Biofermentation of crop residues to improve dairy nutrition and productivity

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Innovation brief

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Key messages

- Crop residue is a major component of the dairy animal diet in Nepal, but it has poor nutritional quality.
- Though several physical, chemical and biological methods are available to improve the quality of crop residues, they are energy intensive and costly.
- Biofermentation of crop residues with lactic acid bacteria in the rice harvest season has been found to substantially improve digestibility and milk productivity at a lesser cost.

Summary

In many countries, ruminant animals rely heavily on crop residue-based feed rations to nutritionally support growth, milk production and reproduction. In Nepal and many other Asian countries, rice straw is one of the most abundant crop residues and serves as a major source of roughage for ruminants. Rice straw has a complex cellulose, hemicellulose, and lignin structure that limits digestibility, as rumen microbes cannot easily break down these components. This results in poor utilization, ultimately reducing animal productivity. While several physical and chemical methods have been developed to improve the digestibility of rice straw, many of these approaches are energy-intensive, costly, and have only limited impact on digestibility.

Biofermentation is a promising and sustainable alternative for improving rice straw utilization. This technology involves inoculating rice straw with lactic acid bacteria that partially degrade the cell walls, releasing cellulose and hemicellulose and making them more accessible to rumen microbes. This enhances rumen fermentability and significantly improves the nutritional quality of the feed. Studies have shown that inoculation with lactic acid bacteria (LAB), including different Lactobacillus species, can reduce indigestible fiber content, and improve dry matter intake and fiber digestibility. Through biofermentation, smallholder farmers can convert an abundant but low-quality feed resource into a more nutritious and efficient livestock feed, supporting improved milk production, better animal health, and more sustainable livestock systems.

Chopping straw before biofermentation (photo credit: Maharanijhoda SFAC/Ujjwal Adhikari).

The potential of crop residues

Crop residues play an important role in ruminant feeding systems in Nepal, contributing around 70% of the total roughage requirement. They are widely available, easily accessible, and relatively inexpensive or free, making them an important feed resource for smallholder farmers. However, their low nutritional quality limits their effective use in livestock production. The adoption of biofermentation technology, particularly with LAB, can significantly improve the quality and digestibility of crop residues. Once biofermented, these residues can serve as quality forage, especially during dry periods, thereby supporting improved livestock productivity at a lower cost.

Packaging baled straw (photo credit: Maharanijhoda SFAC/Ujjwal Adhikari).

Promising technologies and proof of productivity

Biofermentation of rice straw upgrades its nutritional quality using a combination of physical, chemical and biological treatment methods to improve digestibility and reduce methane emission at an affordable cost. The industrial production process consists of collecting rice straw in green form (2–3 days after harvest) when soluble carbohydrate content is high, shredding (twisting or kneading), biofermentation with LAB, and enrichment with feed energy (e.g., molasses) and a nitrogen source (e.g., urea). This multi-treated biomass is then compressed and ensiled (using a bailer cum wrapper machine) and fed to dairy animals after 45 days of fermentation.

In a buffalo feeding trial by the International Livestock Research Institute and Nanjing Agricultural University in Morang District, Koshi Province, the use of biofermented rice straw significantly improved dairy productivity. Milk yield increased from 9.8 liters per day in the control group (fed 5.5 kg of untreated straw daily) to 12.3 liters per day in the treatment group fed 4.7 kg of biofermented green rice straw.

This innovation offers several unique value propositions:

1. It converts a low-value feedstuff (rice straw) into high-quality feed at relatively low cost. Biofermentation improves metabolizable energy content of normal rice straw by 2.6 MJ per kg of dry matter, which increases milk yield.

2. The packaging of the biofermented rice straw into 75 kg bales eases storage and transport.
3. Women are often responsible for feeding the households' animals. Using the packaged biofermented straw is less labor intensive and hence reduces the women's workload.
4. The cost of biofermentation was found to be NPR 9,508 (USD 68) per ton, including the costs of raw material, supplements, electricity, wrapping material, and labor. The selling price was NPR 10,000 per ton (NPR 750 per bale of 75 kg), with a margin of NPR 2,900 per ton. However, it is worth noting that the selling price of untreated straw is almost the same as that of the biofermented straw (but with less dry matter) during summer months. The price of straw varies with seasons and is highest during the dry season. Since the straw used for biofermentation was purchased in the harvest season, the price of the raw material was low.

Wins for smallholders and the environment

Expanding the adoption of biofermentation technology creates real advantages for both dairy farmers and the environment. Small- and medium-scale businesses benefit directly from this technology through improved livestock productivity and generation of additional income through the production and sale of value-added rice straw. Furthermore, converting straw into valuable livestock feed helps reduce open-field burning, air pollution and greenhouse gas emissions. To reduce environmental impact, efforts are being made to find an alternative to the plastic used for wrapping the strawlage. Overall, scaling the biofermentation technology can contribute to more sustainable livestock production systems while supporting rural livelihoods and environmental protection.

Bales of biofermented straw (photo credit: Maharanijhoda SFAC/Ujjwal Adhikari).

Next steps

Currently, two companies in Nepal are producing biofermented rice straw on a commercial basis. However, this is not sufficient to meet the requirements of the dairy farmers. For achieve greater impact, public and private sector investors should support cooperatives or private sector feed industries in establishing biofermentation units in the main dairy producing areas of the country.

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