Macro- and Micro-nutrient Utilization and Milk Production in Crossbred Dairy Cows Fed Finger Millet (*Eleucine coracana*) and Rice (*Oryza sativa*) Straw as Dry Roughage Source

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ABSTRACT : Finger millet straw and rice straw are the major source of dry roughage in southern India. They distinctly vary in their morphological and nutritional characters. Hence an effort was made to study the nutrient utilization, milk yield and composition in crossbred dairy cows fed either finger millet (group 1) or rice straw (group 2) as a source of dry roughage. The cows in both the groups were fed as per requirement with concentrate, green fodder and straw in the ratio of 30:45:25 parts (DM). At the end of 50 days of preliminary feeding a digestibility trial was conducted for 7 days and pooled samples of feed, fodder, feces, urine and milk were analysed for macro and micro nutrient content. Finger millet straw contained more CP, Ca, P, Mg, Cu, Zn and Co than rice straw and rice straw contained higher ADF, ash and silica. The intake of DM, CP, EE, NDF, ADF and most micronutrients (Ca, P, Mg, Cu, Zn, Fe, Mn and Co) was significantly higher in cows fed finger millet straw. The digestibility of DM, CP, NDF and ADF was significantly higher in cows fed finger millet straw and the gut absorption of Ca, Cu, Mn and Co was significantly higher in cows fed finger millet straw. The dietary requirement of all micronutrients in both the group of cows could be met irrespective of the type of roughage fed except that of Ca, which was low (0.61 and 0.40%) in rice straw fed cows. The average daily milk yield (L/cow) was also higher (7.0 L) in cows fed finger millet straw as compared to cows fed rice straw (6.3 L). The average milk composition also did not differ except that of milk fat which was significantly (4.7 and 4.5%) low in cows fed rice straw. The overall results of this study have indicated that finger millet straw is a better source of dry fodder than rice straw and while feeding rice straw as the sole roughage to dairy cows there is need to supplement additional calcium as this could be one of the limiting nutrients for milk production. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 1 : 48-53)***

Key Words : Dairy Cow, Straw, Nutrient Utilization, Milk Production

INTRODUCTION

In most developing countries crop residues like straws and stovers form the major dry matter component in the diet of ruminants. In India, common cereals grown are rice, wheat and finger millet (ragi) and the livestock are predominantly fed on cereal straws for their sustenance. The feeding of rice straw to ruminants is of special importance in Asia where, in some areas it is the only available roughage source. In southern part of India, rice and finger millet straw are routinely used for feeding dairy cattle. Finger millet is a coarse straw, whereas rice straw is slender in nature. The nutritive value in terms of nitrogen and cell soluble nutrients is better in coarse straw as compared to slender straws. Slender straws like rice and wheat as a sole feed can not meet the energy requirement for maintenance of adult cattle, whereas coarse straws like finger millet and sorghum can almost meet the requirement due to higher dry matter intake and better utilization (Prasad et al., 1995). Rice and finger millet straw differ distinctly in their nutritive value in terms of both macro and micronutrients, the former is rich in fibre and silica as compared to the latter. As plants mature, fibre content increases and mineral content declines (Reid and Horvath, 1980) and higher level of fibre and silica is likely to interfere with nutrient utilization. Potential availability of minerals is influenced by distribution of the minerals within the plant cell wall or cell material (Ibrahim et al., 1998). This study was undertaken to study the nutrient utilization in crossbred dairy cows fed either finger millet or rice straw as a source of dry roughage.

MATERIALS AND METHODS

Experimental animals, feeding and balance trial

Eleven healthy Holstein Fresian crossbred medium yielding (8-10 L) dairy cows during their late stage of lactation were selected for the study. Cows were managed in individual tie stalls with a paddock. They were dewormed (Albendazole 10 mg/kg BW) and distributed under two dietary groups of six and five animals based on their body weight and milk yield. Cows in both groups were fed as per requirement (ICAR, 1985) with concentrate mixture, green fodder (para:*Brachiaria mutica*) and finger millet (*Eleucine coracana*) or rice (*Oryza sativa*) straw in the ratio of 30:45:25 parts (DM). Concentrate mixture (16% DCP, 68% TDN) was prepared using ground yellow maize

