Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 8 Issue 1 January 2026

Review Article

Potato Leaves and Stems as Animal Fodder: A Sustainable Solution for Livestock Nutrition

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DOI: 10.31080/ASVS.2025.08.1031

Received: March 11, 2026

Published: June 12, 2026

Abstract

The increasing global demand for animal products fueled by population increase and evolving consumption patterns, requires the investigation of sustainable, cost-effective, and nutritionally adequate feed options. The foliage of the potato plant consisting of the leaves and stems of *Solanum tuberosum* is a plentiful but underappreciated agricultural by-product with significant potential as livestock feed. Potato leaves, comprising 15 - 20% crude protein, abundant fiber, vital vitamins, and minerals, serves as a feasible supplement or partial substitute for traditional forages, potentially decreasing feed expenses by 30 - 40%. Empirical evidence from India and China indicates its efficacy in enhancing milk production, weight gain, and feed efficiency in cattle and goats when incorporated at safe levels. Environmental advantages encompass diminished agricultural waste, reduced greenhouse gas emissions, and a lesser reliance on synthetic fertilizers. The presence of glycoalkaloids (solanine and chaconine) requires suitable processing methods such as drying, ensiling, or heat treatment and regulated inclusion rates (≤ 20% for ruminants; ≤ 10% for monogastrics) to assure safety. Seasonal availability can be managed by preservation techniques like as silage. Effective management of potato foliage can improve livestock production, promote circular agriculture, and bolster the economic and environmental sustainability of global animal husbandry systems.

Keywords: Potato Foliage; Livestock Nutrition; Glycoalkaloids; Sustainable Agriculture; Agricultural Waste Utilization; Silage Preservation

Introduction

In the ever-evolving world of agriculture and animal husbandry, the search for sustainable, cost-effective, and nutritious feed sources is a constant challenge [1]. With the global population projected to reach 9.7 billion by 2050, the demand for animal products such as meat, milk, and eggs is expected to rise significantly [2]. For instance, global meat production is estimated to increase by 15% by 2030, while milk production is expected to grow by 22% in the same period [3]. This surge in demand places immense pressure on farmers to produce more while keeping costs low and minimizing environmental impact [4]. In this context, unconventional feed sources are gaining traction as viable alternatives to traditional animal feed [5]. One such resource, often overlooked and underutilized, is the leaves and stems of the potato plant [6].

Potatoes (*Solanum tuberosum*) are one of the most widely cultivated crops in the world, grown in over 150 countries and serving as a staple food for billions of people [7]. Global potato production exceeds 370 million metric tons annually [8], with China, India, and Russia being the top producers [9]. However, while the tubers are the primary focus of cultivation, the above-ground parts of the plant-leaves and stems-are often treated as agricultural waste [10]. These parts are typically discarded, burned, or plowed back into the soil after harvest. For example, a single hectare of potato cultivation can yield 10 - 15 tons of foliage, which is often left unused [11]. Yet, recent research and practical applications have revealed that potato foliage holds significant potential as a valuable source of animal fodder [12]. This discovery not only addresses the issue of agricultural waste but also provides a sustainable solution to the growing demand for livestock feed [13].

The concept of using potato leaves and stems as animal fodder is not entirely new [14]. In many traditional farming systems, especially in developing countries, farmers have long utilized crop residues and by-products to feed their livestock [15]. However, the practice has gained renewed attention in recent years due to the increasing cost of conventional feed ingredients such as soybean meal, corn, and alfalfa [16]. For example, the price of soybean meal has risen by over 50% in the past decade, making it unaffordable for many small-scale farmers [17]. Potato foliage, on the other hand, is readily available, inexpensive, and rich in nutrients, making it an attractive alternative [18]. Studies suggest that farmers can save 30 - 40% on feed costs by incorporating potato leaves and stems into livestock diets [12].

