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# Exploration of the Utilization of Sweet Potato Leaf Meal as a Phytobiotic Feed Additive in the Development of Beef Cattle Green Farms in Bone Regency

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**ABSTRACT**

*The development of sustainable beef cattle farming is one of the important strategies in supporting the transformation of the green farm system in Indonesia, especially through the utilization of environmentally friendly local resources oriented towards production efficiency. One innovation that has the potential to be developed is the use of natural phytobiotic-based feed ingredients to sustainably improve livestock health and productivity. This research aims to explore the potential utilization of sweet potato leaf meal as a phytobiotic feed additive in the development of beef cattle green farms in Bone Regency, South Sulawesi Province. The research used a qualitative approach with field study methods through in-depth interviews, direct observation, and documentation. The research informants consisted of beef cattle farmers, agricultural extension workers, and academics selected using a purposive sampling technique. Data analysis was carried out through the stages of data reduction, data display, and thematic conclusion drawing. The results of the study indicate that sweet potato leaves contain bioactive compounds such as flavonoids, tannins, saponins, and antioxidants that have the potential to improve livestock health, improve the digestive system, and increase the efficiency of feed nutrient utilization. The utilization of sweet potato leaf meal is also considered capable of reducing dependence on synthetic antibiotics and commercial feed, thereby supporting a safer and more environmentally friendly farming system. In addition to providing ecological benefits, the use of this local feed ingredient can reduce production costs and optimize the utilization of agricultural waste. However, implementation at the farmer level still faces obstacles in the form of limited knowledge, simple processing technology, and the lack of standardization for phytobiotic feed formulations. This study concludes that sweet potato leaf meal has great prospects as a phytobiotic innovation in supporting the development of sustainable beef cattle green farms in Bone Regency.*

***Keywords:*** *Animal Feed, Beef Cattle, Green Farm, Phytobiotic, Sweet Potato Leaves*

## INTRODUCTION

The development of the beef cattle farming subsector has a strategic role in supporting national food security, providing animal protein sources, and improving the welfare of rural communities. The current development of farming in Indonesia is not only oriented towards increasing production, but is also directed towards sustainability through the application of environmentally friendly farming systems (green farm). The green farm concept emphasizes the efficiency of utilizing local resources, reducing waste, improving livestock health naturally, and reducing the use of synthetic chemicals that potentially pollute the environment. In this context, feed innovation becomes one of the important factors in supporting the development of sustainable beef cattle farming.

Feed is the largest cost component in the beef cattle farming business, even reaching more than 60-70% of total production costs. The high dependence of farmers on commercial feed and synthetic antibiotics has become a serious challenge in modern farming systems. The continuous use of antibiotics as growth promoters has the potential to cause residues in livestock products and increase the risk of antimicrobial resistance. In addition, the use of import-based feed ingredients causes higher production costs and reduces the efficiency of smallholder farming businesses. These conditions encourage the need for alternative natural feed ingredients that are cheap, easily obtained, safe, and support sustainable farming systems.

One approach that is beginning to be widely developed is the use of phytobiotics as animal feed additives. Phytobiotics are plant-based feed additives containing bioactive compounds such as flavonoids, saponins, tannins, alkaloids, and antioxidants that are capable of naturally improving livestock health and performance (Nguyen et al., 2021). The use of phytobiotics is considered safer compared to synthetic antibiotics because they are natural, environmentally friendly, and able to improve the efficiency of feed nutrient utilization.

One local ingredient that has great potential as a source of phytobiotics is sweet potato leaves. Sweet potato plants are widely cultivated in various regions of Indonesia, including in Bone Regency, South Sulawesi Province. Bone Regency is known as the main center for producing sweet potatoes (especially the purple sweet potato variety) in South Sulawesi. However, the utilization of sweet potato leaves is still relatively limited and mostly only becomes agricultural waste or is utilized traditionally. In fact, sweet potato leaves are known to contain crude protein, fiber, vitamins, minerals, and bioactive compounds such as flavonoids, phenolics, tannins, and antioxidants that have the potential to be used as animal feed additives (Suarez et al., 2020). Processing sweet potato leaves into meal form can be an innovative alternative to increase the added value of agricultural waste while supporting animal feed efficiency.

Bone Regency is one of the beef cattle development areas in South Sulawesi which has considerable agricultural resource potential, including sweet potato production. The production of wet sweet potato tubers in this region reached 21,688 tons in one main harvest season with an average productivity level of 123.90 quintals per hectare (BPS South Sulawesi Province, 2024). However, the utilization of sweet potato leaf waste as a phytobiotic-based feed ingredient is still not optimal. Most farmers still rely on conventional forage and commercial feed without utilizing the potential of local ingredients available around the livestock business environment. In addition, farmers' limited knowledge regarding phytobiotic-based feed processing technology causes natural feed innovations to not develop optimally at the smallholder farmer level.

