Indian Journal of Animal Sciences **96** (2): 115–119, February 2026/Article
https://doi.org/10.56093/ijans.v96i2.173137

Nutritive value of barnyard, brown top and finger millet straw based diets in lactating dairy cattle

D RAKESH[1], T M PRABHU[2✉], B C UMASHANKAR[3], T S SUKANYA[4], G ANAND MANEGAR[5], A P MALLIKARJUN GOWDA[6] and K T POORNACHANDRA[7]

Karnataka Veterinary, Animal and Fisheries Sciences University Regional Campus, Bengaluru 560 024 India

Received: 09 November 2025; Accepted: 15 June 2026

ABSTRACT

A study was conducted to evaluate the nutritive value of barnyard (BYS), browntop (BTS) and finger millet straw (FMS) based diets in lactating dairy cattle through two phases. In Phase I, proximate composition, fibre fractionation, *in vitro* gas production and digestibility of the straws and compounded feed mixture (CFM) were analyzed. In Phase II, a feeding trial was conducted on six late-lactation crossbred HF cows in Latin square design with three treatments: T_1 (FMS + CFM), T_2 (BYS + CFM) and T_3 (BTS + CFM). CP was lowest in FMS (3.80%) and highest in BTS (5.23%), while lignin content was highest in FMS (4.28%) and lowest in BTS (3.19%). BYS showed highest ($p<0.05$) *in vitro* gas production (34.33 mL/200 mg DM) and ME (7.10 MJ/kg DM) compared to BTS (22.41 mL/200 mg DM and 5.55 MJ/kg DM). *In vitro* digestibility values indicated that BYS and BTS were nutritionally superior to FMS. *In vivo*, total dry matter intake was highest in BTS-fed cows (12.78 kg/d), followed by BYS (12.41 kg/d) and FMS (12.03 kg/d). CP intake and digestibility of DM, OM, CP, NDF and cellulose were higher in BYS and BTS diets while ADF and hemicellulose digestibility were similar in all the groups. Milk yield and 4% FCM were higher in BYS (7.28 and 7.12 kg/d) and BTS (7.22 and 7.16 kg/d) diets than FMS (6.89 and 6.81 kg/d). Therefore, barnyard and browntop millet straws were nutritionally superior to finger millet straw.

Keywords: Barnyard millet, Browntop millet straw, Digestibility, Finger millet, Feed intake, Lactating cattle, Milk yield

Fodder availability is a limiting factor in dairy production. Since feeding animals accounts for nearly 70% of total livestock farming expenses, it is essential to implement strategies to reduce feed costs by utilizing available resources more efficiently. The shortage of feed and fodder remains a pressing issue in India with the current deficit estimated at 35.6% for green fodder and 10.95% for crop residues (ICAR-IGFRI, 2015). To address the disparity between the actual demand and current supply of various livestock feed resources, the use of nonconventional feedstuffs such as crop residues and agro-industrial by-products has been suggested (Okoruwa *et al.* 2012). The deficit in fodder supply is partly met by crop residues-straw and stovers.

Millets are the most secure crops to small farmers as this resilient crop thrives in challenging environments including hot, drought-prone or semi-arid regions, unpredictable climates and soils with low fertility. Millets, with their remarkable diversity and resilience, have emerged as vital crops in addressing the challenges posed by climate change and ensuring agricultural sustainability (ICAR-IIMR, 2018). India is the largest global producer of millets. Annually, millets account for 11% of the 30 million tonnes crop residues produced in India (Bhat *et al.* 2023). Hence the present study was taken up to determine *in-vitro* rumen parameters and thereafter evaluation of millet straw based diets in lactating crossbred HF cows.

MATERIALS AND METHODS

The present experiment was conducted at the Department of Animal Nutrition, Veterinary College, Bengaluru, to evaluate the nutritive value of millet straw-based diets in crossbred HF dairy cattle in late lactation.

