



Effect of replacement of paddy straw with shredded arecanut spathe in total mixed ration on nutrient utilisation and rumen fermentation parameters of crossbred calves[#]

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Abstract

A feeding trial of 120 days was conducted to assess the effect of replacement of paddy straw by shredded arecanut spathe in total mixed ration for crossbred calves on nutrient digestibility and rumen fermentation. Eighteen weaned female crossbred calves of eight to twelve months of age were selected from Cattle Breeding Farm, Thumburmuzhy and randomly allotted to one of the three experimental groups complete rations viz., control- paddy straw based complete feed, T1- complete feed with replacement of 50 per cent paddy straw by areca sheath and T2 – complete feed with replacement of 100 per cent paddy straw by areca sheath (CP 13%, TDN 60%). All the experimental calves were fed as per ICAR, 2013. Statistical analysis of data revealed that there was no difference ($P>0.05$) among the experimental rations in the digestibility coefficient of DM, CP, NFE, EE and NDF studied. However, CF and ADF digestibility were significantly higher ($P<0.05$) in T1 and T2 group than in the control group. Rumen parameters such as pH, rumen ammonia nitrogen and total volatile fatty acids were similar ($P>0.05$) between the treatment groups. Hence, it was concluded that areca sheath can be effectively included in TMR, completely replacing paddy straw, improving fibre utilisation without adversely affecting nutrient digestibility and rumen fermentation in female crossbred dairy calves.

Keywords: Areca sheath, TMR, nutrient utilisation, rumen fermentation

India has a large and diverse livestock sector, with approximately 535.78 million livestock as reported in the 20th Livestock Census. The livestock population includes 192.49 million cattle, 109.85 million buffaloes, 74.26 million sheep, and 148.88 million goats. Livestock farming plays an important role in the Indian economy, contributing about 4.11% to the national GDP and 25.6% to the agricultural GDP (Rashmi et al., 2023). Despite its substantial livestock resources, productivity remains below its potential, primarily due to inadequate feed availability. A deficit of nearly 44 per cent in concentrate feed resources has been reported for animal feeding in India (Singh et al., 2022).

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Furthermore, the declining availability of green fodder, together with increasing competition for conventional feed ingredients from human food systems, has created significant challenges for livestock production. These constraints have highlighted the need to explore alternative feeding options. In this regard, the use of locally available and unconventional feed resources offers a promising and cost-effective strategy for improving livestock productivity while promoting sustainable livestock management practices (Saha et al., 2002).

To achieve food security through enhanced livestock productivity, it is essential to adopt innovative feeding practices. Alternative feed resources provide a viable solution for improving feed availability throughout the year, including during periods of scarcity such as dry and rainy seasons. These resources can also contribute to improved milk and meat production at a relatively lower cost. Non-conventional feed resources (NCFR) refer to all those feeds that have not been traditionally used for animal feeding either by farmers or by feed manufacturers in commercial feeds (Chadhokar, 1984). Such resources include various agricultural and industrial by-products, which can be incorporated into animal diets in suitable proportions depending on their palatability, nutritional composition, and the presence of anti-nutritional or toxic factors (Devendra, 1985).

In certain regions of India, particularly Karnataka, Kerala, and Assam, areca nut (*Areca catechu*) cultivation has gained prominence as a commercial crop due to its higher economic returns compared to traditional cereals. The by-product of this crop, areca sheath, has emerged as a potential alternative dry fodder. For effective utilisation, dried and shredded areca sheath can be incorporated into a total mixed ration (TMR) along with an appropriate proportion of concentrate feed (Gowda, 2016). Studies indicated that the chemical composition and nutritive value of areca sheath are comparable to those of paddy straw, with relatively higher levels of certain minerals such as calcium, copper, and sulphur in areca sheath (Gowda, 2016).

In this context, the present study was undertaken to evaluate the effects of replacing paddy straw with shredded areca sheath in total mixed rations for crossbred calves, with particular emphasis on nutrient utilisation and rumen fermentation parameters.

Materials and methods

The feeding trial was conducted at the Cattle Breeding Farm, Thumburmuzhy Kerala, India.

Experimental animals

Eighteen female crossbred calves formed three treatments: control, T1 and T2. The calves were selected

as uniformly as possible with regard to age (between 8-12 months) and body weight from Cattle Breeding Farm, Thumburmuzhy. These animals were maintained under uniform management conditions prevailing in the farm. All animals were dewormed before the start of the experiment.

