Utilization of Fermented Unconventional Feed for Animal Feeding- An Approach to Reduce Malnutrition

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ABSTRACT

There is higher growth rate of human population and livestock population, due to this, the gap between demand and supply for feed is also increased. High price and insufficient food supply lead to malnutrition in animals. Afterward, antibiotic resistance is also a burning issue. So, there is need to search for economically cheap and organic feed for animal feeding. Therefore, unconventional feeding is best option. Unconventional animal feeds exhibit unique characteristics and considerable variability. However, their effectiveness in monogastric animals is often limited by high levels of anti-nutritional factors and poor palatability. Feed fermentation may provide a viable solution to these challenges. Additionally, fermented unconventional feeds offer significant economic benefits and can serve as an effective alternative to antibiotic growth promoters, especially in light of increasing antibiotic restrictions, showing great promise in animal nutrition. This article delves into the types and characteristics of fermented unconventional feeds, the fermentation processes involved, their application outcomes, as well as the challenges and future prospects in their use for monogastric animals. We aim for this comprehensive overview to be a valuable resource for the development and implementation of unconventional feed resources in the feed industry.

INTRODUCTION

In India, the enforcement of regulations prohibiting the use of antibiotics poses a significant challenge to the livestock industry, making effective management of this issue a priority for professionals in the field. One promising solution is the fermentation of animal feed. Probiotics and their metabolites found in fermented feeds can effectively reduce or replace the need for antibiotics. Fermentation brings numerous advantages, including improved feed palatability, the removal of anti-nutritional factors, enhanced gut health, and superior meat quality. (Clavijo *et al*., 2021)

Fermentation is broadly defined as the process that harnesses microbial activity to produce metabolic products. This practice has a long history, dating back thousands of years when humans first began fermenting products using yeast. In the early 20th century, Finnish biochemist Artturi Ilmari Virtanen conducted groundbreaking research on silage feed fermentation, developing methods that preserved feed quality and nutritional value. For his pioneering work, Virtanen was awarded the Nobel Prize in Chemistry in 1945. While silage primarily serves ruminants, the importance of monogastric animal production—such as poultry and pigs—continues to grow, as these animals are essential for providing meat and eggs to meet human nutritional needs.

The quality of feed is critical, as it directly influences the quality of animal products. Therefore, improving feed quality is a fundamental concern for researchers in the feed industry. As science and technology advance, various disciplines—including fermentation, genetics, and enzymatic engineering—have improved, leading to a greater focus on applying fermentation technology to animal feed. This evolution began with silage fermentation, progressed to the fermentation of individual feed ingredients, and has more recently expanded to include the fermentation of complete diets.

However, many unconventional feed ingredients are associated with poor palatability and high levels of anti-nutritional factors, which limit their effectiveness. While monogastric animals like pigs and poultry possess strong enzymatic digestion capabilities, their microbial digestion is relatively weak, with notable differences between species. Pigs, equipped with teeth, can chew their feed, while poultry, lacking teeth, rely on their glandular and muscular stomachs, as well as the crop, to soften food. Additionally, poultry have shorter intestines, resulting in a faster feed transit time through the digestive tract. Their enzymatic and microbial fermentation digestion is not as robust as that of pigs (Sugiharto *et al*., 2019)

Unlike conventional feeds such as soybean meal, monogastric animals often struggle to digest high crude fiber content found in unconventional feeds, leading to poor nutrient utilization. Fermenting these feed ingredients could help address these limitations. This article provides an overview of the limited research on the fermentation of unconventional feed resources and their application in monogastric animals, aiming to offer theoretical support for the development of these alternative feed resources.

Classifiactaion of Fermented Unconventional Feeds

According to international feed classification standards, feeds are typically divided into eight categories: protein feed, energy feed, roughage, green forage, silage, mineral feed, vitamin feed, and feed additives. Unconventional feeds also fall under these classifications. It's important to note that feed additives do not undergo fermentation, and the fermentation of roughage is primarily relevant to ruminant animal husbandry. Furthermore, fermenting mineral and vitamin feeds may lead to nutrient losses.

Given these considerations, this review will concentrate exclusively on the fermentation of protein and energy feeds, along with recent advancements in the study of silage feeds.

1. Fermentation of Protein Feeds

Protein feeds are defined as feeds with a natural moisture content of less than 45%, a crude fiber content in dry matter of less than 18%, and a crude protein content of at least 20%. These feeds can be further categorized into four subgroups based on their source: plant-based protein feeds, animal-based protein feeds, non-protein nitrogen feeds, and single-cell protein feeds (De Roos *et al*., 2018).

Compared to conventional feeds like soybean meal, unconventional protein feeds often suffer from poor palatability, inconsistent nutritional composition, and lower overall nutritional value, in addition to containing various anti-nutritional factors and toxicants. Fermentation offers a promising solution to these challenges.

The nutritional characteristics of fermented feeds are influenced by several factors, including the choice of microorganisms, substrates, and fermentation conditions (e.g., temperature and duration). This review compiles relevant information on these aspects and their implications for the fermentation of unconventional protein feeds, as summarized in Table 1.

