



Sorghum-Based Complete Feed Innovation for Sustainable Livestock Development: A Collaborative Approach from Subang Regency, Indonesia

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Abstrak - Kabupaten Subang, Jawa Barat, memiliki potensi besar untuk pengembangan industri pakan ternak yang berkelanjutan, didukung oleh ketersediaan sumber daya hijauan yang melimpah serta keterlibatan aktif masyarakat dalam usaha peternakan ruminansia. Tantangan utama dalam pengembangan usaha peternakan di wilayah ini terletak pada optimalisasi sumber daya lokal dan kearifan lokal melalui program pengembangan kawasan usaha peternakan guna meningkatkan produktivitas. Upaya strategis dan berkelanjutan sangat penting untuk mencapai produktivitas dan efisiensi yang tinggi dalam usaha ternak sapi potong, dengan penyediaan pakan berkualitas sebagai salah satu faktor kunci. Kajian ini menyoroti peran *Sorghum bicolor* sebagai tanaman pakan alternatif karena kandungan nutrisinya yang tinggi, kemampuannya beradaptasi di lahan marginal, serta ketahanannya terhadap kekeringan. Melalui model kolaboratif yang melibatkan BRIN, PT Dahana, dan institusi pendidikan tinggi lokal, budidaya sorgum telah diintegrasikan dalam upaya inovasi berbasis masyarakat. Kajian ini menunjukkan bahwa sistem pakan lengkap berbasis sorgum layak secara teknis dan ekonomis, serta memberikan peluang untuk meningkatkan produktivitas ternak, mendukung kesejahteraan masyarakat pedesaan, dan mendorong tujuan nasional dalam diversifikasi pakan dan pangan.

Kata kunci: alih teknologi, ketahanan terhadap kekeringan, pengembangan hijauan pakan, peternakan sapi potong, produktivitas ternak, sorgum

Abstract - Subang Regency, located in West Java, Indonesia, possesses considerable potential for the development of a sustainable livestock feed industry, supported by abundant forage resources and strong community engagement in ruminant livestock farming. A key challenge in this development lies in optimizing local resources and traditional knowledge through livestock business area programs to enhance productivity. Strategic and sustained efforts are essential to improve efficiency and output in beef cattle production, with high-quality feed serving as a critical input. This study highlights *Sorghum bicolor* as a promising alternative forage crop due to its high nutritional value, adaptability to marginal soils, and resilience to drought. Utilizing a collaborative model involving the National Research and Innovation Agency (BRIN), PT Dahana, and local academic institutions, sorghum cultivation has been integrated into community-based innovation initiatives. The findings indicate that sorghum-based complete feed systems are both technically and economically feasible, presenting a strategic opportunity to enhance livestock productivity, improve rural livelihoods, and support national objectives for feed and food diversification.

Keywords: beef cattle farming, drought tolerance, forage development, livestock productivity, sorghum, technology transfer

I. INTRODUCTION

Subang Livestock farming plays a vital role in supporting rural economies across Indonesia, especially in regions with diverse agroecological landscapes. The availability of adequate and affordable feed is one of the primary factors that determines the success of livestock production systems. However, feed supply in many areas remains inconsistent, heavily dependent on conventional sources that are often vulnerable to climate variability and market fluctuations. This dependency underscores the urgent need for alternative, locally available feed resources to ensure sustainable livestock development yet studies exploring region-specific feed alternatives remain limited.

Subang Regency, located in West Java Province, Indonesia, is characterized by a combination of mountainous, lowland, and coastal areas, making it a diverse agroecological zone. With a population of

1,624,386 (BPS, 2023), the region relies significantly on agriculture, particularly livestock farming. Approximately 1,500 families in Subang depend on beef cattle and sheep production for their livelihoods. The region is also endowed with abundant agricultural by-products such as rice bran, cassava residue, and pineapple waste, which have been partially utilized as feed ingredients (Fathurohman & Sobari, 2016). Despite these local feed resources, optimization and innovation in feed formulation remain underexplored, limiting the efficiency and productivity of local livestock systems.