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(23 parts) and wheat bran (40 parts) and deoiled groundnut cake (35 parts) and common salt (1 part). Cows in both groups (G_1 and G_2) were fed concentrate mixture supplemented with 1% commercial mineral mixture. The total quantity of concentrate mixture was divided into two equal parts and was offered individually once in the morning and once in the evening before milking. Straw was offered after milking both in the morning and evening. Chaffed green fodder was offered to each cow during the mid day and clean drinking water was offered to each cow thrice a day. The experimental feeding was continued for 60 days and during the last week of feeding a balance trial of 7 d duration was conducted involving all the cows under both groups in tie stalls. The representative samples of feed and fodder offered and their residues, if any, were collected daily for DM estimation after recording their weights individually.

Recording of milk yields and body weights

Each cow was hand milked at 05:00 h in the morning and 17:00 h in the evening and milk yield was recorded. The milk samples at both in morning and evening at fortnightly interval were collected for estimating fat, solid not fat (SNF) (ISI, 1977), protein and ash content (AOAC, 1980) and micronutrients. Body weight of cows was recorded at weekly intervals before watering and feeding.

Sampling of feces and urine

The feces and urine voided during the trial period were collected from each cow and were respectively weighed/ measured daily at 09:00 h. The feces of each animal was thoroughly mixed in a plastic basin. An aliquot of $1/200^{th}$ of total wet feces voided was taken in pre-weighed petridishes and dried at 100±5°C overnight for DM estimation. The dried feces from each cow was pooled for 7 d for further analysis of ether extract, fibre fractions and minerals. For nitrogen estimation $1/500^{th}$ of the total daily feces voided by each cow was mixed with 1 ml of 1:4 H_2SO_4 and transferred to previously weighed glass bottles. After 7 d of collection, the preserved feces of each cow was mixed thoroughly and an aliquot of $1/10^{th}$ of pooled wet feces was taken for nitrogen estimation by Kjeldahl method. An aliquot of $1/150^{th}$ of total urine voided daily by each cow was collected in plastic bottle. Similarly an aliquot of $1/200^{th}$ of total milk yield during each milking was also collected in plastic bottle. Both the samples of urine and milk collected in bottles were preserved in refrigerated condition (3-4°C) until analysed for minerals.

Preparation of acid mineral extract and mineral analysis

The pooled samples of dried feed, fodder and feces of each animal collected during the trial were ground to 1 mm fineness. The ground samples were subjected to dry ashing in a muffle furnace at 600°C for 2 h, cooled and dissolved in 5 N HCl for the preparation of mineral extract in duplicate. The undissolved residue on Whatman filter paper (No. 42) was again ignited and ashed in muffle furnace at 600°C for 2 h, cooled and its weight recorded as the acid insoluble ash (AIA, silica). The content of ash, AIA and minerals in feeds, fodders and fecal samples were expressed on DM basis. The pooled milk and urine samples from each animal were aliquoted at $1/10^{th}$ proportion and wet digested with 3:1 HNO_3 and perchloric acid mixture for preparing the acid mineral extract. Calcium (Ca), magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), cobalt (Co) and manganese (Mn) were estimated using atomic absorption spectrophotometer (Perkin Elmer AA 300, USA). For estimation of Ca and Mg, acid extracts were suitably diluted (1:50 or 1:100) with 0.1% lanthanum chloride to avoid interference from phosphates. For estimating manganese, acid extracts were suitably diluted (1:10) with 0.2% $CaCl_2$ to avoid interference from sulfates and phosphates. Phosphorus was estimated colorimetrically by the molybdovanadate method (AOAC, 1975). Mineral standards were run for each analysis.

Estimation of crude protein (CP), ether extract (EE), fibre fractions and oxalate

The dried samples of feed, fodder and feces, ground to a fineness of 1 mm, were analysed for crude protein (CP), ether extract (EE) (AOAC, 1990) and fibre fractions (NDF:Neutral detergent fibre; ADF:Acid detergent fibre) (Goering and Van Soest, 1970). The oxalate content of fodders and feces was estimated by potassium permanganate method (Abaza et al., 1968).

Statistical methods

The data pertaining to intake, utilization of nutrients, body weight, milk yield and composition were analysed for standard error and variance in one way classification (Snedecor and Cochran, 1980) and tested for significance in M.S. Excel using systat 8.0.