Experimental ration

Paddy straw-based total mixed ration (TMR) served as the control diet. In treatment T1, 50 per cent of the paddy straw was replaced with shredded *Areca catechu* spathe, whereas in treatment T2, paddy straw was completely (100 per cent) replaced with shredded *areca catechu* spathe (Table 2). All experimental diets were formulated to be isocaloric and isonitrogenous, containing approximately 13 per cent crude protein (CP) and 60 per cent total digestible nutrients (TDN). Proximate analysis of the TMRs was carried out according to the standard methods described by AOAC (2016). The ingredient composition of experimental feed rations, control, T1 and T2 is presented in Table 1.

Table 1. Ingredient composition of the experimental complete feed rations

Ingredient	Parts		
	Control	T1	T2
Maize	30	25	18
Black gram husk	9	7.4	12
De-oiled rice bran	3	12	11
Coconut-oil cake	16	15	18
Alfa-Alfa residue	6	5	4.5
Paddy Straw	30	15	-
Tapioca starch waste	2.5	2.1	3
Areca sheath	-	15	30
Calcite	2	2	2
Salt	0.5	0.5	0.5
Mineral mixture	01.00	01.00	01.00
Total	100.00	100.00	100.00
Vit AB2D3K, g/100kg*	20	20	20

*Nicomix AB₂D₃K (Nicholas Piramal India Ltd, Mumbai Agra Road Balkum Thane, Mumbai-400 608), Composition per gram: Vitamin A- 82,500 I. U, Vitamin B₂- 50 mg, Vitamin D₃ – 12,000 I. U. and Vitamin K -10 mg.

Digestibility trial

A digestibility trial for five days duration was carried out at the end of the feeding trial by total collection method. During the digestibility trial quantities of daily feed offered, residue left and faeces voided were recorded. Dry matter content of the feed offered as well as residue left was determined daily. The dung voided by each animal was collected quantitatively. The entire quantity of dung voided by each animal during the 24 h was weighed separately at 8:30 A.M. every day and representative

samples at the rate of one per cent of the quantity voided were taken after mixing thoroughly and stored in double lined polythene bags. The samples collected each day were stored in a deep freezer (-20°C) for further analysis. At the end of the trial, samples of dung collected for the five consecutive days from each animal were pooled, mixed and representative samples were taken after thorough mixing for chemical analysis. The moisture and crude protein content in faecal samples were estimated. The proximate composition of experimental ration and dung was analysed as per the standard procedure (AOAC, 2016)

Rumen fermentation parameters

Rumen liquor was collected from all the eighteen animals at the end of the feeding trial using a stomach tube after three hours of feeding into a pre warmed thermos- flask at 39°C and brought to the laboratory and subjected to further analysis. pH was measured using a digital pH meter, rumen ammonia nitrogen using colorimetric method described by Beecher & Whitten, 1970 and total volatile fatty acids by Barnett & Reid (1957).

Results and discussion

Data obtained in present study on nutrient digestibility of rations and rumen fermentation parameters of crossbred calves fed paddy straw based complete feed, complete feed with replacement of 50 per cent paddy straw by areca sheath and complete feed with replacement of 100 per cent paddy straw by areca sheath are presented in Table 3 and 4.

Nutrient utilisation

Digestibility coefficients of dry matter, crude protein, ether extract, nitrogen free extract and neutral detergent fiber were similar ($P>0.05$) for all three rations (Table 3). This result corroborated the findings of Singh et al. (2016) and Sharma et al. (2020) in crossbred calves. Rani (2021) did not find any difference ($P>0.05$) in digestibilities of dry matter, crude protein, crude fiber, nitrogen free extract and acid detergent fiber in lactating cows fed complete ration over conventional ration. Trivedi et al. (2025) also found that crossbred heifer calves fed different combinations of energy and protein in total mixed ration had similar ($P>0.05$) digestibility coefficients of dry matter, organic matter, crude protein, ether extract, nitrogen free extract, neutral detergent fibre, and acid detergent fibre among treatments. The crude fiber digestibility in calves fed on T1 and T2 was significantly higher ($P<0.05$) than that on control ration. These results are in agreement with the findings of Purushothaman et al. (2019) who fed with total mixed rations containing concentrate mixture containing turmeric waste and concentrate mixture containing tapioca starch waste to Murrah buffalo calves.

