

# Reevaluating Rice Straw for Livestock Feeding: Opportunities and Challenges in Advancing Sustainable Livestock Development

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## Abstract

*Rice straw, the most prevalent by-product of rice cultivation in the tropics, presents both significant opportunities and challenges for sustainable livestock farming. This study aims to reevaluate the role of rice straw as a forage resource in livestock nutrition, emphasizing its potential to enhance feed security, reduce waste, and support environmentally sustainable agricultural practices. By examining the nutritional characteristics of rice straw, the impact on livestock health, and the role in integrated farming systems, this review provides a comprehensive analysis of the benefits and limitations associated with its use. The findings reveal that while rice straw can serve as a cost-effective feed option that contributes to the circular economy by recycling agricultural waste, issues, such as low digestibility and nutrient content pose challenges that must be addressed. Additionally, the study explores innovative processing techniques and supplementation strategies that can enhance the nutritional value of rice straw, making it a more viable feed resource. By identifying practical applications and strategic interventions, this study contributes to a deeper understanding of how rice straw can be effectively integrated into livestock feeding systems, thereby promoting sustainable livestock development and improving the livelihoods of smallholder farmers.*

**Keywords:** Sustainable, rice straw, livestock feeding, forage, nutritional value

## INTRODUCTION

As the global demand for livestock products continues to rise, the search for sustainable and cost-effective feed resources has become increasingly critical. Among the various agricultural by-products, rice straw emerges as a promising yet underutilized resource in livestock feeding systems. In many rice-producing regions, substantial quantities of rice straw are generated annually, often disposed of through burning or left to decompose in fields, resulting in environmental concerns and economic losses [1]. Despite its abundance, rice straw is frequently perceived as low-quality forage due to its high fiber content and low digestibility, leading to limited adoption in livestock diets.

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However, the potential of rice straw extends beyond its immediate nutritional value. When effectively managed, it can play a crucial role in advancing sustainable livestock development by enhancing feed security, reducing waste, and promoting circular agricultural practices. The integration of rice straw into livestock feeding systems not only supports the recycling of agricultural residues but also mitigates the environmental impacts associated with traditional waste disposal methods [2, 3]. Moreover, it presents an opportunity to support smallholder farmers in resource-limited settings, who often struggle with

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the rising costs of conventional feed.

This study offers a novel approach to utilizing rice straw in livestock feeding by analyzing its nutritional potential and exploring innovative processing techniques to enhance its digestibility and feeding value. Unlike previous research focused on limitations, this study emphasizes practical strategies, such as enzymatic treatments and fermentation, to improve rice straw as a high-quality feed. It also addresses the socio-economic benefits, particularly for smallholder farmers, by highlighting rice straw's role in promoting food security and sustainable agricultural practices, ultimately offering a comprehensive framework for optimizing its use in livestock diets.

## **CONVENTIONAL USES**

Rice straw is widely used in tropical cattle feeding systems due to its availability, though it requires supplementation or treatment to improve its low nutritional value. Common systems include mixing rice straw with concentrates, molasses, or protein-rich forages like legumes. Urea or ammonia treatment is often applied to enhance its digestibility and nitrogen content, while silage or fermented rice straw improves palatability [4]. Supplementing rice straw with byproducts like distillers' dried grains (DDGS) or oilseed meals provides additional protein, and its use in total mixed rations (TMR) ensures balanced diets. Urea-molasses blocks, protein licks, and salt licks are commonly used to meet nutritional gaps. Grazing systems also incorporate rice straw as supplementary roughage during dry seasons [5]. Additionally, pelleting, biochar additives, and ensiling with green forages are other techniques to optimize its use [6]. These systems make rice straw an affordable and feasible option for sustainable livestock feeding in tropical regions.

## **ADVANTAGES**

### **Availability and Cost-effectiveness**

Rice straw is abundantly available in regions where rice is cultivated, making it an easily accessible feed resource for livestock farmers. Its low cost makes it an economical option for farmers, especially in areas with limited access to high-quality forages. The availability of rice straw during the off-season when other forages might be scarce allows farmers to maintain livestock without incurring additional feed costs [7]. Furthermore, the large quantities of rice straw produced during harvesting seasons enable farmers to stockpile it for later use, ensuring a reliable feed supply [8]. This widespread acceptance of rice straw among farmers highlights its practicality as a forage resource. In remote areas, rice straw can significantly reduce feed transportation costs, thereby enhancing the profitability of livestock production. The combination of abundant availability, affordability, and ease of use contributes to its status as a preferred forage option for many farmers, particularly in developing regions, where economic constraints often dictate livestock management practices. By capitalizing on local resources, such as rice straw, farmers can achieve cost savings while ensuring that their livestock receive adequate nutrition, ultimately promoting the sustainability of their farming systems.