RESULTS AND DISCUSSION

Macro and micronutrient content of feeds and fodders

The concentrate mixture contained 21.0% CP, 0.5% Ca and 1.8% P and other minerals were present above the critical limit. Higher level of P than Ca was due to the inclusion of wheat bran and groundnut cake which are good sources of P. The green fodder (para grass) was a moderate source of CP (6.1%) and other minerals but contained relatively higher NDF and ADF contents. Finger millet

Table 1. Macro and micronutrient content of feeds and fodders

	CP	EE	NDF	ADF	Ash	AIA	Ca	P	Mg	Cu	Zn	Fe	Mn	Co
	% DM									ppm				
Concentrate	21.0	4.7	34.3	13.6	6.0	0.94	0.50	1.8	0.50	21	115	405	84	2.5
Green fodder (para grass)	6.1	1.9	78.1	47.1	9.2	4.8	0.31	0.48	0.26	7	26	315	31	1.3
Finger millet straw	4.9	1.0	80.5	45.8	8.4	5.0	1.0	0.13	0.53	7	34	130	295	2.8
Rice straw	2.6	1.1	75.2	56.6	18.8	13.6	0.22	0.05	0.28	11	14	120	190	2.1

Table 2. Intake and utilization of macronutrients

Attribute	Intake through			Total intake	Digestibility (%)
	Concentrate	Green fodder	Straw		
DM (kg)					
$Group_1$	3.9	3.9	2.3	10.1	54.3 ^{a}
$Group_2$	3.6	3.7	1.7	9.0	43.9 ^{b}
SEM	0.22	0.16	0.22	0.46	2.19
P value	0.44	0.51	0.21	0.23	<0.009
CP (kg)					
$Group_1$	0.86	0.23	0.11 ^{a}	1.2	72.8 ^{a}
$Group_2$	0.78	0.22	0.04 ^{b}	1.0	67.5 ^{b}
SEM	0.048	0.009	0.013	0.06	1.25
P value	0.44	0.51	<0.006	0.20	<0.02
EE (gm)					
$Group_1$	185.7	96.6	21.0	303.1	68.1
$Group_2$	168.7	93.9	15.1	277.7	64.9
SEM	10.38	1.75	2.29	12.31	2.25
P value	0.44	0.51	0.21	0.33	0.52
NDF (kg)					
$Group_1$	1.3	2.9	1.8	6.0	39.8 ^{a}
$Group_2$	1.2	2.7	1.3	5.2	24.7 ^{b}
SEM	0.07	0.12	0.19	0.30	2.75
P value	0.44	0.50	0.14	0.15	<0.001
ADF (kg)					
$Group_1$	0.56	1.7	1.0	3.3	23.6 ^{a}
$Group_2$	0.51	1.6	1.1	3.1	14.1 ^{b}
SEM	0.025	0.07	0.10	0.16	2.14
P value	0.86	0.42	0.86	0.59	<0.016

$Group_1$: fed finger millet straw as dry roughage, $Group_2$: fed rice straw as dry roughage.
"Means bearing different superscripts in a column differ significantly"

straw was a superior source of CP, Ca, P, Mg. Zn and Mn as compared to rice straw. The rice straw contained more NDF, ADF, ash and silica (Table 1). The Ca (0.3%), P (0.25%) and Zn (40 ppm) contents of rice straw were lower than the critical levels as suggested by McDowell (1992).

Utilization of macronutrients

The intake of DM through either concentrate or green fodder did not differ significantly (10.1 and 9.0 kg). The intake of DM through rice straw was lower ($p>0.21$) in group 2. The feeds high in silica may be unpalatable due to their abrasive nature during chewing (Van Soest, 1982). The intake of CP was significantly ($p<0.06$) low through rice straw in group 2, however the total intake of CP did not differ significantly. The intake of EE and NDF was non-significantly lower in cows of group 2 consuming rice straw, however, the intake of ADF was higher ($p>0.50$) due to rice straw feeding because of higher ADF content in rice straw.