Trivedi et al. (2025) who fed different combinations of energy and protein in total mixed ration to crossbred heifer calves. Raval et al. (2025) also reported higher crude fiber digestibility ($P<0.05$) in adult cattle fed a total mixed ration in which wheat straw was replaced with urad straw. Acid detergent fiber digestibility was higher ($P<0.05$) for T1 and T2 rations than for the control ration which was in agreement with Kajla et al. (2019) who fed TMR (silage, wheat straw and concentrate with proper hand mixing) to crossbred cows. Terefe et al. (2023) who fed natural pasture hay and concentrate-based total Mixed ration to Jersey calves. In Contrast, Raval et al. (2025) reported similar acid detergent fiber digestibility ($P>0.05$) in adult cattle fed a total mixed ration in which wheat straw was replaced with urad straw.

In contrast to present study, Gowda (2019) observed no difference in the digestibility of dry matter, crude protein, crude fiber, ether extract, nitrogen free extract, neutral detergent fiber and acid detergent fiber in crossbred calves fed complete feed block containing straw, dhanwantharam oil residue and tapioca starch waste. Balamurugan (2026) also reported that supplementation of the herbal mixture in total mixed rations had similar ($P>0.05$) digestibility coefficients of dry matter, organic matter, crude protein, ether extract, crude fiber, nitrogen free extract, neutral detergent fiber, acid detergent fiber, hemicellulose and cellulose in indigenous dairy cattle.

Rumen fermentation parameters

The results revealed that pH, rumen ammonia nitrogen (mg/100 ml) and TVFA (mmol/L) concentrations for animals fed control, T1 and T2 rations were similar ($P>0.05$) as shown in Table 4. Purushothaman et al. (2019) reported that TMRs did not have any effect on rumen fermentation parameters in Murrah buffalo calves of 8-12 months old fed with total mixed rations

Table 2. Chemical composition of the complete feeds (on DM basis)

Nutrients (%)	Dietary treatments		
	Control	T1	T2
Dry matter	90.65	91.20	90.91
Crude protein	13.11	13.07	13.15
Crude fibre	15.98	18.20	21.53
Ether extract	2.57	2.52	2.30
Total ash	10.57	9.31	9.24
Nitrogen Free Extract	56.10	55.11	51.62
Neutral detergent fibre	45.86	44.68	49.86
Acid detergent fibre	26.19	35.20	35.31
Acid insoluble ash	3.45	1.93	0.88
Calcium	1.12	1.00	1.06
Phosphorus	0.43	0.50	0.46
Oxalate	0.49	0.40	0.30

Table 3. Apparent digestibility coefficient of nutrients in three experimental ratios of crossbred dairy calves

Nutrients (%)	Control	T1	T2	P Value
Dry matter	71.11 ± 1.95	69.91 ± 1.94	72.96 ± 1.30	0.484 ^{ns}
Crude protein	58.14 ± 2.55	57.72 ± 3.44	55.84 ± 1.81	0.814 ^{ns}
Crude fibre	61.40 ^a ± 2.59	69.97 ^b ± 2.26	72.68 ^b ± 1.23	0.005*
Ether extract	77.14 ± 1.83	72.78 ± 1.63	76.86 ± 1.63	0.164 ^{ns}
Nitrogen free extract	76.88 ± 2.10	75.75 ± 1.82	76.62 ± 1.69	0.906 ^{ns}
Neutral detergent fibre	65.66 ± 2.06	64.33 ± 2.32	70.90 ± 1.07	0.063 ^{ns}
Acid detergent fibre	46.34 ^a ± 3.33	60.04 ^b ± 2.45	62.85 ^b ± 1.40	0.001*

Mean values are based on six replicates with SE

ns-non significant (P>0.05)

*Means with different superscripts within a row differ significantly (P<0.05)

Table 4. Rumen fermentation parameters of calves maintained on three ration treatments

Parameters	Control	T1	T2	P value
Rumen pH	6.96±0.08	6.88±0.08	6.91±0.12	0.842 ^{ns}
Rumen ammonia nitrogen (mg/100mL)	10.00±0.56	11.01±0.48	9.91±0.43	0.254 ^{ns}
Total volatile fatty acids (mmol/L)	82.25±1.07	86.75±2.24	84.16±1.21	0.171 ^{ns}