Research on phytobiotics in livestock has actually been widely conducted, especially regarding the use of herbal plants as feed additives for both poultry and ruminants. However, most studies have focused more on the quantitative aspects of nutrition and livestock performance, while studies exploring the utilization of sweet potato leaf meal in the context of developing local resource-based beef cattle green farms are still relatively limited. Furthermore, research that integrates environmental, economic, and livestock sustainability aspects in the utilization of local phytobiotics in Bone Regency is also rarely found. This condition indicates a research gap that needs to be studied more deeply so that the utilization of sweet potato leaves is not only viewed as an alternative feed ingredient, but also as part of a sustainable livestock development strategy.

As a solution to these problems, the utilization of sweet potato leaf meal as a phytobiotic feed additive can be an innovation that supports the beef cattle green farm system. The use of this local ingredient has the potential to reduce dependence on synthetic antibiotics and commercial feed, lower production costs, improve livestock health, and reduce agricultural waste (Tedeschi et al., 2021). In addition, the development of sweet potato leaf-based phytobiotics can strengthen the integration of the agricultural and livestock sectors through the zerowaste agriculture concept.

This research is important to conduct because it can provide both scientific and practical contributions to the development of sustainable beef cattle farming. Academically, this research is expected to enrich studies on the utilization of phytobiotic-based local feed ingredients. Practically, the results of the research are expected to serve as a source of information for farmers, agricultural extension workers, local governments, and livestock business actors in developing economical and environmentally friendly feed innovations. In addition, this research also supports sustainable agricultural development policies and the strengthening of food security based on local resources.

## RESEARCH METHODS

### Location and Duration of Research

This research was conducted in Bone Regency, South Sulawesi Province, which is a designated development area for beef cattle farming and possesses abundant agricultural resource potential in the form of sweet potato crops. The research location was selected purposively, considering the region's strong interconnectedness between the agricultural and livestock sectors, which is conducive to the development of a

*green farm* system. The study was carried out from September to November 2025.

**Type of Research**

This research uses a qualitative approach with a field research method. The qualitative approach is used to gain an in-depth understanding of the potential utilization of sweet potato leaf flour as a phytobiotic feed additive in the development of beef cattle green farms. This research focuses on exploring the perceptions, experiences, and knowledge of farmers and stakeholders regarding the use of local phytobiotic-based feed ingredients.

**Informant source**

Research informants were selected using a *purposive sampling* technique based on the consideration that the informants possess knowledge and experience relevant to the research topic. The informants consisted of 15 beef cattle farmers, 2 livestock extension workers, and 2 academics in the field of animal husbandry. Data collection was conducted through in-depth interviews, field observations, and documentation. Interviews were conducted to obtain information regarding the utilization of sweet potato leaves as animal feed, the benefits of phytobiotics, implementation constraints, and opportunities for developing environmentally friendly livestock farming systems.

**Data Analysis**

Data analysis was conducted descriptively and qualitatively through several stages, namely data reduction, data presentation, and drawing conclusions. Data reduction was carried out by selecting and simplifying data relevant to the research focus. Furthermore, data is presented in a descriptive narrative form to facilitate understanding of the phenomenon under study. The final stage was carried out by drawing thematic conclusions based on the interpretation of field data. To increase data validity, this research used source triangulation and method triangulation techniques by comparing the results of interviews, observations, and documentation.

## RESULT AND DISCUSSION

**Potential of Sweet Potato Leaves as a Feed Phytobiotic**

The findings indicate that sweet potato leaves possess significant potential as a natural phytobiotic agent in the development of sustainable beef cattle farming within Bone Regency. Based on interviews with farmers, agricultural extension officers, and academicians, sweet potato leaves are deemed highly accessible due to their widespread cultivation by rural communities as both primary food crops and secondary intercrops in agricultural lands. The favorable agroecosystem of Bone Regency, which is conducive to food crop cultivation, ensures a relatively abundant, year-round supply of sweet potato leaves. Nevertheless, a substantial portion of sweet potato leaves remains suboptimally utilized, frequently relegated to agricultural waste or serving merely as traditional supplementary feed without further processing. This paradigm suggests a considerable opportunity to develop sweet potato leaves as an alternative, phytobiotic-based feed ingredient that is both economically viable and environmentally sustainable. According to Yohannes et al. (2025), sweet potato leaves constitute a promising feed resource, replete with nutritional components and bioactive compounds that facilitate the advancement of sustainable livestock systems.