The nutritional profile of potato leaves and stems is one of the key factors driving their adoption as animal feed [19]. Studies have shown that potato foliage contains 15 - 20% crude protein [20], which is comparable to or even higher than many traditional forage crops like alfalfa (16 - 18% crude protein) [14]. Additionally, it is rich in fiber (20 - 25%), vitamins (A, C, and E), and essential minerals such as calcium (1.5 - 2%), phosphorus (0.3 - 0.5%), and potassium (2 - 3%) [21]. These nutrients are crucial for the growth, development, and overall health of livestock, particularly ruminants like cattle, goats, and sheep [22]. Furthermore, the metabolizable energy (ME) of potato foliage is estimated at 7 - 9 MJ/kg, making it a viable energy source for animals. For comparison, the ME of traditional fodder like maize silage is around 10 - 11 MJ/kg, indicating that potato foliage can serve as a complementary energy source [23].

Despite its nutritional benefits, the use of potato leaves and stems as fodder is not without challenges [24]. One of the primary concerns is the presence of glycoalkaloids, specifically solanine and chaconine, which are natural toxins found in the foliage [25]. These compounds can be harmful to animals if consumed in large quantities, causing symptoms such as gastrointestinal distress, neurological issues, and even death in severe cases. For example, solanine levels in fresh potato leaves can range from 200 - 500 mg/kg, which is toxic if not properly managed [26]. However, research has shown that proper processing methods, such as drying (which reduces solanine levels by up to 50%), ensiling, or heat treatment, can significantly reduce the levels of these toxins, making the foliage safe for animal consumption [27]. Additionally, incorporating potato foliage into the diet in moderation typically less than 20% for ruminants and less than 10% for monogastric animals can mitigate the risks associated with glycoalkaloids. For instance, a study conducted on goats found that a diet containing 15% potato foliage resulted in improved weight gain and feed efficiency without adverse effects [28].

The environmental benefits of using potato foliage as animal feed cannot be overstated [19]. By repurposing agricultural waste, farmers can reduce their reliance on synthetic fertilizers and pesticides, lower greenhouse gas emissions, and promote sustainable farming practices [29]. For instance, utilizing potato foliage as fodder can reduce the need for chemical fertilizers by up to 25%, as the plant residues are recycled into the farming system

[30]. Moreover, the integration of potato foliage into livestock diets can help address the issue of feed scarcity, particularly in regions where access to quality feed is limited [12]. This is especially relevant in developing countries, where smallholder farmers often struggle to meet the nutritional needs of their animals. For example, in India, dairy farmers who incorporated potato foliage into cattle feed reported a 15 - 20% increase in milk yield, demonstrating its potential to enhance productivity [31]. Similarly, in China, goats fed a diet containing 15% potato foliage showed a 12% improvement in weight gain compared to those fed traditional fodder [32].

In addition to its nutritional and environmental benefits, potato foliage can also contribute to economic sustainability. For small-scale farmers, the cost of conventional feed can account for 60 - 70% of total livestock production expenses [33]. By substituting a portion of traditional feed with potato foliage, farmers can significantly reduce these costs. For example, a farmer with 10 dairy cows could save approximately 500-500-700 annually by incorporating potato foliage into their feed regimen. This cost-saving potential makes potato foliage an attractive option for resource-limited farmers [34].

The nutritional value of potato leaves and stems

Potato (*Solanum tuberosum*) is a staple crop grown all over the world, mostly for its tubers. But the leaves and stems of the plant, which are above ground, are full of nutrients that can help feed livestock. Here's a list of the nutrients they contain:

- **Crude protein:** Potato leaves contain approximately 15 - 20% crude protein, making them a good source of plant-based protein for animals.
- **Fiber:** The stems and leaves have a fiber content of around 20 - 25%, which aids in digestion for ruminants like cattle and goats.
- **Energy:** The metabolizable energy (ME) of potato foliage is estimated at 7 - 9 MJ/kg, comparable to other green fodders like alfalfa.
- **Vitamins and minerals:** Potato leaves are rich in vitamins A, C, and E, as well as minerals like calcium, phosphorus, and potassium.

