DOI: 10.21088/jafst.2321.1628.14126.4

Journal of Animal Feed Science and Technology
Volume 14 Number 1 January - June 2026

Review Article

Sustainable Utilization of Paddy Straw for Efficient Ruminant Feeding: Advances in Treatment and Supplementation Strategies

Mohini Tripathi[1], Shipra Tiwari[2], Ambesh Kumar Pandey[3], Chaple Pooja M.[4],Chirag Singh[5], Meena Goswami[6], Vikas Pathak[7]

How to cite this article:

Mohini Tripathi, Shipra Tiwari, Ambesh Kumar Pandey et. al, Sustainable Utilization of Paddy Straw for Efficient Ruminant Feeding: Advances in Treatment and Supplementation Strategies. Jrl of Ani Feed Sci and Tech 2026; 14(1): 31-36.

ABSTRACT

In tropical zones of the world, ruminants depend on grazing on natural pastures usually during summer months when these pastures have abundant biomass or these animals are fed with cut grass and crop residues. Paddy straw is a major agro-residue fed to ruminants in India. Rice straw is a readily available, practical, and cheap source of fodder for feeding ruminants such as buffaloes, cattle, goats, and sheep. Livestock producers commonly haul and stack rice straw from their rice farm, which then forms reserved feed for their animals during lean months or when good-quality roughages are scarce. The feeding of pure rice straw to ruminants during the stages of fast growth and early lactation has been shown to affect both body condition score and animal performance. Feeding only rice straw does not provide enough nutrients to the ruminants even for maintenance

Author's Affiliation:

[1] M.V.Sc. Scholar, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

[2] M.V.Sc. Scholar, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

[3] M.V.Sc. Scholar, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

[4] M.V.Sc. Scholar, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India

[5] M.V.Sc. Scholar, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

[6] Associate Professor and Incharge, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

[7] Professor and Head, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura, Uttar Pradesh, India.

Corresponding Author:

Meena Goswami, Associate Professor and Incharge, Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura 281001, Uttar Pradesh, India.

E-mail: dranitaarya@gmail.com

Received: 22-04-2026 **Accepted:** 26-05-2026

due to the low nutritive value of this highly lignified material containing high concentration of anti-nutrition factors like lignin, silicates and oxalates. Despite the improvements of crop residues through various processing methods such as physical and chemical, the efficient utilization to desirable extent is still awaited. So, utilization of paddy straw in association with concept of complete feed along with biological agents is need of the hour to maximize advantage from given feeds in animal production systems. the major agro-residues in terms of volumes generated in India were rice straw, rice husk, wheat straw, sugarcane tops.

KEYWORDS:

• Biological Treatment • Paddy Straw • Ruminant Feed • Rice • Bran • Digestibility • Rumen • Urea

INTRODUCTION

Most of these areas face seasonal periods in which there is decrease in availability of herbages in this pasture. There is also reduction in the content of digestible energy and crude protein. In these areas rice straw is abundantly available from paddy cultivation and farmers offer rice straw as the main roughage source to their animals. This is particularly the case in developing Asian countries such as Thailand, Vietnam, Indonesia and India (NARC newsletter, 2004). Approximately 80% of the world's rice is grown by small scale farmers in many developing countries including South East Asia and it is common to use rice straw for animal feeding. As per reports of Devendra, (1997) that of the total rice straw production, 30-40% is utilized for animal feeding in South East Asia, including China and Mongolia, as rice straw being the principal crop residue fed to more than 90% of the ruminant livestock in this area (Devendra and Thomas, 2002). Rice straw becomes especially important during periods when other feeds are deficient. In general, the maximum intake of rice straw by ruminants is about 1.0 to 1.2 kg per 100 kg live weight (Devendra, 1997). However, rice straw has low nutritive value, which limits its wide and efficient use in ruminant diets, because of the high content of indigestible structural polysaccharides and low crude protein (CP) content.

Need of Agri replacers

Ruminants can be entirely dependent on crops for their nourishment to achieve normal growth, production, and reproduction. The dynamics of their rumen ecosystem provides a unique environment for microorganisms to grow and multiply so that these can degrade nutrients, especially fibrous components, from the ingested fodders that eventually are transformed into protein rich foodstuffs such as meat and milk. However, the efficiency of the animal to utilize and convert nutrients from dietary sources into nutritious food products are dependent mainly on the availability and quality of the fodder being offered to the animal. The availability of quality forages for feeding ruminants is seasonal. Wet season is a time of feed abundance while dry season is a period of scarcity. In countries that experience feed scarcity or deficiency of good quality forages, rice straw remains as the practical, abundant and cheap source of fodder for feeding cattle, buffalo, goat and sheep.