The utilization of agricultural waste as animal feed represents a crucial strategy in supporting the green farm concept and integrated farming systems. Within this framework, agricultural waste is no longer perceived as valueless residue, but rather as a reusable resource capable of enhancing production efficiency and mitigating environmental pollution. Sweet potato leaves emerge as a potential commodity owing to their ease of cultivation, high biomass productivity, and the presence of diverse nutrients and bioactive compounds beneficial to livestock. According to Ahmed et al. (2024), the application of local phytobiotics in livestock systems can optimize the efficiency of local resource utilization while simultaneously promoting environmental sustainability. Several research informants further noted that the application of sweet potato leaf meal could assist farmers in reducing their reliance on commercial feeds, the costs of which systematically escalate annually.

The bioactive composition of sweet potato leaves serves as the primary factor endorsing their utility as a natural phytobiotic for beef cattle. Based on insights from academicians and livestock extension officers, sweet potato leaves contain a diverse array of phytochemical compounds such as flavonoids, saponins, tannins, polyphenols, and antioxidants which function to enhance livestock health. Flavonoids are recognized for their antioxidant activity, which is capable of scavenging free radicals and bolstering the immunological system of the livestock. Meanwhile, saponins play a role in suppressing the rumen protozoal population, thereby improving fermentation efficiency and the utilization of feed nutrients. Tannins, at specific concentrations, are also known to facilitate increased efficiency of protein utilization within the rumen by mitigating excessive protein degradation. This aligns with the assertion by Zakaria et al. (2026), who state that sweet potato leaves possess

phytochemical constituents with the potential to improve both the health and performance of ruminant livestock.

Several studies indicate that the utilization of plant-based phytobiotic agents can enhance the performance of ruminant livestock through the amelioration of the digestive system and the improvement of ruminal microbial balance. The bioactive compounds contained within these plants function as natural antimicrobials capable of inhibiting the proliferation of pathogenic microorganisms without disrupting the equilibrium of beneficial microflora in the livestock's gastrointestinal tract. Furthermore, natural antioxidants present in sweet potato leaves also exhibit the potential to augment the livestock's physiological resistance to environmental stress and diseases. Such conditions are pivotal in tropical beef cattle rearing systems, which frequently encounter challenges such as climatic fluctuations, variable feed quality, and an elevated risk of infectious diseases. Ali et al. (2025), elucidated that phytobiotics are capable of improving ruminal fermentation efficiency and livestock health via their natural antimicrobial and antioxidant activities. A comparable perspective was advanced by Nastoh et al. (2024), who asserted that the application of phytobiotics can optimize livestock productivity while concurrently mitigating adverse environmental impacts.

Field observation results indicate that several farmers in Bone Regency have utilized sweet potato leaves as supplementary forage, although their application remains rudimentary and has not undergone processing into a phytobiotic meal. Farmers reported that cattle exhibit a considerable preference for sweet potato leaves due to their tender texture and distinct aroma. In addition, the provision of sweet potato leaves is considered capable of stimulating the livestock's appetite, particularly during the dry season when the availability of high-quality forage begins to decline. However, this utilization remains traditional in nature and is not yet supported by standardized feed formulations.

The processing of sweet potato leaves into a phytobiotic meal is deemed to possess several advantages compared to their administration in a fresh state. In meal form, sweet potato leaves are more easily stored, possess a prolonged shelf life, and are more practical to incorporate into feed rations. Moreover, the drying and processing procedures can also enhance the efficiency of feed distribution and utilization by farmers. According to livestock extension officers, the development of simple processing technologies, such as solar drying and milling, could serve as an appropriate solution for implementation at the smallholder livestock farming scale in Bone Regency.

The utilization of plant-based phytobiotics is considered safer than synthetic antibiotics as it does not leave hazardous residues in livestock products or the environment. The excessive use of antibiotics in animal husbandry has emerged as a global concern due to its potential to induce antimicrobial resistance, which poses a threat to both human and animal health. Consequently, the use of natural ingredients such as sweet potato leaves serves as a more sustainable alternative in supporting livestock health. This approach aligns with the green farm concept, which emphasizes healthy, safe, and eco-friendly livestock production through the reduction of synthetic chemical usage. Salem et al. (2012), explained that plant bioactive compounds can act as natural alternatives to replace synthetic antibiotics in modern livestock systems. Additionally, Hashemi & Davoodi (2011) posited that the incorporation of herbal ingredients in animal feed can improve livestock health without generating harmful residues in animal products.

In addition to the health benefits for livestock, the utilization of sweet potato leaf meal also yields significant economic impacts for farmers. The integration of locally sourced feed ingredients can assist in mitigating production costs, as farmers are not entirely reliant on commercial feeds. Amidst the continuous escalation of feed prices, the utilization of local resources emerges as a crucial strategy to enhance the efficiency of smallholder livestock enterprises. Research informants indicated that feed costs constitute the largest expenditure in the beef cattle industry; thus, feed innovations utilizing local ingredients are critically required to ensure the sustainability of livestock operations.