Mean values are based on six replicates with SE

ns-non significant (P>0.05)

containing concentrate mixture containing turmeric waste and concentrate mixture containing tapioca starch waste. Thampi et al. (2024) reported that varying dietary protein concentration in the total mixed ration had similar (P>0.05) pH and total volatile fatty acid concentration in Vechur cattle. Krishnan et al. (2025) also reported that supplementation of heat-moisture-treated cassava at 250 g/day had similar (P>0.05) rumen fermentation parameters such as pH, rumen ammonia nitrogen, total volatile fatty acids in early lactating crossbred cows. Sharma et al. (2020) reported that supplementation of herbal feed additives, Jaiphal, Suva and Haldi at the rate of one per cent of dry matter basis in total mixed ration had a stimulatory effect on rumen fermentation parameters and significantly increased (P<0.05) rumen ammonia nitrogen (mg/100 ml) concentration in male cross bred calves compared to control group. Thampi et al. (2024) reported that ruminal ammonia nitrogen concentration was higher in cattle fed a total mixed ration containing 16 per cent crude protein compared with those fed 14 per cent and 12 per cent crude protein. Vansola et al. (2025) reported that supplementation of *Senna gardneri* at two per cent of the total mixed ration enhanced rumen fermentation, as evidenced by increased total volatile fatty acids and ruminal ammonia nitrogen levels in cattle. Hanusovsky et al. (2025) stated that decrease in total mixed ration particle size leads to decrease in ruminal pH below 6.2 and increases the risk of SARA, while optimum mid-sized particles increase pH stability, reducing time below 6.2 (SARA risk) or above 6.8 in Simmental cows.

Conclusion

Inclusion of areca sheath at the rate of 50 per cent and 100 per cent in total mixed ration by replacing paddy

straw did not show any significant difference in digestibility coefficient of dry matter, crude protein, nitrogen free extract, ether extract and neutral detergent fiber and rumen parameters such as pH, rumen ammonia nitrogen and total volatile fatty acids. It significantly improved crude fiber and acid detergent fiber digestibility in treatment groups than control. Overall results suggested that areca sheath can be effectively utilised up to 100 per cent replacement level of paddy straw in TMR for crossbred calves.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

- AOAC. (2016). *Official Methods of analysis*. (22nd ed.). Association of Official Analytical Chemists.
- Balamurugan, R. (2026). Effect of herbal mixture supplementation in total mixed rations on nutrient digestibility, methane mitigation and milk production in indigenous dairy cattle. *Genetics and Molecular Research*, 25(15s). <https://doi.org/10.4238/0ab90m61>
- Barnett, A.J.G., & Reid, R.L. (1957). Studies on production of volatile fatty acids from grass by rumen liquor in an artificial rumen. 1. The volatile fatty acid production from fresh grass. *Journal of Agricultural Science*, 48(3), 315–321. <https://doi.org/10.1017/S0021859600033270>

Beecher, G. R., & Whitten, B. K. (1970). Ammonia determination: Reagent modification and

