HERBAL FEED ADDITIVES FOR IMPROVING DAIRY PRODUCTIVITY AND OVERALL HEALTH: A SUSTAINABLE APPROACH FOR FOOD SAFETY AND PUBLIC HEALTH

Gautami Sarma[1], Happleraj Singh Dhillon[1], Simran Jeet Singh[1], Sumit Gangwar[2], Ankit Sharma[3]

[1]Department of Livestock Farm Complex, Khalsa College of Veterinary and Animal Science, Amritsar, Punjab, [2]Assistant Technical Manager, Tiwana Nutrition Global Private Limited, Sirhind Punjab, [3]Department of Livestock Production Management, School of Veterinary Science, Abhilashi University, Mandi, Himachal Pradesh

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ABSTRACT

Growing concerns over antibiotic residues and antimicrobial resistance have accelerated the search for safe and sustainable alternatives in dairy production. Herbal feed additives, rich in bioactive phytochemicals such as flavonoids, phenolics, tannins, saponins and essential oils, have emerged as promising natural growth promoters. Medicinal plants exhibit antimicrobial, antioxidant, anti-inflammatory and immunomodulatory properties that enhance animal health, improve nutrient utilization and support milk production. Their use can reduce dependence on antibiotics while promoting the production of safer and higher-quality dairy products, making phytogenic additives an important component of sustainable dairy farming.

INTRODUCTION

The dairy industry plays a crucial role in ensuring food and nutritional security while providing livelihood opportunities to millions of farming families worldwide. India, being the largest producer of milk globally, relies heavily on healthy and productive dairy animals to sustain the increasing demand for milk and milk products. However, intensive dairy production systems are frequently challenged by infectious diseases, metabolic disorders, oxidative stress and declining reproductive efficiency, leading to increased dependence on antibiotics and synthetic growth promoters.

The widespread and often indiscriminate use of antibiotics in livestock production has become a matter of global concern due to the emergence of antimicrobial resistance (AMR) and the presence of drug residues in milk and dairy products. Resistant bacteria and their resistance genes can be transmitted from animals to humans through the food chain, posing a serious threat to public health. Consequently, there is growing emphasis on identifying natural and sustainable alternatives that can maintain animal health while reducing antibiotic usage.

In this context, herbal feed additives or phytogenic feed additives have gained considerable attention as natural growth promoters and immunomodulators. These plant-derived products contain various bioactive compounds capable of improving digestion, immunity, antioxidant status and overall productivity without leaving harmful residues in animal products.

HERBAL FEED ADDITIVES: AN EMERGING ALTERNATIVE

Herbal feed additives are natural substances obtained from medicinal plants, herbs, spices, essential oils or plant extracts that are incorporated into animal diets to improve health and performance. Unlike conventional antibiotics that primarily target microorganisms, phytogenic feed additives act through diverse pathways by improving antioxidant status, modulating immune

responses, reducing inflammation and inhibiting pathogenic microbes.

Several medicinal plants have shown considerable potential as natural feed additives in dairy animals due to their rich bioactive constituents. *Moringa* and *Leptadenia reticulata* (Jivanti) enhance nutrient utilization, immunity and stress tolerance, while turmeric, garlic and ginger provide antioxidant, anti-inflammatory and antimicrobial benefits. Herbs such as tulsi, black cumin, peppermint and lemongrass improve immune function, digestion and gut health. Essential oil–rich plants including thyme, oregano, cinnamon, clove and rosemary support rumen health, enhance feed efficiency and protect against oxidative stress. *Yucca schidigera*, owing to its saponin content, helps reduce ammonia emissions and improves overall feed utilization, making these phytogenic additives promising natural alternatives to antibiotic growth promoters.

These phytogenic feed additives improve digestive efficiency, modulate rumen microbiota, enhance immune competence and reduce the reliance on conventional antibiotics, thereby supporting sustainable dairy production and the generation of safer, residue-free milk for human consumption.

MECHANISM OF ACTION OF HERBAL FEED ADDITIVES

The beneficial effects of herbal feed additives are primarily due to bioactive phytochemicals such as flavonoids, alkaloids, phenolics, tannins, saponins, glycosides and essential oils. These compounds exhibit antimicrobial activity by suppressing pathogenic microbes, provide antioxidant protection against oxidative stress, enhance immune function by stimulating natural defense mechanisms, improve digestive efficiency through better enzyme secretion and rumen microbial balance, and exert anti-inflammatory effects that promote animal health and resilience.