The proximate composition of finger millet straw, barnyard millet straw, browntop millet straw and a compounded feed mixture (CFM) was analyzed following AOAC (2005). The fibre fractions viz., neutral detergent

Present address: [1]PG scholar (rakeshdr08@gmail.com).[2]Sr. Professor and Head (prabhutmann@gmail.com).[3]Associate professor (umashankarbukkapattana@gmail.com) Department of Animal Nutrition, Veterinary College, KVAFSU regional campus, Bengaluru-560024, India.[4]Professor and Head, Department of Agronomy, UAS, GKVK, Bengaluru - 560024, India (sukanyats2002@gmail.com). [5]Professor and Head, Department of Animal Sciences, UAS, GKVK, Bengaluru - 560024, India (dranandamanegar@gmail.com).[6]Senior farm superintendent, Zonal Agricultural Research Station, UAS, GKVK, Bengaluru - 560024, India (mallikarjuna.gowda@gmail.com).[7]PhD scholar, Department of Animal Nutrition, Veterinary College, KVAFSU Regional Campus, Bengaluru – 560 024, India (drpoornakt@gmail.com). ✉Corresponding author email. prabhutmann@gmail.com

fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and acid detergent lignin (ADL) contents were determined using Fibretherm (Gerhardt), as per Van Soest *et al*. (1991).

In vitro gas production for ME estimation: The metabolizable energy (ME) content of finger millet, barnyard millet, browntop millet straws and a compounded feed mixture was estimated using the *in vitro* gas production technique (Menke and Steingass, 1988). Rumen fluid was collected from a 350 kg BW cannulated crossbred HF cattle fed a basal diet comprising finger millet straw and compounded feed mixture to meet nutrient requirement for maintenance as per ICAR (2024) standards. The ME was calculated using Menke and Steingass (1988) equations based on gas output and feed composition.

In vitro digestibility: A modified *in vitro* digestibility method was adopted to determine true DM (IVDMD), OM (IVOMD) and neutral detergent fiber digestibility (NDFD) (Goering and Van Soest, 1970) and Mould *et al.* 2005).

Lactation trial: A lactation trial was carried out using six crossbred HF dairy cattle in late lactation, arranged in a Youden Latin Square (3×3) design across three periods of 21-days. Cows were selected based on milk yield and randomly assigned to one of three dietary treatments: T_1 - finger millet straw + CFM, T_2 - barnyard millet straw + CFM and T_3 - browntop millet straw + CFM. All diets were formulated to meet nutrient requirements as per ICAR (2024) standards. The animals were housed individually, fed *ad libitum* straw and scheduled portions of CFM and provided with fresh water four times daily. The cows were milked twice a day at 05:00 and 15:00 h using milking machine. The four per cent fat-corrected milk (FCM) yield was determined using the NRC (2001) equation. Each study period began with a one-week adjustment phase. Data on dry matter and nutrient intake, total milk yield were taken during the second and third week. Milk composition was analyzed from two samples taken in second week and three samples taken on the last three days of the third week in each period. These samples were then examined for protein, fat, solids not fat (SNF) and lactose using a Hamsa milk analyzer.

Statistical analysis: The data pertaining to intake, digestibility of nutrients, milk yield (4% FCM) and milk composition were analysed using statistical tool/software (SPSS, Version 9.0) following Snedecor and Cochran (1995).

RESULTS AND DISCUSSION

The data on proximate composition and fibre fractions of millet straws and compounded feed mixture are presented in Table 1. The composition of finger millet straw, barnyard millet straw and browntop millet straw was comparable with the values reported by Aglave *et al*. (2025) except for the crude protein of barnyard straw which is lower. The proximates of finger millet straw and barnyard millet straw corresponds to ICAR (2013) values. The ME (MJ / kg DM) content and RIVGP-24 h (mL/200mg DM) of different feedstuffs are presented in Table 1. These results were comparable (Veena *et al.* 2018, Chandrasagara *et al.* 2020). The ME of barnyard millet straw was in agreement

Table 1. Chemical composition (% on DMB) and ME (MJ/Kg DM) of crop residues and compounded feed mixture

Parameter	Feedstuff			
	FMS	BYS	BTS	CFM
Dry matter	90.06	88.74	89.7	89.7
Organic matter	92.03	88.72	91.15	88.3
Crude protein	3.8	3.89	5.23	18
Ether extract	0.79	0.84	0.71	2.96
Total ash	7.97	11.28	8.85	11.7
Neutral detergent fibre	71.78	61.11	64.25	19.95
Acid detergent fibre	41.94	34.47	41.27	9.93
Cellulose	35.64	27.28	36.41	8.2
Hemicellulose	29.84	26.64	22.98	10.02
Acid detergent lignin	4.28	3.69	3.19	1.73
Neutral detergent ash	3.3	2.83	1.89	0.56
Acid detergent ash	2.6	2.3	1.6	0.34
Biogenic silica	0.7	0.53	0.29	0.22
Sand silica	3.33	4.34	1.97	3.31
IVGP (mL)	30.07± 0.4306	34.33 ± 0.7144	22.41 ± 0.5482	52.96 ± 0.8104
ME (MJ/kg DM)	6.51 ± 0.0584 \\	7.10 ± 0.0969	5.55 ± 0.0744	10.59 ± 0.1272