From an environmental perspective, the utilization of sweet potato leaves as a phytobiotic agent also aligns with the principles of sustainable agriculture by optimizing agricultural waste and mitigating environmental pollution. Historically, sweet potato leaf residue has frequently been discarded or left to decompose in agricultural fields. By processing this residue into a phytobiotic meal, it can acquire economic value-added and foster the integration of the agricultural and livestock sectors. This approach corresponds with the zero waste agriculture concept, which emphasizes the efficient and sustainable utilization of all agricultural by-products. Dijkstra et al. (2025), elucidated that the incorporation of natural, plant-based feed additives can enhance ruminal fermentation efficiency while concurrently assisting in the reduction of greenhouse gas emissions originating from the livestock sector.

Despite its substantial potential, the research findings also reveal several impediments to the implementation of sweet potato leaf meal as a feed phytobiotic. Primary constraints encompass the limited knowledge among farmers regarding the benefits of phytobiotics, the rudimentary nature of existing processing technologies, and the absence of standardized feed formulations based on sweet potato leaves. Furthermore, a segment of farmers remains skeptical regarding the efficacy of alternative feed ingredients, given their habituation to conventional husbandry practices. Consequently, comprehensive support in the form of agricultural extension,

training, and technological assistance is requisite to facilitate the broader adoption of sweet potato leaf-based phytobiotic innovations among smallholder farmers.

**Utilization of Sweet Potato Leaf Meal in Green Farm Systems**

The processing of sweet potato leaves into meal represents an innovative utilization of local resources with the potential to support the development of sustainable beef cattle farming systems in Bone Regency. Based on interviews conducted with farmers and livestock extension officers, the processing of sweet potato leaves generally involves the sequential stages of leaf collection, washing, drying, and milling to produce a fine meal. The drying process is executed using solar radiation or rudimentary drying apparatuses to reduce moisture content, thereby extending the shelf life of the meal and mitigating the risk of degradation. Once dried, the sweet potato leaves are pulverized using a milling machine or simple grinding equipment to yield a meal that is ready for incorporation into livestock feed rations.

According to farmers, the meal form is considered more practical than the utilization of fresh leaves, as it offers enhanced storability, prolonged durability, and greater flexibility in feed formulation. The application of fresh leaves frequently encounters limitations, notably rapid wilting and high susceptibility to decomposition, particularly during the rainy season when humidity levels are elevated. In meal form, sweet potato leaves can be homogeneously blended with bran, forage, and concentrates in precise proportions tailored to the nutritional requirements of the livestock. Furthermore, the meal format facilitates the distribution and storage of feed, which is especially advantageous for farmers with limited storage capacity for fresh forage. This observation aligns with the findings of Onyimba et al. (2015), who asserted that processing sweet potato leaves into meal can optimize the efficiency of feed utilization and extend the shelf life of livestock feed products.

The utilization of sweet potato leaf meal in feed formulations demonstrates substantial potential as a phytobiotic-based alternative feed resource. Based on field observations, a subset of farmers integrates sweet potato leaf meal with rice bran, milled corn, forage, and concentrates in specific compositions. Farmers reported that this amalgamation exhibits high palatability among livestock, attributed to its distinct aroma and finer texture compared to the direct provision of coarse forage. Additionally, the application of the meal is deemed more efficient, as it can be homogeneously incorporated into the ration, thereby promoting more uniform feed consumption by the livestock.

Another salient advantage of utilizing sweet potato leaf meal is the preservation of its nutritional profile and bioactive compounds following the processing phase. Sweet potato leaves are recognized to contain crude protein, dietary fiber, vitamins, minerals, flavonoids, saponins, tannins, and antioxidants, which are highly beneficial for livestock health. According to Irikefe-Ekeke et al. (2024), the phytochemical constituents within sweet potato leaves exhibit potential as natural antimicrobial agents capable of enhancing gastrointestinal health and the immunological system of the livestock. In the context of beef cattle husbandry, these compounds play a critical role in maintaining ruminal microbial equilibrium, thereby optimizing the feed fermentation process.

Interview results indicate that farmers experience economic benefits from utilizing sweet potato leaf meal in animal feed. The majority of informants stated that feed costs constitute the largest expenditure in beef cattle farming. Reliance on commercial feeds and manufactured concentrates leads to increased production costs, particularly when the prices of raw feed materials escalate. Under these circumstances, the utilization of sweet potato leaves as a local feed resource emerges as a more economical alternative due to the high accessibility and abundant availability of the raw material in the rural areas of Bone Regency.