Among potential alternative feed crops, sorghum (*Sorghum bicolor* L.) has gained attention due to its adaptability to marginal conditions such as drought, waterlogging, and low soil fertility, as well as its resistance to pests and diseases (Sirappa, 2003). These characteristics make sorghum a suitable candidate for cultivation in Subang's varied agroecosystems. However, while

agronomic and nutritional studies on sorghum have been conducted in controlled environments such as greenhouses, there remains a lack of applied research on its performance and adoption at the field level, particularly in the context of integrated livestock systems.

To address this gap, this study seeks to bridge the divide between experimental research and practical application by evaluating sorghum cultivation and utilization in actual farming conditions in Subang. The project is a collaboration between BRIN (National Research and Innovation Agency), PT Dahana (which provides land for field trials), Subang State Polytechnic (Polsub), and Sutaatmadja College of Economics (STIESA). This initiative not only facilitates knowledge transfer but also enhances student and faculty involvement in community-based agricultural development. The objective of this research is to assess the potential of sorghum as an alternative feed crop through field trials and to evaluate its integration into the local livestock feed system in Subang Regency.

II. METHODOLOGY

This study employs a descriptive qualitative approach using a literature review method as the main instrument to address the identified research gap namely, the lack of applied research on the use of sorghum as an alternative feed at the field level within livestock systems in Subang Regency.

Secondary data were obtained through the review of various scholarly sources, including journal articles, research reports, conference proceedings, and relevant policy documents. The primary sources include research findings from the National Research and Innovation Agency (BRIN), particularly from the Center for Applied Botanical Research, as well as reports and documentation of activities conducted by faculty and students of Subang State Polytechnic (Polsub) related to sorghum cultivation and livestock feed development in Subang.

Inclusion criteria for literature selection consisted of: (1) publications discussing sorghum as a feed material, (2) studies conducted in tropical agroecological contexts, particularly in Indonesia, (3) publications dated between 2000 and 2024, and (4) literature addressing the intersection of crop and livestock systems, especially the integration of forage and feed crops.

Data analysis was carried out using thematic analysis, which involves categorizing information based on key emerging themes such as beef cattle farming practices, availability and processing of local feed resources, and the agronomic potential and adaptability of sorghum. The thematic analysis process included: (1) identifying relevant literature, (2) extracting key data and information, (3) coding major themes, and (4) developing a narrative synthesis to build a comprehensive understanding of the subject matter.

Through this approach, the study aims to provide an in-depth overview of the potential role of sorghum as a sustainable feed solution in the development of livestock systems in Subang Regency.

III. RESULTS AND DISCUSSION

1. Subang Regency as a Cattle Livestock Commodity Area

The Ministry of Agriculture has designated Subang Regency as one of the key beef cattle production areas in West Java Province. This region is also recognized as a

central hub for small-scale beef cattle farming. The designation is based on the region's adequate natural resource potential and the availability of supporting infrastructure that facilitates the development of beef cattle farming enterprises.

Subang Regency is expected to play a strategic role in the national supply of beef cattle (Ministry of Agriculture, 2016). In line with this policy, the Subang Regency Government has focused on developing beef cattle farming in sectors that offer high added value. This initiative aims to foster the creation of independent and self-sufficient beef cattle farmers.

2. Challenges and Opportunities in the Development of the Livestock Feed Industry in the Subang Regency with a Focus on Complete Feed Processing

The development of the livestock feed industry in the Subang region faces several challenges, including limited access to feed processing technology, insufficient farmer knowledge regarding feed formulation, and lack of infrastructure for large-scale feed production. Additionally, the majority of locally available forage are utilized in raw form without processing, leading to suboptimal nutrient utilization. However, these challenges present significant opportunities for the advancement of complete feed systems, which combine roughage and concentrates in a nutritionally balanced form. The abundant availability of forage biomass in Subang, such as *Pennisetum purpureum* and *Indigofera*, provides a strong foundation for feed innovation. By introducing appropriate processing techniques and strengthening farmer education, the region has the potential to become a key hub for sustainable livestock feed production, particularly in the context of complete feed manufacturing.

According to Fathurohman et al. (2018), the main challenge in the development of livestock businesses is the implementation of livestock business area development programs aimed at increasing productivity through the optimization of local resources and the utilization of local wisdom. Therefore, strategic and sustainable efforts in the management of beef cattle enterprises are required to achieve high productivity and efficiency.