Other Agri crops as option

Many by-products from the human food industry have in common a high biomass, low crude protein content of approximately 3 to 4% and high content of crude fiber of approximately 35 to 48% (Devendra, 1997). In many developing countries these fibrous crop residues, such as cereal straws, sugarcane tops, bagasse, cocoa pod husks, pineapple waste, etc., are usually fed to ruminants.

Paddy straw as Agri replacer

Approximately 80% of the world's rice is grown by small-scale farmers in many developing countries of Asia and it is common to use rice straw for animal feeding. Devendra and Thomas (2002) mentioned that rice straw is the principal crop residue fed to more than 90% of the ruminant livestock in this area. The calculated utilization of rice straw for animal feed in South East Asia, including China and Mongolia, was 30-40% of the total rice straw production (Devendra, 1997). Rice straw is especially important during periods when other feeds are inadequate. In general, the maximum intake of rice straw by ruminants is about 1.0 to 1.2 kg per 100 kg live weight (Devendra, 1997). In Southeast Asia rice straw is mainly utilized by swamp buffaloes and cattle with adult live weights of 350 and 200 kg respectively (Devendra, 1997). With an average intake of 1 kg of rice straw per 100 kg live weight, this gives a total annual intake of 1.28 and 0.73 t for buffaloes and cattle respectively. The annual requirements for the current populations of swamp buffaloes and cattle are therefore 51.2 and 89.4 million t respectively and a total requirement of 140.6 million t, representing 30.4% of the total annual available rice straw.

Hence, due to the low degradability and the poor rate of degradation, animals will tend to consume less. The mechanism regulating voluntary intake of low quality feeds, such as rice straw, is still not fully understood. The generally accepted theory of feed intake regulation for poor quality roughages is that the capacity of the rumen to process the feed is the major factor determining voluntary feed intake (Conrad, 1966; Baile and Forbes, 1974). The rumen processing capacity is characterized by rumen fill, the rate of degradation of potentially degradable matter and the rate of passage out of the rumen. Devendra (1997) summarized that the main determinants of intake and degradability of rice straw depend on their morphological characteristics, such as the proportion of the different plant parts (leaves and stems), their chemical composition and the distribution of the different chemical components in the tissues, their relative amounts of cell contents and cell walls and the physical and chemical nature of the cell walls.

Treatment of rice paddy

Enteric methane (CH4) resulting from ruminants is an important source of greenhouse gas and represents a loss of 2–14% of dietary energy [Beauchemin *et. al,* 2008]. Feeding straw results in greater CH4 emissions per unit of feed digested than high quality forage, because it has a slow passage rate and prolonged residency time in the rumen (McAllister *et. al,* 1996). Before promoting the use of rice straw in ruminant diets, strategies are needed to improve its digestibility and decrease its CH4 emissions. Urea can be used to pretreat rice straw to enhance its nutritional quality by destroying fiber structure and increasing non-protein nitrogen content (Sarnklong 2010), leading to increased ruminal fiber digestibility. Nitrate supplementation has been identified as a possible strategy to reduce CH4 emissions because nitrate reduction to ammonia incorporates metabolic hydrogen [H] away from methanogenesis (Latham *et, al.* 2016). Urea plus nitrate pretreatment has been reported to increase degradation and reduce CH4 production of rice straw in vitro [Zhang *et. al,* 2018], and further verification of these combined

Oil supplementation

Oil supplementation is another option to decrease enteric CH4 emissions from ruminants and improve final quality of product (i.e., milk). Oil supplementation increases energy density of the diet, provides additional unsaturated fatty acids and decreases numbers of protozoa and associated methanogens, but may also decrease ruminal organic matter fermentation. Additionally, inhibition of ruminal protozoa can decrease microbial N cycling in the rumen (Jouany, 1996) and increase the flow of microbial protein from the rumen to the small intestine (Veira *et. al,* 1984), leading to an improvement of N utilization. Thus, oil supplementation of diets containing urea plus nitrate pretreated rice straw may further help to improve efficiency of dietary N use in ruminants. Pretreatment of rice straw with urea plus nitrate would enhance fiber digestibility and inhibit CH4 production, and supplementation of corn oil to a diet containing the pretreated straw would further exert additional beneficial effects on dietary nitrogen use