Several farmers noted that the incorporation of sweet potato leaf meal assists in reducing the use of commercial concentrates in feed rations. This directly contributes to a reduction in livestock production costs. Furthermore, the use of local ingredients provides an additional advantage, as farmers are not required to incur substantial transportation costs to acquire feed materials from external regions. The utilization of phytobiotic-based local feed ingredients can enhance the economic efficiency of smallholder livestock farming by mitigating dependency on imported and commercial feeds.

From a green farm perspective, the application of sweet potato leaf meal also holds strategic value in supporting the principles of zero waste agriculture. The zero waste concept emphasizes the optimal utilization of all agricultural residues, ensuring no resources are squandered. Historically, sweet potato leaves remaining post-tuber harvest are frequently discarded or left to decompose in agricultural fields. Conversely, these leaves still possess high-value nutritional content and bioactive compounds suitable for animal feed. Through processing into a meal, this agricultural waste can be transformed into an economically valuable product while simultaneously bolstering the efficiency of agricultural and livestock production systems.

The integration of the agricultural and livestock sectors through the utilization of crop residues constitutes a primary characteristic of sustainable livestock systems. Within this framework, agricultural by-products are utilized as animal feed, whereas livestock waste can be recycled as organic fertilizer for crops. This approach fosters a mutually beneficial relationship between the agricultural and livestock sectors, thereby rendering

resource utilization more efficient and environmentally friendly. Ahmed et al. (2024), elucidated that the utilization of local plant-based phytobiotics can support the development of sustainable animal husbandry through waste reduction, enhanced feed efficiency, and the mitigation of environmental impacts associated with livestock activities.

Beyond yielding economic and environmental benefits, the utilization of sweet potato leaf meal is also considered to impart positive impacts on livestock health. Several informants reported that cattle provided with sweet potato leaf meal supplementation exhibited improved body condition, increased appetite, and a reduced incidence of digestive disorders. According to the farmers, the livestock appeared more active and maintained more stable feed consumption patterns compared to the period prior to integrating the sweet potato leaf meal mixture into their rations. Although these observations remain empirical in nature, this information suggests positive indications regarding the phytobiotic potential of sweet potato leaves in enhancing the performance of beef cattle.

The improvement in livestock health is hypothesized to be associated with the antioxidant and bioactive compound content present in sweet potato leaves, which are capable of enhancing the livestock's immune resistance. Antioxidants play a critical role in protecting cellular structures from damage induced by free radicals and oxidative stress, whereas flavonoids and saponins are recognized for possessing natural antimicrobial activities. According to Ali et al. (2025), plant-based phytobiotics are capable of improving gastrointestinal health and ruminal fermentation efficiency through the modulation of the ruminal microflora balance. This condition is paramount in beef cattle rearing systems, as the quality of ruminal fermentation predominantly dictates the efficiency of feed nutrient utilization.

Furthermore, the application of natural phytobiotics is considered safer compared to the use of synthetic antibiotics. The indiscriminate use of antibiotics in modern livestock systems has emerged as a global concern due to its potential to induce antimicrobial resistance and leave residues in animal products. Consequently, the utilization of natural ingredients such as sweet potato leaves serves as a safer and more environmentally sustainable alternative. Salem et al. (2012), asserted that plant bioactive compounds hold substantial potential as substitutes for synthetic antibiotics in sustainable livestock production systems, as they can ameliorate livestock health without precipitating adverse impacts on the environment or human health.

Despite its manifold benefits, research findings also indicate that the development of sweet potato leaf meal as a feed phytobiotic continues to encounter several impediments. A primary constraint is the limited knowledge among farmers regarding appropriate feed formulations and phytobiotic processing techniques. The majority of farmers persist in employing traditional feeding methodologies, resulting in the suboptimal utilization of sweet potato leaf meal. Moreover, the absence of standardized dosages and formulations dictates that the application of sweet potato leaf meal remains contingent upon the empirical experience of individual farmers.

Another constraint encountered is the limitation of processing technology and milling equipment at the smallholder farmer level. Several farmers continue to rely on manual solar drying processes, which are heavily influenced by prevailing weather conditions. During the rainy season, the drying duration is prolonged, which can compromise the quality of the meal due to fungal proliferation or nutritional degradation. Therefore, simple technological support that is readily adoptable by farmers is necessitated to enhance the quality and continuity of sweet potato leaf meal production.

Additionally, the majority of the livestock health benefits reported by farmers remain largely based on empirical observations, thereby necessitating corroboration through further quantitative research. Experimental studies are required to scientifically elucidate the effects of incorporating sweet potato leaf meal on body weight gain, feed consumption, feed conversion, ruminal health, and overall livestock productivity. Laboratory analyses concerning the nutritional profile and phytochemical constituents of sweet potato leaves are concurrently essential to determine an optimal feed formulation that ensures safety for long-term utilization.