In spite of similar intakes of DM, CP, EE, NDF and ADF in both groups, the digestibility of all nutrients except EE differed significantly (Table 2). There is a negative correlation between the ash and silica content with the DM digestibility in several varieties of rice straw (Reddy and Sivaiah, 2001). Silica uptake and length of time for the plant to mature are related to the molecular structure of fibre (Bainton et al., 1991). Higher level of ash (>18%) and silica (13.6%) as compared to finger millet straw (8.4 and 5%) is the most probable reason for reduced DM digestibility of rice straw in the present study.

Utilization of macrominerals

The intake of Ca in group 1 was higher ($p<0.00$) because finger millet straw contained higher Ca than rice straw, which resulted in significantly ($p<0.00$) higher intake. The gut absorption (25.9 and 15.4%) and net retention (9.6 and 3.0 gm) and retention as percentage of total intake (15.6

Table 3. Intake and utilization of micronutrients

	Intake through			Total intake	Level in DM (%)	Out go			Total out go	Gut absorption (%)	Net retention	Retention (% of intake)
	Concentrate	Green fodder	Straw			Feces	Milk	Urine				
Ca (gm)												
$Group_1$	19.7	14.7	27.5 ^{a}	61.9	0.61 ^{a}	45.9 ^{a}	5.2 ^{a}	1.3 ^{a}	52.3 ^{a}	25. 9 ^{a}	9.6 ^{a}	15.6 ^{a}
$Group_2$	17.1	14.3	3.1 ^{b}	34.4	0.40 ^{b}	29.0 ^{b}	2.2 ^{b}	0.31 ^{b}	31.5 ^{b}	15.4 ^{b}	3.0 ^{b}	8.3 ^{b}
SEM	0.96	0.24	4.13	4.67	0.037	3.07	0.63	0.170	3.64	2.20	1.14	1.43
P value	0.187	0.53	<0.00	<0.00	<0.00	<0.001	<0.008	<0.00	<0.00	<0.008	<0.00	<0.003
P (gm)												
$Group_1$	70.2	21.9	3.7 ^{a}	95.8	0.94	77.7	3.5	8.4	89.7	18.8	6.2	6.4
$Group_2$	63.8	21.2	0.3 ^{b}	85.2	0.94	69.2	3.4	7.6	80.2	18.1	5.08	5.5
SEM	3.92	0.51	0.56	4.43	0.020	3.08	0.53	0.39	3.39	3.94	0.88	0.84
P value	0.44	0.52	<0.00	0.25	0.99	0.18	0.88	0.34	0.25	0.78	0.54	0.65
Mg (mg)												
$Group_1$	19.7	14.8	13.0 ^{a}	47.6 ^{a}	0.46 ^{a}	28.1 ^{a}	4.8	4.4	37.1	40.3	10.5 ^{a}	21.8
$Group_2$	17.9	14.7	5.3 ^{b}	37.9 ^{b}	0.42 ^{b}	23.0 ^{b}	6.0	2.6	31.7	38.7	6.2 ^{b}	16.4
SEM	1.11	0.07	1.51	2.17	0.009	1.12	0.79	0.43	1.48	2.77	0.95	1.45
P value	0.04	0.28	<0.003	<0.01	<0.02	<0.01	0.50	0.14	0.06	0.73	<0.01	0.059
Cu (mg)												
$Group_1$	82.8	30.4	15.3	128.5	12.7 ^{a}	37.4	4.40	1.7	43.5	71.2	85.0 ^{a}	66.4
$Group_2$	71.2	29. 4	17.5	122.1	13.6 ^{b}	45.2	4.00	2.6	51.8	63.1	70.3 ^{b}	58.7
SEM	4.63	0.73	1.82	5.67	0.20	4.38	0.34	0.24	4.50	2.32	3.27	2.34
P value	0.44	0.51	0.57	0.60	<0.02	0.40	0.59	0.15	0.39	0.14	<0.01	0.10
Zn (mg)												
$Group_1$	472.6	125.3	88.4 ^{a}	686.3 ^{a}	68.2	212.6	189.3	33.6	440.5	68.1	245.9	35.6
$Group_2$	411.9	122.0	21.0 ^{b}	554.9 ^{b}	61.7	176.7	158.6	35.8	371.1	65.5	183.5	32.3
SEM	24.41	2.34	11.88	32.20	1.79	15.94	12.61	2.35	21.48	3.28	22.63	4.55
P value	0.23	0.51	<0.00	<0.03	0.07	0.22	0.24	0.67	0.11	0.71	0.18	0.55
Fe (mg)												
$Group_1$	1,597.0	1,666.2	301.2	3,564	353.2	2,883.6	178.2	108.2	3,169.8	19.4	394.1	11.0
$Group_2$	1,450.7	1,640.9	215.8	3,307.5	372.2	2,627.0	161.0	99.2	2,886.8	20.6	420.2	12.7
SEM	89.33	17.99	29.37	113.95	7.12	111.88	11.36	6.06	125.65	1.64	64.96	1.83
P value	0.46	0.51	0.16	0.28	0.20	0.27	0.48	0.49	0.28	0.73	0.85	0.67
Mn (mg)												
$Group_1$	331.3	122.5	739.4 ^{a}	1,193.0	117.2 ^{a}	848.9	11.0 ^{a}	5.8	865.6	28.7 ^{a}	327.7 ^{a}	27.0 ^{a}
$Group_2$	300.9	115.9	371.1 ^{b}	793.9	88.2 ^{b}	671.6	6.8 ^{b}	4.4	682.8	13.5 ^{b}	110.9 ^{b}	13.8 ^{b}
SEM	18.53	4.69	76.44	86.45	5.29	48.31	0.96	0.46	49.47	2.66	42.16	2.42
P value	0.44	0.51	<0.008	<0.01	<0.001	0.06	< 0.02	0.16	0.06	<0.00	<0.003	<0.001
Co (mg)												
$Group_1$	9.8	4.6	5.4 ^{a}	20.6	2.0 ^{a}	8.3	7.6 ^{a}	ND	16.0	59.8 ^{a}	4.6	22.8
$Group_2$	8.9	4.3	3.2 ^{b}	16.3	1.8 ^{b}	10.1	4.2 ^{b}	ND	14.3	31.2 ^{b}	3.1	18.6
SEM	0.55	0.23	0.73	1.15	0.04	0.81	0.82	-	1.13	4.82	0.47	2.03
P value	0.44	0.48	<0.03	0.06	<0.002	0.29	<0.03	-	0.50	<0.00	0.09	0.32