### **Environmental Benefits**

Utilizing rice straw as livestock forage can have significant environmental benefits. Traditionally, rice straw is often disposed of by open burning, contributing to air pollution and greenhouse gas emissions [1, 9, 10]. By incorporating rice straw into livestock diets, farmers can help reduce these environmental impacts while also managing agricultural waste effectively. This recycling of agricultural by-products minimizes the risk of fungal toxins that can arise from decaying straw, thereby improving animal health. Furthermore, using rice straw in livestock feeding helps reduce pressure on pasturelands, which can be overgrazed if not managed properly [11]. This practice promotes a more sustainable approach to livestock production, as it decreases the need for additional grazing lands and supports biodiversity. Additionally, the integration of rice straw in livestock diets contributes to mixed farming systems, enhancing overall farm productivity and sustainability. By promoting carbon-neutral practices, such as utilizing rice straw instead of burning it, farmers can play a crucial role in mitigating climate change effects. Ultimately, these environmental benefits highlight the importance of integrating rice straw into livestock feeding systems for sustainable agricultural practices.

### **Sustainability and Resource Optimization**

The use of rice straw as a forage resource exemplifies sustainability in agricultural practices. By integrating crop residues like rice straw into livestock diets, farmers can promote a circular economy that minimizes waste and maximizes resource utilization [12]. This sustainable approach not only reduces reliance on commercial feed sources but also conserves valuable agricultural resources. Furthermore, using rice straw in livestock feeding systems encourages farmers to adopt practices that improve soil health, such as reducing soil erosion and enhancing nutrient cycling [13]. The non-competitive nature of rice straw, as it does not compete with food crops for land, ensures that food security is maintained while providing livestock with necessary nutrition. Additionally, rice straw supports smallholder farmers who may have limited access to high-quality feeds and resources. By integrating rice straw into their livestock management practices, these farmers can achieve a more balanced and sustainable approach to their agricultural systems. This reduction in dependence on imported feeds fosters economic resilience and stability, especially in developing countries where feed prices can fluctuate significantly. The adoption of rice straw as a primary forage resource supports sustainable livestock systems and contributes to the long-term viability of agricultural practices.

### **Nutritional Value and Livestock Health**

Rice straw is recognized for its nutritional contributions to livestock diets, primarily as a source of fiber and energy. The fibrous nature of rice straw fulfills the roughage needs of ruminants, promoting healthy digestion and rumen function [14]. Its inclusion in diets encourages longer chewing times, which stimulates salivation and aids in ruminal fermentation processes. This, in turn, can lead to improved nutrient absorption and overall animal health [15]. Moreover, when properly supplemented with other nutrients, rice straw can help maintain optimal body condition in livestock. The slow decomposition of rice straw in manure also contributes to a more balanced nutrient release, supporting soil fertility when used as fertilizer. The fiber-rich nature of rice straw enhances the quality of manure produced by livestock, which can be beneficial for subsequent crops. Additionally, incorporating rice straw into livestock diets can help prevent bloat, a common issue in ruminants, by ensuring a gradual introduction of high-fiber forages. This emphasis on livestock health underscores the critical role that rice straw plays in promoting better animal welfare, ultimately enhancing productivity and economic returns for farmers. The nutritional benefits of rice straw make it a valuable resource for sustainable livestock production systems.

### **Feed Security and Risk Management**

The utilization of rice straw as livestock feed contributes significantly to feed security and risk management strategies for farmers. Its extended shelf life allows farmers to store rice straw for use during periods when other forage resources are limited or unavailable. This characteristic is particularly important in regions prone to droughts or feed shortages, as rice straw can serve as a reliable alternative when other sources fail [16]. Moreover, its use as an emergency feed resource provides a safety net for farmers, ensuring that their livestock can be sustained during challenging times. By incorporating rice straw into their feeding strategies, farmers can reduce their dependence on external feed sources, which are often subject to price fluctuations and supply chain disruptions [17]. This proactive approach to feed management not only enhances the resilience of livestock systems but also supports overall food security in communities reliant on livestock for income and nutrition. Additionally, encouraging the establishment of fodder banks stocked with rice straw helps mitigate risks associated with seasonal feed shortages, allowing farmers to access vital resources when needed. The integration of rice straw into livestock feeding systems thus serves as a critical strategy for maintaining feed security and supporting sustainable agricultural practices.