All nutrient values are presented according to the references [35] and [36].

It is crucial to acknowledge that potato leaves and stems possess anti-nutritional compounds, including solanine and chaconine, which may be hazardous to animals when ingested in substantial amounts. Appropriate processing and moderation are essential for safe utilization [37].

Benefits of using potato leaves and stems as fodder

Minimization of agricultural waste

Worldwide, potato cultivation produces millions of tons of foliage and stems as by-products. A single hectare of potato farming can produce 10 - 15 tons of leaves [38]. Employing this biomass as feed lowers waste and fosters circular agriculture [39].

Economical feed substitute

Due to the escalating expenses of traditional animal feed, potato foliage presents a cost-effective substitute. Farmers can reduce feed expenses by 30 - 40% by integrating potato leaves and stems into livestock diets [40].

Ecological sustainability

Utilizing potato leaf as livestock feed diminishes the necessity for synthetic fertilizers and pesticides, as the plant remnants are repurposed rather than incinerated or disposed of. These results in reduced greenhouse gas emissions and enhanced soil health [41].

Enhanced livestock well-being

The elevated protein and vitamin levels in potato leaves can improve the growth and immunity of animals, especially in areas with little access to quality feed [42].

Obstacles and safeguards

Although potato leaves and stems provide various advantages, their utilization as fodder presents certain challenges:

- **Concerns regarding toxicity:** The presence of glycoalkaloids (solanine and chaconine) in potato leaf might be detrimental to animals if ingested in excessive amounts. Research indicates that a secure inclusion rate is below 20% of the overall diet for ruminants and under 10% for monogastric species such as pigs and poultry [43].
- **Processing specifications:** To mitigate toxicity, potato leaves may be desiccated, ensiled, or subjected to thermal treatment. Drying diminishes solanine concentrations by as

much as 50%, although ensiling (fermentation) can further decrease these levels [43,45].

- **Seasonal availability:** Potato leaf is exclusively accessible during the growing season, hence restricting its utility as a perennial feed source. Effective storage techniques, including silage production, can enhance its longevity [46].

Case studies and success stories

In various potato-producing countries, especially India and China, the use of potato leaves as an alternative animal feed resource has demonstrated significant potential [47]. These nations possess extensive regions dedicated to potato agriculture, and the above-ground biomass-particularly the foliage and stems frequently remains unutilized or is discarded post-harvest. Through the use of novel feed management practices, farmers and researchers have successfully converted this agricultural by-product into a valuable nutritional resource, enhancing both livestock production and farm profitability [25].

In India, where smallholder dairy farming is prevalent, potato foliage has been effectively integrated into the diets of crossbred cows and buffaloes during periods of fodder scarcity [48]. Dairy producers in the Firozabad district of Uttar Pradesh observed significant enhancements in milk output upon the incorporation of potato leaves at safe levels into cattle diet. Controlled feeding trials shown that substituting 10 - 15% of standard green fodder with sun-wilted potato leaves resulted in a 15 - 20% enhancement in daily milk production, with no negative impact on animal health (Singh., *et al*. 2015). Farmers credited this enhancement to the comparatively elevated crude protein content and palatability of the leaves, which promoted feed consumption and improved rumen microbial activity [49]. This integration also lowered feed expenses, as potato leaves was abundantly accessible at no extra cost during harvest periods [46].

In China, where goat rearing is a significant economic activity in rural and semi-arid areas, researchers investigated the incorporation of potato leaf into the diets of small ruminants [50]. Research conducted in Yunnan province revealed that goats receiving diets with 15% dried and processed potato foliage showed markedly superior average daily weight gains and enhanced feed conversion efficiency compared to control groups that were exclusively fed traditional forages like alfalfa and maize stover [51]. The enhancement was associated with the digestible protein fraction and the existence of secondary metabolites in potato leaves that may have favorably affected rumen fermentation processes [25]. Furthermore, producers said that goats consuming potato foliage had shinier coats and attained greater market value owing to improved body condition ratings [51].