"Means bearing different superscripts in a column differ significantly"

and 8.3%) were also superior in cows of group 1. The gut absorption of Ca in peri-parturient or lactating animals is much lower (34-44%) due to bone resorption at the time of greatest need (Suttle, 2000). The level of Ca in the dietary DM was significantly (p<0.00) lower in group 2 fed rice straw (0. 40%) as compared to group 1 fed finger millet straw as against the Ca requirement of 0.43 to 0.77% for dairy cattle (NRC, 1989). This suggests additional Ca supplementation to meet the Ca requirement when rice straw is fed. The oxalate content of rice and finger millet straws used in this study was estimated to be 0.32 and 0.12%, respectively. Higher levels of oxalate in ruminant diet can adversely influence Ca utilization (Ranganekar et al., 1995). Further, oxalic acid is degraded in the rumen to certain extent by the rumen bacteria (Allison et al., 1984). Total oxalate intake at a level of 0.58% in the DM of cattle was harmless but oxalate at a level of 1.19% in the DM adversely affected the utilization of Ca (Panda and Sahu, 2002). Hence in this experiment the oxalate intake through rice straw was low as to interfere with Ca utilization. The silica in plants is present on the cell wall along with hemicellulose and lignin. The higher level of silica in rice straw is the most likely factor for reduced DM and ADF digestibilities which is also responsible for reduced Ca release from the cellular content. Supplementation of minerals (Ca, P, S, Zn and Mn) at 10-20% higher than the normal requirement has improved the nutrient utilization and mineral retention in lambs (Sharma et al., 2004).