One of the key factors supporting the potential of the livestock industry in Subang Regency is the provision of high-quality feed inputs. The processing of forage and other feed materials into complete feed could present an opportunity for the development of agro-industry that adds value to local feed ingredients. This innovation has the potential to become a strategic alternative for increasing the income of local communities, particularly the farmers in Subang Regency.

3. Economic Feasibility of Complete Feed Agro-Industry in Subang Regency

Fathurohman et al. (2018) conducted a financial feasibility analysis of an agro-industrial enterprise focused on processing forage into complete livestock feed. The results demonstrated that the business is economically viable. The analysis showed a Break-Even Point (BEP) of 1,200 feed packages, with a Net Present Value (NPV) of IDR 110,000,000, which is positive and exceeds zero. Additionally, the Internal Rate of Return (IRR) was recorded at 45%, substantially higher than the Minimum Attractive Rate of Return (MARR) and prevailing market interest rates. The Payback Period was calculated at 2.5

years, falling within the planned investment horizon, and the Benefit-Cost Ratio (B/C Ratio) was 1.4, indicating that the benefits outweigh the costs. A sensitivity analysis incorporating an inflation rate of 8.79% confirmed the business remains feasible and resilient to moderate inflationary pressures.

In a subsequent study, Fathurohman and Baharta (2020) assessed the implementation of complete feed production using mechanization at the livestock group level in Subang Regency during the period of January to March 2019. The methodology integrated mechanized equipment in the production process and included comprehensive financial analysis. The findings indicated a BEP of 1,100 packages, with a consistently positive NPV. The IRR remained above the MARR and actual interest rate benchmarks. Annual production values exceeded IDR 100,000,000, while net income per group surpassed IDR 60,000,000. In contrast, traditional basic feed production yielded only IDR 22,000,000 in annual output, with net income of IDR 11,000,000. The Payback Period was also 2.5 years, and the B/C Ratio stood at 1.3, reaffirming the economic feasibility of the mechanized approach.

Moreover, sensitivity analysis under the same inflation rate (8.79%) confirmed the financial stability of the mechanized complete feed enterprise, suggesting minimal vulnerability to price increases. The study concludes that complete feed offers a viable and strategic alternative for small-scale farmers, and highlights its potential to drive the development of value-added, forage-based agro-industries in rural areas.

4. Potential Utilization of Sorghum as a Forage Source for Ruminant Feed

Approximately 80% of livestock farmers in Subang Regency, Indonesia, raise ruminant animals, predominantly cattle (*Bos taurus*) and sheep (*Ovis aries*), while the remaining 20% rear non-ruminant species. The predominance of ruminant husbandry is largely attributed to the abundant availability of forage resources in the region. According to the Ministry of Agriculture (2016), the annual production of forage in Subang Regency reaches approximately 3 million tons. Commonly utilized forage species include *Pennisetum purpureum* cv. Mott (commonly known as odot grass), king grass (*Pennisetum hybridum*), native field grasses, and elephant grass (*Pennisetum purpureum*). In addition, *Indigofera* spp., recognized for their high protein content, are widely distributed throughout the region. However, these forages are predominantly supplied to livestock in unprocessed form, which limits their nutritional efficacy and overall feed efficiency.

One promising strategy to enhance feed utilization and add value to livestock products involves the incorporation of complete feed systems, which are formulated by combining forage (either fresh or conserved as hay) with concentrate ingredients in balanced proportions. Within this context, *Sorghum bicolor* has emerged as a promising source of fiber for complete feed formulations due to its agronomic adaptability and nutritional characteristics.

Sorghum bicolor is widely acknowledged for its high dietary fiber content and its functional role in supporting gastrointestinal health. Its nutritional profile is notable, containing approximately 322 kcal per 100 grams of grain, with 11 g protein, 3.3 g fat, 73 g carbohydrates, and substantial mineral concentrations, including 28 mg

calcium, 287 mg phosphorus, and 4.4 mg iron (Ministry of Agriculture, 2016). During the vegetative stage, sorghum's aboveground biomass—including stems and leaves—contains between 12.8% and 16.2% crude protein (CP), and crude fiber levels ranging from 26.06% to 31.85%. When harvested at 50 days and conserved as hay, sorghum maintains a CP concentration of approximately 16.2% (Paternakan Kita, 2016), indicating its potential as a quality forage source.