Urea treatment of rice Straw

Mgheni *et al.* (1993) earlier reported that the finding of UTRS and RB (70:30) could provide optimum rumen environment for straw degradation without necessarily affecting cell wall digestibility. However, even if the nutritive value of the rice straw is improved by urea treatment, it alone cannot supply nutrients beyond the maintenance level (Sharma *et, al.* 1995). To correct the nutritional imbalance of rice straw-based diet, supplementation of energy and protein rich concentrate has often been suggested (Umunna *et, al.* 1995). Rice bran is locally available and a cheap energy source. It supplies energy to the rumen and ensures synchronicity of protein and energy in UTRS based diet for more efficient utilization and microbial protein synthesis. But the higher level affects microbial growth and ultimately affects the nutrient digestibility. Therefore, it is important to find out the suitable level of RB for maximum growth among ruminants. Leucaena leucocephala is rich in by-pass protein and minerals. It is widely grown in Asian region. It can also be used as a supplement to straw-based diet to improve microbial growth and fiber digestion in the rumen of ruminants (Murry et al. 1990).

Rice straw nutritional value

Rice straw contains a relatively high proportion of leaf (60%), compared to other cereal straws such as barley (35%), oats (43%) and wheat (20-41%) (Theander and Aman, 1984). Leaves of rice straw contain less NDF than the stems, but more ash and acid-insoluble ash, resulting in a lower in vitro dry matter digestibility (IVDMD) of the leaves (50-51%) compared to the stems (61%) (Vadiveloo, 2000). In goats, Phang and Vadiveloo (1992) observed an in vivo dry matter digestibility of 56.2% for rice leaf and 68.5% for the stem. However, treatment with a 4% urea solution for 21 d increased the IVDMD of the leaf fraction more than that of the stem fraction (Vadiveloo, 2000). Since rice straw consists of approximately 60% leaves, which are less degradable than stems, improving the feed value of rice straw should focus on improving the degradability of the leaves.

EFFECT ON MILK PRODUCTION

Aquino *et, al.* (2016) reported on the effects Results of feeding urea molasses solution-treated rice straw (UMTRS) to dairy buffaloes showed a total milk production of 974 kg cow−1 in 210 milking days. In contrast, buffaloes fed no UMTRS produced 777 kg of milk during the same lactation period. Comparing the effect of UMTRS feeding with that of pure rice straw showed a difference of 147 kg milk production or with a milk yield difference of 0.7 kg milk cow−1 day−1. It was also noted that the UMS improves the crude protein content of treated rice straw from 4.7% to 7.9% and the DM digestibility of rice straw was increased from 47% to 55%.

Effects of Feeding Pure or Pretreated Rice Straw to Ruminants

Generally, in feeding dry cows, rice straw can be used for about 50% of the ration. Additional urea-molasses mineral blocks could be used as supplements to support the requirement of the dry cows. When feeding lactating cows, rice straw alone is not adequate to support milk synthesis or milk production. One consideration in feeding rice straw to ruminants is to balance the quantity of phosphorus and other trace minerals in the ration. Rice straw has lower phosphorus and trace mineral contents, thus supplementation with trace minerals and phosphorus, especially in high-yielding cows, is necessary. For cows with calves, the use of rice straw should not exceed 25% of the total ration, with the remaining 75% being good-quality hay or legumes or a concentrate supplement. Chenost and Kayouli (1997) emphasized that it is primarily necessary to supply the rumen microorganisms with the nutritive elements needed for self-multiplication as well as for degradation of the cell walls of straw, leading to suitable conditions for maintenance of good cellulolysis. Different supplements can be used, such as concentrates, molasses, multi-nutrient blocks, green leaves, crop residues and locally available by-products. In the case of high-yielding dairy cows, the supplements can be the major part of the ration where fibrous feed only serves to supply the rumen with enough fiber. Warly *et al.* (1992) showed in a field trial that a ration of rice straw supplemented with soybean meal increased both degradability and intake. Because of the poor quality of untreated rice straw, supplementation easily can increase milk production, as shown for supplementation with cottonseed meal (Wanapat *et al.*, 1996) and with a ureamolasses-multi-nutrient block.