These case studies illustrate the dual advantages of integrating potato leaves into livestock diets: (1) improving animal performance regarding milk production, growth rates, and overall health, and (2) fostering sustainable resource use by minimizing agricultural leftover waste. These success stories emphasize the importance of appropriate processing and regulated inclusion rates to reduce possible glycoalkaloid toxicity, hence ensuring safe and effective application in animal feeding systems [25].

Methods for integrating potato foliage into animal diets

- **Harvesting:** Harvest potato leaves and stems at the late vegetative stage, ideally 50 - 60 days post-planting and prior to blooming, to maximize crude protein content (15 - 20%) and minimize glycoalkaloid levels. Delayed harvesting may lead to heightened toxicity and diminished palatability [49].
- **Processing:** Adequate processing is essential for safe utilization. Sun-drying for 2 - 3 days can diminish moisture content and decrease glycoalkaloid levels, whilst ensiling with molasses or other carbohydrate-rich substances for 30 - 45 days can further detoxify the leaves and enhance digestibility [52]. Ensiling is very efficient in humid environments where desiccation is difficult.
- **Mixing:** Combine potato foliage with additional feed resources-such as Napier grass, maize stover, or leguminous forages-to achieve a balanced nutritional composition and mitigate potential toxicities. Suggested inclusion rates generally range from 10 - 20% of the overall diet for ruminants and 5 - 10% for monogastrics [47].
- **Surveillance:** Consistently assess animals for initial indicators of toxicity, such as diminished feed consumption, increased salivation, gastrointestinal distress, or diarrhea. Modify the inclusion rate or cease usage if symptoms manifest. Conducting laboratory analyses of glycoalkaloid concentrations before to consumption can assist in preserving safety thresholds.

Summary

The escalating global demand for animal products, propelled by population increase, is intensifying pressure on livestock farmers to identify sustainable, economical, and nutrient-dense feed options. A potential but underutilized option is potato foliage, comprising the leaves and stems of Solanum tuberosum. This biomass, generated in substantial amounts as a by-product of potato farming, frequently goes to waste despite its considerable nutritional value, which includes 15 - 20% crude protein, notable fiber, vitamins, and vital minerals. Research and practical experiences in nations such as India and China indicate that including potato leaves into animal diets can augment milk production, promote weight gain, and reduce feed expenses by as much as 40%. Environmental advantages encompass diminished agricultural waste, reduced greenhouse gas emissions, and a lesser dependence on chemical fertilizers. Nonetheless, its application is constrained by the presence of glycoalkaloids (solanine and chaconine), which may be hazardous when ingested in substantial amounts. Safe use necessitates appropriate harvesting, processing (drying, ensiling, or heat treatment), and regulated inclusion rates-typically under 20% for ruminants and 10% for monogastrics. Seasonal availability also requires preservation techniques such as silage. Case studies demonstrate that, with proper management, potato leaves can serve as an effective feed additive, providing nutritional, economic, and environmental benefits.

Conclusion

Potato leaf serves as a feasible and sustainable alternative feed resource for livestock production, especially in areas experiencing feed shortages and elevated conventional feed prices. Its abundant nutritional composition, extensive accessibility, and capacity to diminish waste and production costs render it a significant enhancement to animal meals. Successful integration, however, relies on meticulous regulation of glycoalkaloid toxicity by appropriate processing, modest inclusion rates, and diligent animal monitoring. By using these precautions, farmers can achieve both greater animal performance and increased environmental sustainability. The recorded achievements from India and China highlight its potential for wider implementation in global livestock systems, fostering resilient, economical, and environmentally sustainable animal husbandry techniques.

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