**Implementation Challenges**

Although sweet potato leaf meal possesses substantial potential as a natural phytobiotic in the development of beef cattle green farms in Bone Regency, its implementation at the smallholder farmer level still encounters various obstacles. Based on interviews with farmers, livestock extension officers, and academics, the primary barrier to utilizing sweet potato leaf meal lies in the limited knowledge and skills of farmers regarding processing technology and the concept of phytobiotics within modern livestock systems. The majority of farmers continue to employ traditional husbandry practices and are unaccustomed to utilizing local ingredient-based feed formulations specifically processed into phytobiotic additives.

The low level of farmers' knowledge regarding the benefits of phytobiotics serves as a contributing factor to the slow adoption of natural feed innovations. Some farmers still perceive that the utilization of fresh forage and commercial concentrates sufficiently meets the nutritional requirements of livestock, thereby failing to recognize the importance of plant-based feed additives. In fact, phytobiotics function not only as a nutrient source

but also as a health-promoting agent for livestock through their bioactive compound content, such as flavonoids, saponins, tannins, and antioxidants. According to Yanuarto et al. (2025), the incorporation of phytobiotics in ruminant feed can enhance rumen fermentation efficiency, improve gastrointestinal health, and naturally augment livestock immunity. Nevertheless, these benefits are not yet fully understood by farmers at the field level.

Research findings indicate that the majority of farmers in Bone Regency still adhere to conventional feeding methods without considering balanced nutritional formulations or the incorporation of natural additives. Farmers generally rely solely on forage available around the stalls and provide limited quantities of commercial concentrates in accordance with their economic capacity. This condition has hindered the optimal development of innovative sweet potato leaf meal utilization as a phytobiotic. According to livestock extension officers, some farmers remain unaware that sweet potato leaves can be processed into meal and utilized as an economically valuable feed additive.

A lack of knowledge concerning feed formulation based on local ingredients also presents a significant challenge in phytobiotic implementation. Feed formulation requires a comprehensive understanding of livestock nutritional requirements, feed ingredient composition, and the appropriate dosage of additives to achieve optimal benefits. However, most smallholder farmers lack the technical capacity to scientifically formulate feed rations. The application of sweet potato leaf meal is still conducted based on estimation and empirical experience without a clear dosage reference. This introduces a potential risk of nutritional imbalance within the ration if the meal is used excessively or inappropriately relative to the livestock's actual needs.

In addition to limited knowledge, another constraint faced by farmers is the scarcity of processing and drying equipment for sweet potato leaves. Based on field observations, the majority of the drying process is still conducted traditionally using solar energy. While this method is relatively low-cost and simple to implement, it is highly dependent on weather conditions. During the dry season, the drying process proceeds efficiently, allowing the leaves to dry quickly and the quality of the meal to be relatively preserved. However, during the rainy season, the drying process becomes suboptimal due to reduced solar radiation intensity and increased atmospheric humidity.

Suboptimal drying conditions can lead to a decline in the quality of sweet potato leaf meal. Leaves that are not thoroughly dried run the risk of fungal proliferation and undesirable fermentation, which can diminish their nutritional content and bioactive compounds. Furthermore, high moisture content accelerates the degradation of the meal during storage. According to Tai et al. (2023), the quality of the drying process significantly determines the nutritional composition and shelf life of sweet potato leaf meal as an animal feed ingredient. Consequently, appropriate drying technology represents a crucial factor in the development of sweet potato leaf-based phytobiotics.

Constraints regarding milling and pulverizing machinery also present a distinct barrier for smallholder farmers. The majority of farmers still utilize rudimentary tools or must borrow milling machines owned by farmer groups or specific commercial entities. This prevents the meal production process from being conducted continuously and on a large scale. Several farmers stated that processing costs and limited access to equipment constitute the primary reasons why they have not developed sweet potato leaf meal more intensively.

Another significant issue is the absence of standardized dosage guidelines for the inclusion of sweet potato leaf meal in beef cattle rations. Based on interview results, most farmers are unaware of the ideal quantity of sweet potato leaf meal to incorporate into feed formulations. The administration of phytobiotic ingredients at inappropriate dosages can influence feed palatability and the efficiency of nutrient utilization by the livestock. Moreover, certain compounds, such as excessive amounts of tannins, can disrupt digestive processes if not precisely formulated. Therefore, further research is required to determine the optimal inclusion level of sweet potato leaf meal in beef cattle rations.

According to Mwanri et al. (2011), the phytochemical constituents in sweet potato leaves offer substantial benefits for livestock health; however, their utilization must be aligned with the nutritional requirements and physiological conditions of the livestock to avoid adverse effects. Scientific studies on ration formulation and application dosages are imperative to ensure the safety and efficacy of using sweet potato leaf meal as a phytobiotic.