In addition to its nutritional attributes, sorghum exhibits remarkable physiological resilience under water-limited conditions, making it highly suitable for cultivation in arid and semi-arid regions. It demonstrates a dry matter (DM) content of 27.10% in fresh forage and up to 82.53% in hay form (Harmini, 2021). Key traits contributing to this drought tolerance include high leaf water potential, stable stomatal conductance, and a larger leaf area index compared to maize (*Zea mays*). These physiological advantages enable sorghum to maintain biomass productivity even under suboptimal moisture availability.

Beyond its primary use as forage, sorghum also produces significant fibrous residues, such as straw, which are often underutilized despite their abundance. Although sorghum straw has relatively low nutritional value in its raw form, recent advances in fermentation technology have shown promising results in enhancing its utility as ruminant feed. For instance, the application of white-rot fungi like *Phanerochaete chrysosporium* or microbial inoculants such as Starbio has been reported to significantly improve the feed value of sorghum straw. This bioconversion process has been linked to notable increases in animal performance, including live weight gains of male sheep ranging from 29.48% to 44.60%. Further supporting this potential, Zheng et al. (2025) evaluated the use of white-rot fungi such as *Ceriporiopsis subvermispura* and *Lentinula edodes* for upgrading lignocellulosic biomass, including sorghum straw. Their study revealed that fungal fermentation markedly increased in vitro gas production, reduced lignin content, and improved digestibility. These findings suggest that fungal bioconversion offers an effective strategy to enhance the nutritional quality of low-value crop residues for ruminant diets.

Similarly, Olagunju et al. (2024) assessed solid-state fermentation of sorghum straw using three fungal species: *Pleurotus ostreatus*, *P. djamor*, and *Trametes versicolor*. Their results showed significant improvements in crude protein content (up to 330%), ash content (up to 190%), and fiber digestibility (NDF and ADF). Moreover, fermentation also enhanced the production of volatile fatty acids (VFAs), particularly propionate, and reduced greenhouse gas emissions during in vitro rumen fermentation. These outcomes reinforce the role of fungal fermentation in improving feed quality while contributing to environmental sustainability. Complementary to these findings, Özkan et al. (2023) investigated the agronomic performance of two sorghum × sudangrass hybrids—Hay Day and Super-graze—under varying nitrogen fertilization regimes. Their study reported that higher nitrogen doses led to improved plant height, fresh forage yield, dry matter content, and enhanced nutritional profiles, particularly crude protein and metabolizable energy. Notably, Hay Day produced more fresh forage, while Super-graze exhibited superior dry matter yield and digestibility, highlighting the versatility of sorghum hybrids in forage production systems.

Despite the growing body of evidence supporting sorghum's multifunctional value, its utilization in Indonesia remains predominantly grain-focused, with the vegetative parts—leaves and stalks—frequently discarded or underexploited. Yet, these by-products hold significant promise as feed resources and can be further developed into value-added products such as bio-pellets (Purnomohadi, 2006). Maximizing the use of both grain and non-grain biomass components of sorghum could play a crucial role in enhancing the sustainability and efficiency of integrated livestock systems, particularly in forage-rich regions like Subang Regency.

5. Identification of Drought-Tolerant Sorghum Accessions for Livestock Feed Development

A two-season greenhouse study involving 30 sorghum (*Sorghum bicolor*) accessions identified four promising candidates with strong growth performance and high drought tolerance: *Buleleng Empok*, *Suri 4*, *Jagung Rote*, and *6-1115C*. The research aimed to assess sorghum's adaptability under water stress, which is crucial for its development as a forage crop in arid and semi-arid regions.

In the first growing season (May–June 2018), Desty et al. (2022) investigated the effects of water stress on leaf morphology across 15 sorghum accessions. The experimental setup included three irrigation levels—30%, 50%, and 80% of field capacity. Results indicated that the *6-1115C* accession demonstrated superior drought resilience, maintaining stable growth under reduced water availability. A proportional decline in leaf morphology parameters—leaf area, length, and width—was observed as water supply decreased. However, sorghum plants were able to survive even under severe water stress (30% irrigation), albeit with reduced leaf size.