Increased digestibility due to urea treatment

Mira *et al.* (1983) and Orskov *et al.* (1981) reported little change in digestibility due to urea treatment of barley straw under temperate conditions. Results of feeding trials with cattle and buffaloes compiled by Doyle *et, al.*1986., showed that animals fed urea treated straw ate more and grew faster than those receiving untreated straw. It is not clear, however, whether this response was due to an increase in the N content of the diet (supplementation effect) or to a change in the chemical structure arising from a reaction with

NH3 (treatment effect) leading to an increase in digestibility. Results indicate that, in goats at least, supplementation with urea did not increase intake or digestibility, while urea treatment significantly increased both intake and digestibility. A similar lack of response to the provision of soluble N has been reported by Dryden and Kempton (1983) with sheep fed barley straw. In contrast, Diasand Sundstol 1986, and Fahmy and Sundstol 1984, reported that urea supplementation per se increased digestion of straw by sheep while Perdock *et al.* (1984), reported improvement in both intake and liveweight gain when cattle and buffaloes were fed rice straw supplemented or treated with urea. Values of rumen pH and ammonia generally reflect the concentration of N in the diet. Together with VFAs they indicate the extent of digestion and hence microbial activity in the rumen. At rumen pH below 6 and ammonia concentration below 50 mg/L the rate and extent of fibre digestion in the rumen is reduced. Maximum utilization of available nutrients by the rumen microorganisms should occur when the peak of NH3 production matches that of VFA production. This was evident in goats fed urea treated straw but not in goats fed urea supplemented straw, where there was a four-hour time lag between the peak of NH3 and VFA production. Hence feed intake and digestibility were higher in goats fed urea treated straw.

CONCLUSION

Efficient utilization of agro-residues, particularly paddy straw, offers a sustainable solution to feed scarcity in ruminant production systems of tropical regions. Although rice straw is abundant and economical, its low nutritive value and poor digestibility limit animal performance when fed alone. Various treatment strategies such as urea ammoniation, biological processing, and supplementation with concentrates, oils, and minerals have demonstrated significant improvements in digestibility, intake, and overall productivity. Integration of urea-treated straw with energy-rich supplements like rice bran and protein sources enhances rumen function and microbial protein synthesis. Moreover, innovative approaches such as nitrate and oil supplementation contribute to reduced enteric methane emissions, improving environmental sustainability. Therefore, adopting a complete feed approach combining treated agro-residues with appropriate supplements is essential for maximizing nutrient utilization, improving animal productivity, and ensuring eco-friendly livestock farming. Future research should focus on cost-effective, farmer-friendly technologies for large-scale adoption.

REFERENCES

1. Aquino, D. L., Fujihara, T., Baltazar, H., & Santos, J. (2016).Community-based S & T farm project on the preparation and utilization of urea-treated rice straw (UTRS) as fodder for dairy buffaloes. *Proceedings of PCC R&D Review of Completed and On-going Research Projects*, July 27–29.
2. Baile, C. A., & Forbes, J. M. (1974). Control of feed intake and regulation of energy balance in ruminants. *Physiological Reviews*, 54, 160–214.
3. Beauchemin, K. A., Kreuzer, M., O'Mara, F., & McAllister, T. A. (2008). Nutritional management for enteric methane abatement: A review. *Australian Journal of Experimental Agriculture*, 48, 21–27.
4. Chenost, M., & Kayouli, C. (1997). *Roughage utilisation in warm climates*. FAO Animal Production and Health Paper 135, Rome.
5. Conrad, H. R. (1966). Physiological and physical factors limiting feed intake. *Journal of Animal Science*, 25, 227–235.
6. Devendra, C. (1997). Crop residues for feeding animals in Asia: Technology development and adoption in crop/livestock systems. In C. Renard (Ed.), Crop Residues in Sustainable Mixed Crop/Livestock Farming Systems (pp. 241–267). CAB International.
7. Devendra, C., & Thomas, D. (2002). Crop-animal interactions in mixed farming systems in Asia. *Agricultural Systems*, 71, 27–40.
8. Dias Da Silva, A. A., & Sundstøl, F. (1986). Urea as a source of ammonia for improving the nutritive value of wheat straw. *Animal Feed Science and Technology*, 14, 67–79.
9. Doyle, P. T., Devendra, C., & Pearce, G. R. (1986). *Rice straw as feed for ruminants*. International Development Programme, Canberra.
10. Dryden, G. M., & Kempton, T. J. (1983). Digestion of organic matter and nitrogen in ammoniated barley straw. *Animal Feed Science and Technology*, 10, 65–75.
11. Fahmy, S. T. M., & Sundstøl, F. (1984). Effect of urea and protein supplementation on digestibility of barley straw. *Zeitschrift für Tierphysiologie Tierernährung und Futtermittelkunde*, 52, 118–128.