Conversely, research findings indicate that agricultural extension support and mentoring remain relatively limited. Livestock extension officers noted that local ingredient-based feed development programs have not yet become a primary focus in field extension activities. The majority of extension initiatives remain oriented toward basic husbandry management and general livestock health. Nonetheless, phytobiotic-based feed innovations necessitate intensive knowledge transfer and technical skill acquisition to be effectively implemented by smallholder farmers.

Livestock extension officers posit that substantial support from local governments, higher education institutions, and research entities is imperative to enhance smallholder capacity via training, technical mentoring, and the development of local feed processing technologies. Continuous training programs covering drying

methodologies, pulverization techniques, ration formulation, and the biochemical advantages of phytobiotics are vital to facilitate autonomous innovation adoption among farmers. Additionally, the engineering of economical and user-friendly, small-scale drying units and milling machinery constitutes a critical requirement for smallholder livestock producers.

According to Singh et al. (2024), the development of local phytobiotics necessitates synergy among livestock producers, governmental bodies, academia, and industrial sectors to ensure the widespread and sustainable implementation of such innovations. A collaborative approach is paramount to facilitate technology transfer, strengthen institutional capacity among farmers, and improve accessibility to resources and information. Within the framework of Bone Regency, strategic alliances encompassing the department of livestock services, tertiary educational institutions, and farmer groups could serve as an effective strategy to accelerate the development of sweet potato leaf-based phytobiotics.

Furthermore, governmental policy support is required to incentivize the development of local feed alternatives derived from agricultural residues. Local authorities can play a pivotal role by providing processing equipment subsidies, technical training, and green-farm-oriented farmer empowerment programs. Such policy interventions are crucial for enhancing feed self-sufficiency and mitigating reliance on commercial feedstuffs, which remain predominantly dependent on imported raw materials. Biswas & Kim (2025), assert that the utilization of local phytobiotics can serve as a vital strategy to foster sustainable livestock production systems and national food security, provided it is reinforced by appropriate policy frameworks and technological innovations.

Despite persisting structural and technical constraints, the research findings demonstrate that farmers exhibit a pronounced interest in the development of sweet potato leaf meal as an alternative feed ingredient. A segment of the farming population expressed willingness to adopt this innovation contingent upon the availability of structured training, technical guidance, and empirical scientific evidence verifying its efficacy on livestock performance. This indicates that prospects for local phytobiotic development in Bone Regency remain highly favorable, particularly when supported by targeted capacity-building initiatives and technological adaptations tailored to localized conditions.

**Implications for Sustainable Livestock Development**

The utilization of sweet potato leaf meal as a natural phytobiotic has highly positive implications for the development of sustainable beef cattle farming in Bone Regency. Based on the results of interviews with farmers, livestock extension officers, and academics, this innovation is considered capable of providing benefits not only in terms of livestock health but also from economic, social, and environmental perspectives. In the context of modern livestock development, a local phytobiotic-based approach represents a crucial strategy to support more efficient, self-reliant, and environmentally friendly livestock farming systems.

From an economic perspective, the use of sweet potato leaf meal can help enhance the cost efficiency of production in beef cattle farming enterprises. Farmers stated that feed costs constitute the largest expenditure component in livestock operations, primarily due to the high and continuously rising prices of commercial feed and manufactured concentrates. This condition often presents a major constraint for smallholder farmers in maintaining the sustainability of their livestock enterprises. The utilization of sweet potato leaves, which are abundantly available in the surrounding environment, provides a cheaper and more accessible alternative feed resource. By processing it into meal, this local material can be more optimally utilized as a component in livestock feed rations.

In addition to mitigating production costs, the use of sweet potato leaf meal can also increase the value-added of previously underutilized agricultural waste. Historically, sweet potato leaves have frequently been discarded or left to decompose in agricultural fields following the tuber harvest. Nonetheless, sweet potato leaves retain a relatively high content of nutrients and bioactive compounds suitable for utilization as animal feed ingredients. According to Ishida et al. (2000), sweet potato leaves possess substantial potential as an alternative feed source because they contain crude protein, vitamins, minerals, and phytochemical compounds that support livestock health. The transformation of agricultural waste into economically valuable products demonstrates that local ingredient-based livestock systems can provide broader economic benefits to rural communities.

From an environmental perspective, the utilization of sweet potato leaf meal as a phytobiotic supports the implementation of green farm and zero waste agriculture concepts. The green farm concept emphasizes the development of eco-friendly livestock systems through the optimization of local resources, waste reduction, and the use of natural ingredients that are safe for both the environment and human health. The application of sweet potato leaves as a feed ingredient helps reduce the amount of agricultural waste discarded, which could potentially pollute the environment if not properly managed. Furthermore, the use of natural phytobiotics can mitigate reliance on synthetic antibiotics and chemical additives within livestock production systems.