[1]Variation in duplicate measurements was within ±3% of the mean.
†FMS, Finger millet straw; BYS, Barnyard millet straw; BTS, Browntop millet straw; CFM, Compounded feed mixture.
ǂ *In vitro* gas production, values represent gas production from 200 mg substrate over 24 h period from three trials.

Table 2. *In vitro* digestibility (per cent) of different crop residues and compunded feed mixture

Attribute	FMS	BYS	BTS	CFM
IVDMD	52.80 ± 0.416	57.06 ± 0.801	57.41 ± 0.888	81.76 ± 0.434
IVOMD	58.64 ± 0.364	62.73 ± 0.695	63.86 ± 0.754	85.31 ± 0.349
NDFD	32.66 ± 0.600	34.02 ± 1.244	38.67 ± 1.295	38.31 ± 1.578

IVDMD: *In vitro* true dry matter digestibility; IVOMD: *In vitro* organic matter digestibility; NDFD: Neutral detergent fiber digestibility.

Table 3. Daily mean intake and apparent digestibility of nutrients in crossbred HF cows

Attribute	Dietary groups[1]			SEM	P-value
	T_1	T_2	T_3		
		DMI (kg/d)			
CFM	5.32[b]	5.31[b]	5.69[a]	0.026	0.000
Straw	6.71	7.10	7.09	0.140	0.078
Straw, % of body weight	1.686[b]	1.784[a]	1.793[a]	0.025	0.04
Total DMI	12.03[b]	12.41[ab]	12.78[a]	0.157	0.004
% of body weight	3.04[b]	3.13[b]	3.25[a]	0.027	0.000
g per kg B $W^{0.75}$	135.5[b]	139.4[b]	144.5[a]	0.0	0.000
		Digestibility (%)			
DM	58.15[b]	62.17[a]	61.80[a]	1.001	0.009
OM	60.51[b]	64.78[a]	65.22[a]	0.962	0.001
CP	60.00[b]	62.83[a]	64.92[a]	0.677	0.000
NDF	54.31[b]	57.64[ab]	58.93[a]	1.132	0.023
ADF	41.13	43.89	44.03	1.604	0.36
Hemicellulose	46.77	50.03	51.05	1.33	0.066
Cellulose	38.18[b]	41.75[ab]	43.00[a]	1.26	0.023
DOMDM	54.70[b]	57.36[ab]	58.62[a]	0.858	0.006

[ab]Mean values within a row bearing different superscripts differ significantly (P <0.05/0.01).
[1]T_1- FMS+CFM; T_2- BYS+CFM; T_3- BTS+CFM.
Digestible organic matter in DM.

with ICAR (2013) value (7.1 MJ/kg).

Among the straws, BYS and BTS recorded higher IVDMD values compared to FMS, indicating better digestibility of these millet straws (Table 2). The difference between FMS and the other millet straws can be attributed to variations in fibre fractions, lignin and crude protein composition. Since lignin forms a physical and chemical barrier around cellulose and hemicellulose, its higher proportion in FMS might have contributed to reduced microbial digestion and thus lower IVDMD. The *in vitro* OM digestibility of FMS in the present observation was 58.64%, although lower value (52.1) was reported by Mediksa *et al*. (2021).

Average daily DM intake and digestibility of nutrients in different treatments are presented in Table 3. DMI was higher (P<0.01) in group T_3 compared to T_1. The increased DMI observed in cows fed browntop millet straw (T_3) based diet could be attributed to its better palatability, increased frequency of feeding, quality of straw, reduced particle size of feed and favourable fiber characteristics, which is likely to have enhanced voluntary feed intake. Mediksa *et al*. (2021) reported significant decrease in DMI through FMS. Devendra (1997) reported an average intake of straw about 1% of body weight in cattle and buffaloes. Prasad *et al*. (1998) reported DMI of 3% for untreated rice straw in lactating cattle. Schiere and Wieringa (1988) reported an intake of urea treated rice straw at 1.8-2.4% of body weight in heifers.