### **Soil Fertility and Agricultural Integration**

The integration of rice straw into livestock feeding systems offers numerous benefits for soil fertility and agricultural integration. When livestock are fed with rice straw, their manure contains enhanced nutrient levels, contributing to improved soil fertility. This organic matter boosts soil structure, water retention, and microbial activity, ultimately leading to healthier soils that support subsequent crop yields

[18]. The application of manure rich in rice straw not only replenishes nutrients but also enhances the overall fertility of the land, promoting sustainable farming practices. Furthermore, using rice straw in livestock diets encourages the adoption of integrated crop-livestock systems, where livestock and crop production work synergistically. This integration improves overall farm productivity, as crop residues are effectively utilized as feed resources, reducing waste and maximizing resource efficiency [19]. Additionally, rice straw can be strategically combined with other crop residues to create balanced feeding rations for livestock, further enhancing nutritional value. This holistic approach to farming promotes nutrient cycling and reduces the need for synthetic fertilizers, ultimately supporting the long-term sustainability of agricultural practices. By fostering soil fertility and encouraging crop-livestock integration, rice straw plays a vital role in promoting sustainable farming systems and enhancing agricultural resilience.

### **Economic and Farm-Level Benefits**

The economic benefits of using rice straw as a livestock forage resource are manifold. One significant advantage is the reduction in landfill use, as rice straw, often considered agricultural waste, is repurposed into a valuable feed resource. This practice not only alleviates waste management challenges but also contributes to the overall sustainability of agricultural systems. By incorporating rice straw into livestock diets, farmers can achieve farm income stability through reduced feed costs, which can be especially beneficial during periods of market fluctuations [20]. The absence of the need for complex processing techniques further enhances the economic viability of using rice straw, as farmers can easily integrate it into their existing feeding systems without incurring significant additional costs. Customizable feeding strategies that incorporate rice straw enable farmers to tailor diets according to the specific needs of their livestock, optimizing health and productivity. Moreover, the use of rice straw reduces reliance on imported feeds, which can be costly and subject to international market dynamics. This approach helps stabilize local economies and supports smallholder farmers in achieving greater profitability. Overall, the economic and farm-level benefits of using rice straw as a forage resource contribute to more resilient and sustainable agricultural practices.

### **Feed Processing and Enhancement**

Rice straw's versatility extends to its potential for feed processing and enhancement, allowing farmers to improve its nutritional profile and digestibility. The incorporation of feed additives and treatments can significantly enhance the nutritional value of rice straw, making it a more effective forage resource. For instance, treatments that increase the digestibility of the fiber content can lead to improved feed efficiency and better livestock performance. Furthermore, the potential for upgrading rice straw through various processing methods, such as ensiling or pelleting, can make it more palatable and easier to digest for livestock [6, 21]. This adaptability ensures that rice straw can be tailored to meet the specific nutritional requirements of different animal species, promoting better health and productivity. Additionally, the development of innovative processing techniques opens avenues for value addition, transforming rice straw into high-quality feed products that can command higher market prices. Such enhancements not only benefit farmers economically but also encourage more sustainable livestock production practices. By emphasizing the importance of feed processing and enhancement, rice straw can play a pivotal role in improving livestock diets and overall farm productivity.

### **Practical Farm Applications**

The practical applications of rice straw in livestock farming are extensive and contribute to various aspects of farm management. One notable application is its ability to reduce pressure on grazing lands. By utilizing rice straw as a forage resource, farmers can alleviate the burden on pastures, preventing overgrazing and promoting the sustainability of grazing systems. Additionally, rice straw can serve as an alternative bedding material for livestock, further maximizing its utility on the farm [22]. Its use as mulch can also enhance soil moisture retention, benefiting crop production in intercropping systems [23]. The slow dry matter loss in storage allows farmers to maintain a stable feed supply over time, ensuring that livestock have access to necessary nutrition even during periods of scarcity. Furthermore, the simplicity of integrating rice straw into existing feeding systems means that farmers do not need

special equipment or extensive training to implement its use effectively. This accessibility encourages widespread adoption among farmers, particularly those in resource-limited settings. By highlighting these practical farm applications, rice straw emerges as a versatile and valuable resource for enhancing livestock management practices and promoting sustainable agriculture.