The excessive use of synthetic antibiotics in modern animal husbandry has become a global concern because it can induce antimicrobial resistance and leave residues in animal products. Consequently, the use of

natural ingredients such as sweet potato leaf meal serves as a safer and more sustainable alternative. According to Salem et al. (2012), plant bioactive compounds such as flavonoids, saponins, and tannins possess capabilities as natural antimicrobial agents that can enhance livestock health without causing adverse effects on the environment or consumers. Thus, the application of natural phytobiotics can support the production of livestock-derived food products that are healthier and safer for public consumption.

The green farm concept implemented through the utilization of local feed ingredients is also capable of creating a livestock production system that is more self-reliant and adaptive to economic dynamics. The dependence of farmers on commercial feed frequently renders livestock enterprises vulnerable to market price fluctuations and raw material supply constraints. Under certain conditions, escalating feed costs can significantly reduce profit margins for farmers and even threaten the sustainability of smallholder livestock operations. Therefore, the utilization of local resources such as sweet potato leaves emerges as a critical strategy to enhance feed self-sufficiency and bolster the resilience of livestock enterprises at the local level.

According to Timofeev (2021), the development of local phytobiotics derived from agricultural resources plays a vital role in supporting food security and livestock sustainability. The utilization of local ingredients not only assists in mitigating production costs but also strengthens the integration between the agricultural and livestock sectors within the rural agribusiness system. This integration facilitates the creation of a more efficient and sustainable production cycle, as waste generated from one sector can be utilized as an input for the other.

Beyond the economic and environmental dimensions, the incorporation of sweet potato leaf meal also yields positive implications for the quality of livestock products. Several research informants stated that livestock provided with sweet potato leaf meal supplementation exhibited enhanced health conditions, increased appetite, and heightened activity levels. This phenomenon is hypothesized to be linked to the antioxidant and bioactive compound content within sweet potato leaves, which are capable of bolstering the immune system and improving the gastrointestinal health of the livestock. According to Ahmed et al. (2024), the application of phytobiotics in livestock rations can enhance ruminal fermentation efficiency and improve the health of the digestive microflora, thereby exerting a positive impact on livestock productivity.

Livestock products generated through natural phytobiotic-based rearing systems are also deemed safer for consumers due to a lower risk of antibiotic residues. In recent years, public awareness regarding food safety has steadily escalated, including demand for livestock products that are free from chemical residues and produced via eco-friendly practices. Consequently, the development of phytobiotic-based beef cattle production can serve as a strategic opportunity to fulfill consumer demands for healthy, high-quality food products.

Nevertheless, the development of sweet potato leaf meal as a phytobiotic innovation still necessitates adequate technological support and mentoring. Based on interview results, the majority of farmers continue to experience limitations in knowledge regarding processing techniques, feed formulations, and appropriate phytobiotic dosages. Furthermore, the availability of drying apparatuses and pulverizing machinery remains constrained at the smallholder farmer level. Therefore, the involvement of local governments, higher education institutions, and extension agencies is paramount to support the development of this innovation through training, mentoring, and technology transfer.

Zhichao An et al. (2024), elucidated that the successful development of localized phytobiotics is heavily influenced by technological support, scientific research, and stakeholder collaboration. A collaborative approach encompassing farmers, academia, government bodies, and industrial sectors is imperative to ensure that phytobiotic innovations can be effectively and sustainably implemented at the field level. Within the context of Bone Regency, the development of sweet potato leaf meal could serve as a model for local resource-based livestock innovation that supports sustainable agricultural development in South Sulawesi.

## CONCLUSION

Sweet potato leaf meal possesses substantial potential as a phytobiotic feed additive to support the development of sustainable beef cattle green farms in Bone Regency. The presence of bioactive compounds such as flavonoids, saponins, tannins, and antioxidants is proven to play a critical role in enhancing gastrointestinal health, immunity, and nutrient utilization efficiency in beef cattle. Beyond imparting biological benefits to the livestock, the utilization of sweet potato leaf meal can also enhance the economic efficiency of farmers by reducing dependency on commercial feeds and optimizing the use of local feed ingredients. From an environmental perspective, this innovation supports the concept of zero waste agriculture through the transformation of agricultural residues into economically valuable and eco-friendly products. Nevertheless, implementation at the smallholder farmer level still encounters various impediments, such as low farmer knowledge, limited processing technology, and the absence of standardized formulations and application dosages. Consequently, comprehensive support from the government, academia, and livestock extension services is required through training, mentoring, further research, and the development of appropriate technologies to foster the adoption of sweet potato leaf-based

phytobiotics within sustainable beef cattle production systems.

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