The digestibility of DM, OM, CP NDF and cellulose was significantly (p<0.05) different among treatments. The digestibility of nutrients was higher in diets containing barnyard and browntop millet straws compared to finger millet straw, which could be due to their lower fibre and lignin contents. Reduced lignification enhances ruminal degradation of cell wall components by improving microbial access to structural carbohydrates (Zhong *et al.* 2021). Van Soest (1994) emphasized that lignin physically restricts enzymatic attack on cellulose and hemicellulose and therefore, its reduction markedly increases nutrient availability. Improved hemicellulose and cellulose digestibility in barnyard and browntop millet straws indicated fewer cross-linkages within their structural

Table 4. Yield of milk and its composition

Attribute	Dietary groups[1]			SEM	P-value
	T_1	T_2	T_3		
		Milk yield (kg/day)			
Milk yield	6.892[b]	7.284[a]	7.217[ab]	0.166	0.012
4% FCM	6.807[b]	7.12[a]	7.163[a]	0.148	0.014
		Milk composition (%)			
Total solids	12.39	12.27	12.40	0.097	0.582
Fat	3.92	3.85	3.95	0.053	0.37
SNF	8.47	8.43	8.45	0.07	0.91
Protein	3.09	3.11	3.09	0.027	0.84
Lactose	4.64	4.59	4.64	0.04	0.60
Ash	0.74	0.73	0.72	0.008	0.441
CLR[2]	28.16	28.24	28.04	0.34	0.916

[ab]Mean values within a row bearing different superscripts differ significantly (P<0.05/0.01).
[1]T_1- FMS+CFM; T_2- BYS+CFM; T_3- BTS+CFM.
[2]CLR: Corrected Lactometer Reading.

Table 5. Body weight changes of crossbred HF cows

Attribute	Dietary groups[1]			SEM	P-value
	T_1	T_2	T_3		
Initial body weight (kg)	392.0	395.3	391.4	1.22	0.950
Final body weight (kg)	396.6	399.4	396.0	1.05	0.765
Body weight gain (kg)	4.60	4.10	4.60	0.174	0.342
Gain (g/d)	221	194	218	0.586	0.361

[1]T_1- FMS+CFM; T_2- BYS+CFM; T_3- BTS+CFM.

matrices which might have facilitated better microbial degradation. The higher (P<0.05) nitrogen availability from browntop millet straw would have supported enhanced microbial synthesis, contributing to improved digestion of crude protein. Chandrasagara *et al*. (2020), observed lower digestibility in finger millet straw based diets compared to other roughages.

The total milk yield of group T_2 was higher ($p \leq 0.05$) compared to group T_1 while 4% FCM yield was higher ($p \leq 0.05$) in groups T_2 and T_3 compared to T_1 (Table 4). The composition of milk in terms of fat, SNF, protein, total solids and lactose content were similar in all the groups. The improved performance observed in T_3 may be attributed to greater digestibility and a higher proportion of fermentable carbohydrates relative to the other two straws. The comparatively improved performance in group T_2 (barnyard millet straw) over group T_1 indicated that barnyard millet straw provided more metabolizable energy than finger millet straw. Comparable findings were documented by Chandrasagara *et al*. (2020) and Mediksa *et al*. (2021), who reported reduced milk production in cows maintained on finger millet straw-based rations. However, Gowda and Prasad (2005) observed enhanced milk yield when cows were fed diets incorporated finger millet straw.

As the animals were in late lactation, the rations were formulated to provide sufficient energy for an expected daily gain of 100 g and the actual gains recorded were higher (Table 5).

Feeding of barnyard millet straw and browntop millet straw based diets resulted in improved dry matter intake, nutrient digestibility and milk yield compared to finger millet straw, while milk composition and body weight gain remained unaffected in crossbred HF cows.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India, under the SURE (State University Research Excellence) scheme (Sanction Order No: SUR/2022/004786) for supporting field work and analysis. The authors also express their gratitude to the University of Agricultural Sciences, GKVK, Bengaluru and KVAFSU, Bidar for providing the necessary facilities to carry out the research work successfully.