The intake of P and Mg was also low through rice straw feeding in group 2. Though the total intake of P and Mg was lower in group 2 consuming rice straw, the gut absorption and retention as the percentage of total intake were almost

Table 4. Body weight, average milk yield and composition in dairy cows

Parametre	$Group_1$	$Group_2$	SEM	P value
Body weight (kg)				
Start	355.0	356.6	11.84	0.951
Final	366.8	358.1	11.58	0.583
Milk yield (L per day/cow)				
Start	8.0	7.0	0.50	0.469
Final	6.0	5.7	0.45	0.578
Average	7.0	6.3	0.48	0.595
4% FCM	7.7	6.8	0.45	0.521
Composition (%)				
SNF	8.9	8.8	0.05	0.847
Fat	4.7^a	4.5^b	0.14	<0.000
Protein	3.0	2.9	0.02	0.275
Ash	0.60	0.57	0.007	0.067

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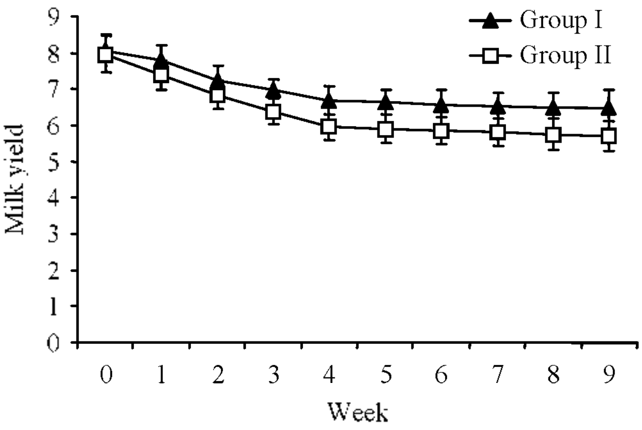

Figure 1. Average weekly milk production (L/head/day).

comparable (Table 3). The dietary levels of P (0.94%) and Mg (0.46 and 0.42%) in both groups were much above the suggested levels of 0.25-0.49% and 0.20-0.25%, respectively (NRC, 1989). In the present study, the ratio of Ca:P was 0.64:1 and 0.42:1 in diet 1 and 2, respectively as against the optimum level of either 2:1 or 1:1 for efficient utilization. Ruminants can tolerate a wider ratio of Ca:P than the monogastrics but feeding excess of P for long time might reduce Ca absorption and result in excessive bone resorption (NRC, 2001). If the Ca level in the diet is adequate, maximum tolerable concentration of P in dairy cattle diet is 1% (NRC, 2001) and hence under rice straw feeding system, this aspect needs special attention.

Utilization of trace minerals

The intake of Cu and Fe through straw was comparable in both the groups whereas that of Zn, Mn and Co was significantly low in cows fed rice straw (Table 3). The dietary (DM) level of all the trace minerals studied were more than the suggested level in dairy cattle ration. The gut absorption of Cu (71.2 and 63.1%), Zn (68.1 and 65.5%) and Fe (19.4 and 20.6%) was comparable in both the groups, however, the gut absorption was significantly lower for Mn (28.7 and 13.5%) and Co (59.8 and 31.2%) in group 2 fed rice straw. The retention as the percentage of total intake were also comparable for Cu (66.4 and 58.7%), Zn (22.8 and 18.6%) and for Mn (27.0 and 13.8%), the retention being superior in cows fed finger millet straw. The absorption and retention values for trace minerals vary greatly depending on several factors like dietary components, amount of other minerals, age and physiological condition of animals (Ammerman, 1995). Higher dietary level of P in the present study probably reduced the Mn absorption as excess P exerts antagonistic effect on Mn utilization (Wedekind and Baker, 1990). Higher intake of Fe also adversely influence the Mn utilization (Johnson and Korynta, 1992). Iron is generally present in excess of its requirement as most of the feeds and fodders are rich sources of Fe (Gowda et al., 2003) and the utilization of Fe is also relatively low due to the interference of fibre, Ca, P and Zn (Henry and Miller, 1995).

Body weight, milk yield and composition

The average final body weight in cows fed rice straw was lower (p>0.583) during the 60 days of feeding. Milk yield (4% FCM) was also lower (7.7 and 6.8 L/cow/day) (p>0.052) in cows of group 2 consuming rice straw.The milk composition (SNF, protein and ash) did not differ significantly except the milk fat (4.7 and 4.5%), which was lower (p<0.009) in cows fed rice straw, probably due to lower NDF and ADF digestibility as fibre is the main source of volatile fatty acids production in rumen.

CONCLUSION

From the findings of this study, it can be concluded that finger millet straw is a better source of roughage for lactating animals in terms of macro and micronutrient content and their utilization. Under rice straw feeding system, there is a need to supplement additional calcium, as this could be one of the limiting nutrients.

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