### **Supporting National and Local Agricultural Systems**

The use of rice straw as a livestock forage resource supports both national and local agricultural systems, playing a vital role in enhancing food security and agricultural resilience. By incorporating rice straw into livestock diets, farmers contribute to national feed security plans, ensuring a stable food supply for growing populations [24]. The utilization of locally sourced rice straw fosters self-sufficiency, reducing dependence on imported feed resources and mitigating the risks associated with global market fluctuations. Additionally, the contributions of rice straw to livestock production are crucial for maintaining food security at the local level, particularly in rural communities that rely on livestock for income and nutrition. The integration of rice straw into farming systems also supports feed efficiency improvement, enabling farmers to maximize the use of available resources while minimizing waste [25]. By promoting sustainable practices and reducing fossil fuel usage associated with feed transportation and processing, the adoption of rice straw contributes to a more environmentally friendly agricultural sector. Furthermore, the encouragement of integrated crop-livestock systems bolsters the resilience of agricultural communities, ensuring their long-term viability. Overall, the use of rice straw in livestock feeding is a key element in strengthening national and local agricultural systems and fostering sustainable development.

### **Climate Resilience**

The incorporation of rice straw into livestock feeding systems plays a significant role in enhancing climate resilience for farmers. In regions prone to climate variability, such as droughts or flooding, rice straw serves as a reliable forage resource when other feeds may become scarce [26]. Its ability to be stored for extended periods allows farmers to access nutrition for their livestock during challenging climatic conditions. This adaptability is particularly crucial in maintaining livestock health and productivity when other forage options fail. Moreover, rice straw can contribute to sustainable land management practices, which help mitigate the impacts of climate change. By utilizing rice straw instead of burning it, farmers reduce greenhouse gas emissions and improve carbon sequestration in the soil [27]. This practice not only supports environmental sustainability but also enhances soil health and fertility over time. Furthermore, the use of rice straw contributes to a diversified feeding strategy, which can improve the resilience of livestock systems against climate-related shocks. As climate change continues to pose challenges to agricultural productivity, the integration of rice straw into livestock diets emerges as a vital strategy for promoting adaptability and sustainability in farming practices. Ultimately, rice straw helps farmers navigate the uncertainties of a changing climate while ensuring the health and productivity of their livestock.

## **DISADVANTAGES**

### **Nutritional Deficiencies**

Rice straw is notably deficient in key nutrients essential for optimal livestock performance. Its low digestibility, high fiber, and poor crude protein content make it an inadequate sole feed source [6]. The low energy content fails to meet the metabolic needs of most livestock, especially during growth, reproduction, and lactation phases. Additionally, rice straw's imbalanced nutrient profile, high lignin content, and slow rumen fermentation rates reduce nutrient absorption and utilization [28]. The absence of essential fatty acids, including omega-3s, and a deficiency in vitamins A, D, and E further exacerbate nutritional inadequacies. Its mineral content is also insufficient, lacking vital elements, such as calcium, phosphorus, and magnesium, which are critical for bone development, fertility, and immune function [29]. These nutritional deficits necessitate external supplementation, driving up costs and complicating feed management. Moreover, the fiber in rice straw is not easily bioavailable, limiting its utility as an energy source for livestock. Animals may experience nutrient deficiencies that impair growth, productivity, and overall health. In extreme cases, these inadequacies can lead to conditions like anemia,

reduced fertility, and poor immune response, making rice straw an unreliable forage option without substantial supplementation.

### **Health Issues**

Feeding rice straw as a sole forage resource can lead to a range of health issues in livestock due to its inadequate nutritional profile. The high fiber content can cause gastrointestinal issues like bloating, impaction, and blockages, which may result in discomfort or even death in severe cases. Low crude protein and inadequate mineral intake impair immune function, making animals more susceptible to diseases and infections [29]. Moreover, anemia, caused by deficiencies in iron and copper, weakens livestock and reduces productivity. Reproductive health is also negatively affected, with delays in puberty, reduced fertility, and extended calving intervals observed in animals fed exclusively on rice straw [30]. Poor milk quality and yield are frequent in lactating animals, which negatively impacts calf survival rates and growth. Bone development is compromised due to insufficient calcium and phosphorus intake, leading to lameness or skeletal deformities. Overall, the health of livestock deteriorates on a rice straw-only diet, making animals more vulnerable to metabolic disorders, such as ketosis and acidosis. The weakened immune system, coupled with poor nutrient absorption, results in increased disease incidence, higher veterinary costs, and reduced productivity, all of which challenge the sustainability of rice straw as a primary feed source.