REFERENCES

AOAC (Association of Official Analytical Chemists). 2005. *Official Methods of Analysis*. 15th Edition. Association of Official Analytical Chemists. Washington, DC.

Aglave S P, Patil R, Deshmukh M, Shinde V and Jadhav S. 2025. Nutritional composition of millet straw varieties. *Animal Nutrition and Feed Technology* **15**(1): 45–54.

Bhat B V, Singode A and Balakrishna D. 2023. Millet crops as source of fodder. *Indian Farming* **73**(1): 19–21.

Chandrasagara A N, Umashankar B C, Singh K C, Prabhu T M, Nagesh D R, Gouri M D and Bhajantri S. 2020. Evaluation of extruded finger millet straw based complete diet in lactating dairy cows. *Animal Nutrition and Feed Technology* **20**(1): 131–140.

Devendra C. 1997. Crop residues for feeding animals in Asia: Technology development and adoption in crop/livestock systems. (In) *Crop Residuals in Sustainable Mixed Crop/ livestock Farming System.,* pp. 241–267. CAB International, Kenya.

Goering H K. and Van Soest P J. 1970. *Forage Fiber Analysis*. Agriculture Handbook. United States Department of Agriculture, Washington DC.

Gowda N KS and Prasad C S. 2005. 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. *Asian-Australasian Journal of Animal Sciences* **18**(1): 48–52.

I.C.A.R. 2024. Nutrient Requirements of Cattle and Buffalo (ICAR-NIANP). Indian Council of Agricultural Research, New Delhi.

ICAR-Indian Institute of Millets Research (IIMR). 2018-19. Millets Genetic Resources Management: Progress Report 2017-18. All India Coordinated Research Project (AICRP) on Small Millets, ICAR-IIMR, Hyderabad.

IGFRI, 2015. *Vision 2050*. Indian Grassland and Fodder Research Institute (IGFRI). 7–23.

Mediksa T, Bekele D, Aberra H and Marsha T. 2021. Comparative evaluation of urea and effective microbes treated finger millet straw on feed intake, milk yield and composition of lactating crossbred dairy cows at BARC. *Agricultural Economics* **6**(3): 116–121.

Menke K H and Steingass H. 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development* **28**: 7–55.

Mould F L, Morgan R E, Kliem K E and Krystallidou E. 2005. A review and simplification of the in vitro incubation medium. *Animal Feed Science and Technology* **123**: 155–172.

NRC. 2001. Nutrient Requirements of Dairy Cattle. Seventh Revised Edition., National Research Council, National Academy of Sciences, National Academy Press, Washington, D.C.

Okoruwa M I, Igene F U and Isika M A. 2012. Replacement value of cassava peels with rice husk for guinea grass in the diet of West African Dwarf (WAD) sheep. *Journal of Agricultural Science* **4**(7): 254–261.

Prasad R D D, Reddy M R and Reddy G V N. 1998. Effect of feeding baled and stacked urea treated rice straw on the performance of crossbred cows. *Animal Feed Science and Technology* **73** (3–4): 347–352.

Schiere J B and Wieringa J. 1988. Overcoming the nutritional limitations of rice straw for ruminants. Response of growing sahiwal and local cross heifers to urea upgraded and urea supplemented straw. *Asian-Australasian Journal of Animal Sciences* **1**(4): 209–212.

Snedecor G W and Cochran W G 1994. *Statistical Methods*. 9th Ed. Affiliated East-West Press, IOWA State University Press.

Van Soest, P. J. 1994. *Nutritional Ecology of the Ruminant*, second Ed. Ithaca, USA.

Van Soest P V, Robertson J B and Lewis B A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* **74**(10): 3583–3597.

Veena N, Singh K C, Prabhu T M, Gloridoss R, Rajeshwari Y B and Ajith K S. 2018. Effect of supplementing slow release nitrogen product on the lactation performance of dairy cows. *Animal Nutrition and Feed Technology* **18**(2): 205–210.

Zhong H, Zhou J, Abdelrahman M, Xu H, Wu Z, Cui L, Ma Z, Yang L and Li X. 2021. The effect of lignin composition on ruminal fiber fractions degradation from different roughage sources in water buffalo (*Bubalus bubalis*). *Agriculture* **11**(10): 1015.