During the second growing season (January–February 2019), Desty et al. (2021) conducted a follow-up study to evaluate plant height, leaf count, chlorophyll content, and leaf water potential at three weeks after planting (WAP) for the same 15 accessions. Among the accessions, *Kawali* exhibited the lowest performance across all growth parameters and was deemed the least tolerant to drought conditions. In contrast, several accessions demonstrated strong performance in multiple indicators, notably:

- *Buleleng Empok*: high plant height and leaf count,
- *Suri 4*: high plant height, leaf count, and leaf water potential,
- *Jagung Rote*: high plant height, leaf count, and chlorophyll content.

Based on combined data from both growing seasons, *Buleleng Empok*, *Suri 4*, *Jagung Rote*, and *6-1115C* were identified as drought-tolerant sorghum accessions with strong potential for development as forage crops, particularly suitable for drylands and dry-season livestock feeding strategies.

6. Development of the Livestock Feed Industry in Subang Regency: A Collaborative Model for Sustainable Sorghum-Based Innovation

The development of the livestock feed industry in Subang Regency holds significant potential and aligns with national agricultural policy objectives as stipulated in the Indonesian Ministry of Agriculture Regulation No. 22 of 2017 concerning Animal Feed (Ministry of Agriculture, 2017). This regulation aims to enhance the welfare of livestock farmers while establishing a regulatory

framework for feed production in Indonesia.

The National Research and Innovation Agency (BRIN), through the Center for Appropriate Technology Research (PRTTG) at the Subang Science and Technology Area, has initiated a strategic collaboration with PT Dahana to support the development of sorghum cultivation in Subang, West Java. This initiative is designed to empower local communities surrounding the PT Dahana industrial area by leveraging research and innovation in agricultural practices. The partnership focuses on the dissemination and application of appropriate technology (AT) across all stages of sorghum cultivation, including seed selection, planting techniques, and post-harvest processing. BRIN contributes technological expertise and training, while PT Dahana provides corporate land for community-based sorghum development (Dahana, 2024).

This initiative is expected to increase local employment and strengthen the regional economy. Sorghum was selected for its multifunctional value—as a raw material for food, animal feed, and bioenergy—owing to its high nutritional content, including carbohydrates, protein, fiber, iron, magnesium, and B vitamins. Furthermore, sorghum's adaptability to diverse soil types and drought resilience makes it a strategic crop for sustainable agriculture (Antara, 2024).

The project also involves local academic institutions such as the Subang State Polytechnic (Polsub) and Sutaatmadja College of Economics (STIESA) to reinforce research and training components. The involvement of higher education institutions aims to expand local knowledge and skillsets in sorghum cultivation, while simultaneously supporting national food diversification goals. Through this multi-sectoral collaboration, Indonesia's research and education institutions play a vital role in transforming the livestock sector toward greater efficiency, sustainability, and environmental stewardship. This joint initiative between BRIN and PT Dahana aspires to establish large-scale sorghum cultivation and promote sorghum-based food, feed, and renewable energy industries. Ultimately, this collaboration serves as a model for community empowerment through the integration of local resources and appropriate technology.

IV. CONCLUSION

The development of the livestock feed industry in Subang Regency presents a strategic opportunity to enhance the sustainability and productivity of the local livestock sector. Supported by abundant forage resources and favorable agroecological conditions, the region is well-positioned to become a key player in Indonesia's livestock feed production, particularly through the adoption of complete feed systems. Sorghum (*Sorghum bicolor*), with its high nutritional value, drought tolerance, and multipurpose utility, emerges as a promising alternative feed crop to strengthen feed security and resilience in the face of climate variability.

Collaborative efforts between research institutions, private enterprises, and educational organizations—such as BRIN, PT Dahana, Polsub, and STIESA—illustrate a successful model of integrated innovation that bridges scientific research with community-based application. These partnerships have demonstrated not only the technical feasibility and economic viability of sorghum-based feed solutions but also their potential to stimulate rural economies and empower local farmers.

By leveraging local resources, appropriate technology, and institutional collaboration, the Subang experience offers valuable insights into how region-specific innovations can contribute to national goals of food and feed diversification. The findings underscore the importance of continued investment in applied research, farmer education, and agro-industrial development to ensure long-term efficiency, profitability, and environmental sustainability in Indonesia's livestock sector.

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