight of all the groups of ram lamb were similar (Table 5), however, after providing them rations differentially (TMR groups), a significantly ($p<0.05$) superior body weight was attained by animals fed on TMR_2 ration (21.27 kg) followed by TMR_1 (19.92 kg), TMR_3 (19.5 kg) and least in control (18.02 kg). The group of sheep fed on TMR_2were having superior growth rate (119.96 g day^{-1}) as compared to those fed on TMR_1 (104.03 g day^{-1}), TMR_3 (97.25 g day^{-1}) and control (83.52 g day^{-1}). At the end of 91 days of experiment, maximum body weight gain was observed in the TMR_2 (43.68%) fed animals followed by TMR_1 (24.61%) and TMR_3 (16.44%), as compared to control fed animals (7.6 kg). These body weight achievements are in conformity with those reported by Suresh *et al.* (2008), Yadav and Tailor (2010), Rao *et al.* (2013) and Venkatraju *et al.* (2015).

Table 5: Changes of animal's body weight for different treatment groups

Parameters	Treatment group				SEM
	Control	TMR_1	TMR_2	TMR_3	
Initial body weight	10.42	10.45	10.35	10.65	0.04
Average body weight (kg)	18.02^{a}	19.92^{b}	21.27^{c}	19.5^{b}	0.07
Total body weight gain (kg)	7.6	9.47	10.92	8.85	-
Daily weight gain (g day^{-1})	83.52^{a}	104.03^{c}	119.96^{d}	97.25^{b}	1.23

Means with uncommon superscript within the same row differed significantly ($p<0.05$).

Feed conversion efficiency

The findings are surprising in terms of dry matter used for gaining per kg of live weight which is significantly ($p<0.05$) higher in control group (14.61) as compared to the treatment groups (Table 6). This suggests that the form of diet in this case is making difference where as compared to the ration fed individually, if fed together makes a significant difference in feed conversion efficiency which may be attributed to better digestibility of nutrients and may also be due to better partitioning of nutrients in Nellore sheep. The results were similarly reflected in terms of CP or TDN requirement per kg of live weight gain.

Table 6: Changes in feed conversion efficiency for different treatment groups

Parameters	Treatment group				SEM
	Control	TMR_1	TMR_2	TMR_3	
Kg DMI/ Kg gain	14.61^{c}	9.71^{ab}	8.75^{a}	10.08^{b}	0.5
Kg CP/ Kg gain	2.04^{c}	1.35^{ab}	1.25^{a}	1.44^{b}	0.08
Kg TDN/ Kg gain	12.57^{b}	5.48^{a}	5.75^{a}	6.27^{a}	0.3

Means with uncommon superscript within the same row differed significantly ($p<0.05$).

Nitrogen balance

Though dry matter intake per animal was significantly ($p<0.05$) higher in control, TDN % was similar in all the feed offered to four groups, digestibility of protein has made a dent reversing the nutritive value where control group of ration had significantly ($p<0.05$) less DCP followed by similar DCP in treatment groups (Table 7). The difference was reflected in nitrogen intake where control animals were fed on significantly higher nitrogenous content diet, however, physiologically all groups had absorbed similar quantity of nitrogen. Nitrogen loss through faeces was significantly ($p<0.05$) higher in control group as compared to the treatment groups. Loss of N through urine and total nitrogen loss (g/day) were similar ($p>0.05$) in TMR_1, TMR_2, and TMR_3 rations in comparison to control ration due to variation in the DMI and proportion of nutrients in the diet. All experimental animals were in positive N balance. Santra and Karim (2009) also reported the similar results in ruminants.

Table 7: Nutritive value and nitrogen utilization of the experimental TMRs fed to Nellore sheep

Items	Treatment group			
	Control	TMR_1	TMR_2	TMR_3
DMI per animal (kg/day)	1.22[b]	1.01[a]	1.05[a]	0.98[a]
Nutritive value				
TDN (%)	66	63	64	62
DCP (%)	5.83[a]	6.58[b]	6.96[c]	6.69[b]
Nitrogen utilization				
N-intake (g/d)	23.42[b]	19.39[a]	20.16[a]	18.82[a]
N-absorbed (g/d)	11.38	10.63	11.69	10.49
N-balance (g/d) - through faeces and urine	6.42[b]	5.12[a]	4.84[a]	5.18[a]
N-balance as % of N intake	27.41	26.40	24.01	27.53
N-balance as % of N-absorption	56.41	48.15	41.39	49.38

Means with uncommon superscript within the same row differed significantly *($p<0.05$)*.

Economic efficiency of TMR ration

Average daily feed cost (Table 8) was estimated to be minimum in the group TMR_2 (Rs. 15.61), however, maximum in the group TMR_3 (Rs. 18.96). When the price of daily gain was calculated based on the average daily gain observed during the experiment, the same trend as above was followed where maximum price was gained in TMR_2 (Rs. 35.99) and least gain in the group control (Rs. 25.06). Thus, economic efficiency (%) was maximum in TMR_2 group (2.30), followed by TMR_1 (1.81), TMR_3 (1.54) and Control (1.46). The economic return in TMR_2 group of sheep (Rs. 20.37) was more than double as compared to control (Rs.7.95). At a livestock farm with 100 sheep, using control feeding system can give an economic return of Rs. 23850 per month, with TMR_1 feeding system can yield Rs. 41880, TMR_2 can bestow Rs. 61110 and TMR can provide Rs. 30660 per month as per the economic return estimated in the present experiment which suggests superiority of all TMRs over convention feeding system.

Table 8: Effect of different types of TMRs on economic efficiency of growing ram lambs

Items	Treatment group			
	Control	TMR_1	TMR_2	TMR_3
Average daily feed cost (Rs.)	17.11	17.25	15.61	18.96
Price of daily gain (Rs.)	25.06	31.21	35.99	29.18
Economic return (Rs./sheep/day)*	7.95	13.96	20.37	10.22
Economic efficiency (%)	1.46	1.81	2.30	1.54

*Price of 1 kg live weight = Rs. 300/-

Conclusion

Feeding all the ingredients together in the form of TMR was found to be the best in terms of economic gains as well as body growth as compared to when fed separately. TMR ration based on red gram chunni was found to be the best option among the stover and straw based TMRs both in terms of growth rate as well as economic efficiency. In order to improve nutrient availability and profitability of poor households, there is need to promote the total mixed ration in the crop residue abundant areas.

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