EFFECT OF HERBAL FEED ADDITIVES ON DAIRY PRODUCTIVITY

Improvement in Milk Yield and Composition

Several studies have reported that herbal feed additives can improve milk production by enhancing feed intake, nutrient utilization and metabolic efficiency. *Moringa oleifera*, owing to its rich content of protein, minerals and antioxidants, has been shown to improve milk yield and milk composition. Traditional Ayurvedic galactagogues such as *Leptadenia reticulata* (Jivanti), *Asparagus racemosus* (Shatavari) and *Trigonella foenum-graecum* (Fenugreek) have also been reported to support lactation and mammary gland function. In addition, herbs such as Garlic (*Allium sativum*), Peppermint (*Mentha piperita*) and Lemongrass (*Cymbopogon citratus*) may improve rumen fermentation and feed efficiency, indirectly contributing to enhanced milk production. Besides increasing yield, several phytogenic additives also improve milk fat, protein and antioxidant content, thereby enhancing the nutritional quality and shelf life of dairy products.

Enhanced Reproductive Performance

Oxidative stress and poor immune status often impair reproductive efficiency in dairy animals. Herbal antioxidants help improve ovarian function, hormonal balance and uterine health, leading to better conception rates and reduced reproductive disorders.

Strengthening of Immune System

Medicinal herbs such as *Leptadenia reticulata* and Tulsi have demonstrated immunostimulatory effects by enhancing leukocyte function and improving the animal's ability to combat infections. Improved immune competence reduces disease incidence and the need for antibiotic treatments.

Mitigation of Heat Stress

Heat stress adversely affects feed intake, milk production and fertility in dairy cattle, particularly under tropical conditions. Herbal antioxidants help reduce oxidative damage associated with thermal stress and improve physiological adaptation.

FOOD SAFETY BENEFITS OF HERBAL FEED ADDITIVES IN DAIRY PRODUCTION

Food safety has become a major concern in modern dairy farming due to increasing awareness about antibiotic residues, antimicrobial resistance (AMR) and the quality of animal-derived foods. Residues of antibiotics in milk may cause allergic reactions in sensitive individuals, disturb the normal gut microbiota and interfere with the manufacture of fermented dairy products by inhibiting beneficial starter cultures. Moreover, continuous exposure to low levels of antibiotics through food can contribute to the development and spread of antimicrobial-resistant bacteria. Recognizing these concerns, international organizations such as WHO, FAO and WOAH advocate reducing the non-therapeutic use of antibiotics in livestock under the "One Health" approach. In this context, herbal feed additives have gained importance as natural alternatives that support animal health and productivity without increasing dependence on synthetic antimicrobials.Herbal supplements improve gut health, optimize rumen function and enhance immune responses, helping dairy animals better withstand infectious and environmental stress. Their antioxidant, antimicrobial and anti-inflammatory properties also contribute to improved udder health, lower somatic cell counts and better oxidative stability of milk, thereby enhancing its quality and shelf life. The use of phytogenic feed additives offers several food safety advantages, including reduced antibiotic use, production of residue-free milk, lower risk of AMR development and greater consumer acceptance of natural and sustainable dairy products. Consequently, these additives are emerging as valuable components of eco-friendly and integrated dairy production systems.

CHALLENGES AND FUTURE PROSPECTS

Despite their promising potential, the widespread adoption of herbal feed additives in dairy farming faces several challenges. The concentration of bioactive compounds in medicinal plants often varies with species, geographical location, cultivation practices and harvesting conditions, leading to inconsistent responses in animals. In addition, the lack of standardized extraction methods, formulation techniques and quality control measures affects the uniformity and efficacy of herbal products. Scientific information regarding optimum dosage levels, long-term safety and interactions with other feed ingredients is also limited for many phytogenic additives. Furthermore, most available studies have been conducted under experimental conditions, and large-scale field validation in commercial dairy farms is still needed. Future research should focus on the standardization of herbal formulations, identification of key bioactive molecules and development of scientifically validated feeding protocols. Advances in phytochemical and molecular research, coupled with robust quality assurance systems, will facilitate the wider adoption of herbal feed additives as safe and sustainable alternatives to antibiotic growth promoters in dairy production.

CONCLUSION

In conclusion, herbal feed additives represent a scientifically sound and sustainable approach for improving food safety in dairy production. By reducing antibiotic dependence, minimizing drug residues in milk and helping to combat antimicrobial resistance, these natural supplements not only enhance animal health but also contribute significantly to the protection of public health and the long-term sustainability of the dairy industry.

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