12. Ibrahim, M. N. M., Wijeratne, A. M. U., & Costa, M. J. I. (1984). Sources of urease for reducing treatment time of straw with urea. In *Utilisation of Fibrous Agricultural Residues as Animal Feeds* (pp. 145–155). University of Melbourne.

13. Jouany, J. P. (1996). Effect of rumen protozoa on nitrogen utilization by ruminants. *Journal of Nutrition*, 126, 1335S–1346S.

14. Latham, E. A., Anderson, R. C., Pinchak, W. E., & Nisbet, D. J. (2016). Alterations to the rumen ecosystem by nitrate and nitrocompounds. *Frontiers in Microbiology*, 7, 228. https://doi.org/10.3389/fmicb.2016.00228

15. McAllister, T. A., Cheng, K. J., Okine, E. K., & Mathison, G. W. (1996). Methane production in ruminants. *Canadian Journal of Animal Science*, 76, 231–243.

16. Mgheni, D. M., Khimambo, A. E., Sundstøl, F., & Madsen, J. (1993). Effect of urea treatment on rice straw utilization in goats. *Animal Feed Science and Technology*, 44, 209–220.

17. Mira, J. J. F., Kay, M., & Hunter, E. (1983). Treatment of barley straw with urea or ammonia for cattle. *Animal Production*, 36, 271–277.

18. Murray, R. J., McAllan, A. B., & Smith, R. H. (1990). Effect of nitrogen source on rumen microbial growth. *Animal Feed Science and Technology*, 31, 55–64.

19. Orskov, E. R., Tait, C. A. G., & Reid, G. W. (1981). Utilization of treated barley straw for dairy heifers. *Animal Production*, 32, 388.

20. Perdok, H. B., et al. (1984). Production responses of ruminants fed treated paddy straw. In *Utilisation of Fibrous Agricultural Residues as Animal Feeds* (pp. 213–230). University of Melbourne.

21. Phang, O. C., & Vadiveloo, J. (1992). Feeding value of rice straw in goats. *Small Ruminant Research*, 6, 295–301.

22. Sarnklong, C., Cone, J. W., Pellikaan, W., & Hendriks, W. H. (2010). Rice straw utilization and treatment methods. *Asian-Australasian Journal of Animal Sciences*, 23, 680–692.

23. Sharma, D. D., Rangnekar, D. V., & Singh, M. (1995). Treatment of fibrous crop residues. In *Review on Fibrous Crop Residues* (pp. 263–276). NDRI, India.

24. Theander, O., & Aman, P. (1984). Anatomical and chemical characteristics of straw. In F. Sundstøl & E. Owen (Eds.), *Straw and Other Fibrous By-products as Feed* (pp. 45–78). Umunna, N. N., Osuji, P. O., Khalili, H., Nsahlai, I. V., & Crosses, S. (1995). Feeding value of forage systems for beef production. *Animal Science*, 61, 35–45.

25. Vadiveloo, J. (2000). Nutritional properties of rice straw components. *Animal Feed Science and Technology*, 83, 57–65.

26. Veira, D. M., Ivan, M., & Jui, P. Y. (1984). Effect of protozoa on amino acid flow in sheep. *Canadian Journal of Animal Science*, 64, 22–23.

27. Wanapat, M., Sommart, K., & Saardrak, K. (1996). Cottonseed meal supplementation in dairy cattle. *Livestock Research for Rural Development*, 8(3). 22-25.

28. Warly, L., Matsui, T., Harumoto, T., & Fujihara, T. (1992). Utilization of rice straw in sheep. *Asian-Australasian Journal of Animal Sciences*, 5, 695–698.

29. Zhang, X., Wang, M., Wang, R., Ma, Z., Long, D., & Mao, H. (2018). Urea plus nitrate pretreatment improves straw degradation and reduces methane. *Journal of the Science of Food and Agriculture*, 98, 5205–5211. https://doi.org/10.1002/jsfa.9043