Numerous studies have shown that protein feed fermentation can lead to significant nutritional enhancements, such as increased crude protein content and decreased crude fiber content. Additionally, fermentation has been found to alleviate the adverse effects of heat stress in broilers. The key to these improvements lies in fermentation's ability to break down large molecular nutrients in protein feeds into smaller molecules, such as peptides, free amino acids, and oligosaccharides.

2. Fermentation of Energy Feeds

Energy feeds are characterized by a crude fiber content of less than 18% and a crude protein content lower than 20% in dry matter. In China, conventional energy feeds include maize and wheat, while unconventional options encompass grains such as sorghum and oats, tuber and root crops like sweet potatoes, and by-products such as vinegar production residue, distillers' grains, and beet pulp.

These grains are typically rich in starch but low in crude fiber and protein, often resulting in low overall quality and an imbalanced mineral and vitamin profile. Tuber and root crops have high moisture content and are abundant in non-nitrogenous extracts. By-product feeds, while useful, often present several drawbacks, including high fiber content, elevated moisture levels, significant anti-nutritional factors, and susceptibility to spoilage. These limitations make them less commonly utilized in practical applications for monogastric animals.

3. Silage Feed

Silage feed is a valuable component of animal nutrition, created through the fermentation of green forage using lactic acid bacteria under anaerobic, low-pH conditions. This process serves two primary purposes: it alters the nutritional composition of the forage and preserves it for future use. During fermentation, silage feed undergoes significant transformations, resulting in decreased crude fiber content, improved palatability, and the development of an aromatic odor. The lactic acid produced during fermentation plays a crucial role in inhibiting harmful bacteria and extending shelf life (Kyle *et al*., 1981).

With its low crude fiber content and high nutritional value, silage feed can be effectively incorporated into the diets of monogastric animals in appropriate proportions. Studies have shown that adding apple pomace-mixed silage to the basal diet can enhance feed conversion efficiency in finishing pigs. Additionally, numerous studies have reported improvements in meat quality for monogastric animals due to the inclusion of silage feed (Kung *et al*., 2018).

4. Challenges and Prospects

While fermented feeds offer numerous advantages, they also face several significant challenges:

1. **Complex Microbial Communities**: The diversity of microbial strains involved in fermentation can lead to issues such as contamination by unwanted microorganisms, transfer of antibiotic resistance genes, production of toxic metabolites, and potential immune overactivity.

2. **Strain Source and Safety**: Ensuring the standardization and safety of microbial strain sources, along with their specific application characteristics, is crucial when preparing fermented unconventional feeds.

3. **Mechanisms of Nutritional Improvement**: The mechanisms underlying the enhancement of nutritional value during fermentation are not fully understood, necessitating further research in this area.

4. **Mixed Microbial Fermentation**: There is a lack of data on mixed microbial fermentation processes, particularly concerning the identification of dominant strains within these cultures. Given that different strains have varying abilities to degrade anti-nutritional factors, identifying effective strains for these processes is essential.

5. **Pelleted vs. Non-Pelleted Feeds**: The choice between producing pelleted or non-pelleted feeds during fermentation needs further investigation. Non-pelleted feeds may preserve beneficial substances like live probiotics, while pelleted feeds could enhance starch gelatinization, enzyme activity, and protein denaturation, all of which support digestion and absorption. Thus, making a decision between the two poses challenges.

6. **Single-Strain vs. Multi-Strain Fermentation**: Research has primarily focused on single-strain fermented feeds in China, while multi-strain fermented feeds remain underexplored. Investigating multi-strain fermentation, particularly identifying dominant strains, presents promising opportunities.

7. **Segmented Fermentation**: The establishment of segmented fermentation processes, such as aerobic and anaerobic stages, is an emerging trend that could enhance fermentation efficiency.

8. **Economic Evaluation**: The economic benefits of fermented unconventional feeds need thorough assessment. While they can improve feed conversion rates and effectively utilize agricultural waste, there are initial equipment costs and risks

associated with improper preservation that may lead to feed deterioration.

Prospects for Fermented Feeds:

1. **Liquid Fermented Feeds**: The adoption of liquid feeding following biological fermentation could represent a significant advancement in the livestock feed industry. However, this approach is still in its early stages in China, with limited commercial applications due to high costs. Wider acceptance may require additional time and promotion.
2. **Nutritional Database for Fermented Feeds**: As the production and utilization of fermented feeds increase, establishing a comprehensive nutritional database becomes essential. This is especially important considering the potential benefits of fermented feeds for animal health and environmental sustainability. Developing a scientific assessment system is also crucial.
3. **Exploration of Alternative Forms**: While research has largely focused on individual unconventional feed ingredients, there is a need for increased attention on alternative forms, such as fermented concentrates and other products, by both feed enterprises and research institutions.

These challenges and prospects underscore the need for continued innovation and research in the field of fermented animal feeds to fully realize their benefits and address existing limitations.

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