### **Performance and Productivity Decline**

Livestock performance and productivity suffer significantly when rice straw is used as the sole feed source. The low energy and protein content, combined with poor digestibility, leads to weight loss and a decline in growth rates [30]. For young animals, this manifests as stunted growth and impaired muscle development, while adult livestock experience reduced carcass yield and diminished meat quality. In breeding animals, reproductive efficiency is compromised, with prolonged calving intervals, lower fertility, and poor colostrum quality contributing to decreased calf survival rates. Lactating animals produce less milk, and its quality is often poor, further hampering the growth of offspring [31]. Additionally, the overall productive lifespan of livestock is reduced due to nutritional deficiencies, which also lead to lower body condition scores and decreased wool or fiber quality. In high-performance animals, such as those in competitive or work environments, rice straw is inadequate in meeting their energy needs, leading to fatigue and suboptimal performance. The economic implications of reduced productivity and performance are severe, as farmers face lower yields, reduced product quality, and increased costs associated with veterinary care and supplementary feeding, making rice straw an unsustainable option for livestock production.

### **Economic Impact and Resource Management**

Using rice straw as a sole forage resource increases the overall costs of livestock farming. The need for supplements to compensate for rice straw's low nutrient content significantly raises feed expenses [24]. High labor costs are incurred for handling and distributing the bulky straw, which is less efficient to store and transport than more nutrient-dense feeds. Additionally, the increased need for veterinary services due to health problems associated with poor nutrition leads to higher operational costs. Rice straw produces more manure than digestible feeds, contributing to waste management challenges and higher expenses for manure handling. The fiber-rich manure also has a lower nutrient content, diminishing its value as fertilizer. Moreover, rice straw's low palatability leads to feed waste, which adds to economic losses [32]. Increased ammonia emissions from poorly digested fiber also present environmental costs, as regulatory compliance in emissions may incur penalties. The economic impact extends to the environmental footprint, with inefficient nutrient recycling and land use. Farmers must allocate more resources to balance these challenges, making rice straw a costly and inefficient forage solution without supplementary feeding and proper management practices.

### **Environmental and Feed Safety Concerns**

Rice straw presents several environmental and feed safety concerns when used as a sole livestock forage resource. Its low digestibility leads to higher methane production during rumen fermentation,

contributing to greenhouse gas emissions and exacerbating climate change [33]. Additionally, undigested fiber increases manure output, which creates environmental challenges in waste management, particularly in terms of increased ammonia emissions and nutrient runoff that can pollute water sources. The high fiber content in the manure also reduces its value as an organic fertilizer, impacting soil health and crop yields. If rice straw is not stored properly, it can develop mold, leading to mycotoxin contamination, which poses a serious health risk to livestock [34]. Furthermore, rice straw harvested from fields treated with pesticides may retain harmful residues, compromising the safety of the feed. The potential for nutrient leaching during storage and improper handling further exacerbates its environmental footprint. As a result, reliance on rice straw increases the need for careful feed safety and environmental management practices, raising the complexity and costs for farmers, while also posing broader risks to ecological sustainability.

### **Management and Feeding Challenges**

Feeding livestock rice straw presents numerous practical challenges. Its bulky nature makes it difficult to store, transport, and distribute efficiently, leading to higher labor demands and associated costs. The low palatability of rice straw often results in feed rejection, which increases feed waste and necessitates supplementation with more nutritious feed sources [4]. For non-ruminant animals like pigs and poultry, rice straw is not digestible, rendering it unsuitable as a feed resource. Furthermore, rice straw requires high water intake for proper digestion, putting additional pressure on water resources, especially in regions where water is scarce. Its high fiber content also contributes to slow rumen fermentation, leading to reduced feed efficiency and increased risks of gastrointestinal disorders, such as bloating, blockages, and impaction [35]. The removal of rice straw for feeding purposes can lead to soil erosion in agricultural fields, as it is no longer available for use as much. Overall, the labor, storage, and health-related challenges associated with feeding rice straw as a primary forage increase the complexity of livestock management, making it less practical for commercial farming operations.