- interfering compounds. *Analytical Biochemistry*, 36(1), 243–246. [https://doi.org/10.1016/0003-2697\(70\)90429-1](https://doi.org/10.1016/0003-2697(70)90429-1)
- Chadhokar, P. A. (1984). Non-conventional feed resources for livestock in soil and water conservation programme. Community Forestry and Soil Conservation Development Department, Ministry of Agriculture.
- Devendra, C. (1985). Characteristics and limitations of non-conventional feedstuffs in the Asian Region. In *Proceedings of the Symposium on Feeding Systems of Animals in temperate areas*, (pp. 338–348).
- Gowda, N. K. S. (2016). Areca sheath as an alternate dry fodder for livestock. *Broadening Horizons, FAO, Feedipedia*, 29, 1-2.
- Gowda, S. (2019). *Evaluation of densified complete feed blocks in crossbred cattle*. [Master's thesis, Kerala, Veterinary and Animal Sciences University].
- Hanušovský, O., Šimko, M., Rolinec, M., Gálik, B., Kapusniaková, M., Drotárová, S., Džima, M., Zábranský, L., & Juráček, M. (2025). Effect of TMR physical structure and ruminal pH environment on production and milk quality. *Dairy* 6(5), 51. <https://doi.org/10.3390/dairy6050051>
- ICAR. (2013). *Nutrient Requirements of Animals-Cattle and Buffalo*. (3rd ed.). Indian Council of Agricultural Research.
- Kajla, J.S., Grewal, R.S., Kaur, J., Lamba, J.S. Kaur, S., & Malhotra, P. (2019). Effect of total mixed ration feeding with roughage: concentrate ratio of 60: 40 on performance and residual feed intake of crossbred cows. *International Journal of Current Microbiology and Applied Sciences*, 8(4), 2866–2870. <https://doi.org/10.20546/ijcmas.2019.804.334>
- Krishnan, C. G., Lalu, K., Ally, K., Ajith, K. S., Sahib, L., & Babitha, V. (2025). Effect of heat-moisture treated cassava (*Manihot utilissima*) supplementation on lactational performance and rumen fermentation of early lactating crossbred cows. *Journal of Veterinary and Animal Sciences*, 56 (1), 146–151. <https://doi.org/10.51966/jvas.2025.56.1.146-151>
- Purushothaman, S., Shyama, K., Ally, K., Dildeep, V., Anil, K.S. & Joseph, S. (2019). Evaluation of rumen fermentation parameters and hematological profile in Murrah buffalo calves maintained on total mixed ration containing agricultural by-products. *Journal of Entomology and Zoology Studies*, 7(4), 974–977.
- Rani, J. (2021). *Improving efficiency of production in early lactating dairy cows through augmentation of rumen biomass production*. [Doctoral Dissertation, Kerala Veterinary and Animal Sciences University].
- Rashmi, K.M., Ranganath, G.J., Sathisha, K.B., Chandrashekara, N. and Ramesh, D. (2023). Non-conventional feed resources. *The Pharma Innovation Journal*, 12(2), 2789–2793.
- Raval, N. H., Pandya, P. R., Sorathiya, K. K., Patel, A. N., & Vahora, S. G. (2025). Effect of replacing wheat straw with urad straw in TMR on rumen fermentation and enteric methane emission in adult cattle. *International Journal of Advanced Biochemistry Research*, 9(11), 438–441. <https://doi.org/10.33545/26174693.2025.v9.i11f.6318>
- Saha, R. C., Singh, R. B., & Roy, P. K. (2002). Effect of feeding locally made concentrate mixture on milk production in crossbred cows in some districts of West Bengal. *Animal Nutrition and Feed Technology*, 2(1), 83–88.
- Sharma, V., Lamba, J. S., Grewal, R. S., Hundal, J. S., & Singh, C. (2020). Effect of Supplementation of Herbs Containing Essential Oils on Nutrients Digestibility, Rumen Fermentation and Blood Parameters in Cross Bred Calves. *International Journal of Current Microbiology and Applied Sciences*, 9(5), 1327–1336. <https://doi.org/10.20546/ijcmas.2020.905.148>
- Singh, D.N., Bohra, J.S., Tyagi, V., Singh, T., Banjara, T.R., & Gupta, G. (2022). A review of India's fodder production status and opportunities. *Grass and Forage Science*, 77(1), 1–10. <https://doi.org/10.1111/gfs.12561>
- Singh, P. K., Chandramoni, C., Kumar, K., & Kumar, S. (2016). Effect of feeding wheat and rice straw based complete feed blocks on nutrients utilization, blood biochemical and growth performance in crossbred calves. *The Indian Journal of Animal Sciences*, 86(7), 771–776. <https://doi.org/10.56093/ijans.v86i7.59910>
- Terefe, G., Nurfeta, A., Kitaw, G., Assefa, G., Walelegne, M., & Dejene, M. (2023). Effects of natural pasture hay and concentrate-based total mixed ration on the performance of Jersey Calves. *Ethiopian Journal of Agricultural Sciences*, 33(3), 41–57.
- Thampi, G., Rani, J.K., Ally, K., Bunglavan, S.J. and Kurian, E. (2024). The impact of various protein concentrations in total mixed ration on rumen fermentation and haemato-biochemical indicators in Vechur cattle. *Journal of Veterinary and Animal Sciences*, 55(1), 94–102. <https://doi.org/10.51966/jvas.2024.55.1.94-102>

- Trivedi, P. G., Lunagariya, P. M., Patel, A. C., Parmar, C. P., Patel, Y. G., Chauhan, V. D., & Wadhwani, K. N. (2025). Effect of different combinations of energy and protein in total mixed ration on digestibility of nutrients, nutritive value and nutritive intake in crossbred heifer calves. *International Journal of Advanced Biochemistry Research*, 9(7), 191-195. <https://www.doi.org/10.33545/26174693.2025.v9.i7Sc.4781>
- Vansola, J. H., Patel, M. M., Sorathiya, K. K., Pandya, P. R., Patel, J. H., & Patel, A. N. (2025). Effect of dry leaves of *Senna gardneri* on feed intake, body weight, nutrient digestibility, rumen parameters & methane emission in cattle. *International Journal of Advanced Biochemistry Research*, 9 (12), 537 - 541. <https://doi.org/10.33545/26174693.2025.v9.i12g.6557> ■