### **Reproductive and Growth Impacts**

The use of rice straw as a sole forage resource has profound negative effects on the reproductive health and growth of livestock. Due to its low nutrient density, animals fed on rice straw often experience delayed puberty, which can prolong the time to reach reproductive maturity [36]. In breeding animals, rice straw compromises fertility, leading to reduced conception rates and increased calving intervals. Calves born to cows fed on rice straw tend to have lower birth weights, which increases the risk of neonatal mortality and hampers early growth [37]. Additionally, poor colostrum quality further diminishes the survival and immunity of newborn calves. Lactating animals struggle to produce enough milk, and the milk produced is often of lower nutritional quality, affecting the growth and health of their offspring. Bone development in young animals is also impaired due to deficiencies in calcium and phosphorus, leading to skeletal abnormalities and lameness. The overall reproductive efficiency of the herd declines, leading to economic losses for farmers and compromised animal welfare. Long-term reliance on rice straw thus hinders both the short-term and long-term reproductive performance and growth potential of livestock [38].

### **CONCLUSIONS**

The study underscores the significant potential of rice straw as a valuable resource for sustainable livestock feeding. By reevaluating the nutritional properties of rice straw and exploring innovative processing methods, this study demonstrates how rice straw can be effectively integrated into livestock diets to enhance feed security and promote environmentally sustainable agricultural practices. The findings reveal that, despite its historical perception as a low-quality forage, rice straw offers unique opportunities for improving livestock nutrition, especially when supplemented with appropriate additives and processing techniques. Moreover, the utilization of rice straw contributes to waste reduction, supports smallholder farmers in resource-limited settings, and fosters a more circular agricultural economy. To fully realize the benefits of rice straw, it is imperative for stakeholders including farmers, researchers, and policymakers to collaborate on developing strategies that optimize its use in livestock production systems. Future research should focus on refining processing

technologies and evaluating the long-term impacts of rice straw utilization on livestock health and productivity. Ultimately, embracing rice straw as a primary forage resource can lead to more resilient and sustainable livestock systems, enhancing both food security and environmental stewardship in agricultural communities.

### Limitations

While this study provides valuable insights into the potential of rice straw as a forage resource for livestock, several limitations warrant consideration. Firstly, the nutritional composition of rice straw can vary significantly based on factors, such as rice variety, soil conditions, climate, and harvesting practices. This variability may affect the generalizability of the findings, necessitating context-specific evaluations to determine the suitability of rice straw for different livestock species and production systems. Secondly, the study primarily focuses on the nutritional and processing aspects of rice straw, potentially overlooking other critical factors, such as animal behavior, palatability, and acceptance of rice straw-based diets. Understanding these aspects is essential for ensuring successful integration into livestock feeding strategies.

Additionally, the economic feasibility of implementing innovative processing techniques may pose challenges for smallholder farmers with limited resources. Future research should address the cost-effectiveness and scalability of these technologies in diverse agricultural contexts. Lastly, the environmental implications of large-scale rice straw utilization remain to be thoroughly explored. While incorporating rice straw into livestock diets can reduce waste, it is crucial to assess the potential impact on soil health, nutrient cycling, and greenhouse gas emissions associated with increased straw usage in farming systems. Overall, addressing these limitations through further research will be essential for fully understanding the role of rice straw in sustainable livestock development.

### Future Directions

Future research on rice straw as a livestock forage resource should focus on conducting large-scale field trials to evaluate its nutritional benefits across different livestock species and production systems. Investigating innovative processing methods, such as enzymatic treatments and fermentation, will be essential to enhance the digestibility and overall feed quality of rice straw. Additionally, understanding the effects of rice straw incorporation on animal health, behavior, and productivity will provide a comprehensive view of its utility in livestock diets. Exploring the economic implications and cost-effectiveness of using rice straw as a primary feed resource will help identify barriers to adoption, particularly for smallholder farmers. Research should also examine the environmental impact of large-scale rice straw utilization, focusing on soil health, greenhouse gas emissions, and nutrient cycling. Developing educational programs for farmers about the benefits and management of rice straw will promote its integration into livestock feeding systems. Collaborating with policymakers will be critical to create supportive frameworks that encourage sustainable practices. Investigating the potential role of rice straw in mixed crop-livestock systems could yield insights into optimizing resource use and improving farm resilience. Lastly, examining consumer perceptions and market dynamics regarding livestock products fed with rice straw will help understand the market potential and acceptance of such products.

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