

Production and Quality of Murrah Buffalo Milk through Improvement of Feed Based on Local Forage and Silage in Nagari Kapau, Agam Regency

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ABSTRACT

Feed for Murrah buffaloes is a significant factor in the success of a business. Good quality feed will have a positive effect on the production and quality of Murrah buffalo milk, which has a fat content of 6–8% and a protein content of 3–8%, compared to cow's milk, which has a fat content of only 3–4% and a protein content of only 3–4%. This study aims to increase milk production and quality in Murrah buffalo by providing feed based on local grass and silage. This study is an experimental study with a Latin Square (LSD) design, using four female Murrah buffalo as research samples with the following feeding patterns: P1 = 100% basal feed, P2 = 90% local forage + 10% silage + concentrate, P3 = 80% local forage + 20% silage + concentrate, P4 = 70% local forage + 30% silage + concentrate. The parameters measured in this study included milk production, protein content, fat content, nonfat solids, and total solids of Murrah buffalo milk. The results obtained in this study were as follows: Milk production (4.12–5.46 kg/head/day); Protein (3.19–5.23%); Fat (6.36–8.92%); Nonfat solids (7.01–8.57%), and Total solids (13.37–17.49%). Based on the study's results, it can be concluded that feeding local forage and silage resulted in a significant increase ($P < 0.05$), with treatment P4 showing the best results for Murrah buffalo milk production and quality.

Keywords: Murrah buffalo; Local forage; Silage; Milk production; Milk quality.

INTRODUCTION

Buffaloes are a type of livestock with great potential for development, as they offer several advantages over cattle, particularly their ability to thrive in areas with challenging environmental conditions and limited feed availability. In addition, buffalo have a high tolerance to various stresses and extreme environmental changes. Buffaloes are highly adaptable, enabling them to thrive in a wide range of agroecosystems, from arid regions and swamplands to mountainous areas and lowlands. They are also able to withstand changes in environmental temperature (heat load) and changes in grassland vegetation (Diwyanto and Handiwirawan 2006).

In West Sumatra, buffalo play an important role as a source of meat, labor, milk, and as a complementary part of various traditional ceremonies. In their role as milk producers, buffalo contribute significantly, as buffalo milk is processed into various daily consumption products, one of which is dadiah, a typical West Sumatran food made from buffalo milk. However, buffalo milk production is still relatively low, ranging from 1 to 2 liters per head per

day, because the type of buffalo that is generally milked is the mud buffalo, which limits the production of dadiah. Currently, buffalo farming is gaining more attention, particularly as a source of milk. One of the efforts being made is the development of Murrah buffalo in West Sumatra. Several studies have reported that Murrah buffalo milk production can reach 6–8 liters per animal per day, with a fat content of 6–8% and a protein content ranging from 4% to 8% (Roza et al. 2017).

According to data from the Badan Pusat Statistik (2025), the buffalo population in West Sumatra in 2023 was recorded at 30,913 heads, decreasing to 26,752 heads in 2024. This population decline has resulted in low buffalo milk production. This condition is caused by the limited knowledge of farmers, both in terms of maintenance management and feed management. So far, the feeding system that has been implemented is still not optimal, both in terms of quantity and nutritional content. Insufficient nutritional intake has led to a decline in milk production. In some cases, the cattle do not produce milk at all, which can cause disturbances in the reproductive function of buffaloes. To overcome this problem, local forage can be

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utilized by processing it into silage for Murrah buffaloes. One type of local forage that has potential for use is cassava leaves. West Sumatra has considerable potential for supplying this type of forage, given its extensive agricultural land, particularly in the highland areas of Bukittinggi and Agam Regency. This region is recognized as one of the largest centers for cassava cracker production in West Sumatra. Based on data from the West Sumatra Central Statistics Agency (BPS) in 2022, the area of cassava agricultural land in Agam Regency and Bukittinggi City reached around 502 hectares. After harvesting, cassava leaves are generally only piled up and rarely utilized by farmers. In addition to their abundant availability, cassava leaves also have a relatively high nutritional content, especially crude protein, which reaches 19.5% (Badan Pusat Statistik 2022).

Cassava leaves also contain antinutritional compounds in the form of tannins, tannins act as a defaunation agent that can reduce the population of rumen protozoa, thereby potentially reducing methane emissions (Fonseca et al. 2025). In addition, the presence of tannins can protect feed proteins from degradation by rumen microorganisms, allowing these proteins to function as bypass proteins and be absorbed directly by the livestock's body (Loregian et al. 2023). Roza et al. (2024a) stated that feeding 2 kg of cassava leaves and turmeric powder can significantly increase the production and quality of Murrah buffalo milk. Other studies also mention that cassava leaf supplementation has a positive effect on improving hematological parameters and production in Murrah buffaloes (Roza et al. 2025). In addition to utilizing local forage, feeding in the form of silage can also be applied. Silage is a method of preserving forage through anaerobic fermentation, which aims to maintain feed quality for a longer period of time. Through this preservation technique, farmers can ensure a sustainable supply of forage, especially during the dry season. Feeding silage to dairy cattle is known to provide various benefits, including improved milk quality and productivity, as well as enhanced resistance to disease (Hong et al. 2003). According to Craig et al. (2023) and Craig et al. (2024), feeding silage to dairy cattle can increase feed consumption, thereby increasing milk production and quality. In addition, feeding silage can optimize rumen fermentation (Cueva et al. 2024). Fajar and Haryuni (2024) added that the nutritional consistency of silage can support an increase in dry matter intake by cattle, thereby positively affecting milk production. Furthermore, in terms of milk quality, other studies have shown that silage feeding can affect milk composition, including increased protein and mineral components, which are related to improved fiber digestibility and feed efficiency in ruminant diets (Ako et al. 2016). Based on the above description, it is hoped that feeding on local forage and silage can increase the production and quality of Murrah buffalo milk.

MATERIALS AND METHODS

Experimental site

This study was conducted at a Murrah buffalo farm located in Kapau Village, Agam Regency, West Sumatra Province, Indonesia. Kapau Village is recognized as one of

the areas that has developed Murrah buffalo farming for dairy production. Topographically, Kapau Village is situated at an altitude of approximately 500–1,000 meters above sea level, with relatively calm environmental conditions characterized by daily temperatures ranging from 21 °C to 25°C. These temperature conditions are considered suitable for supporting the development of Murrah buffalo in tropical climates. This is in line with the statement by Matondang and Talib (2015), which states that the optimal temperature range for buffalo livestock is between 16 °C and 24°C, with a maximum temperature tolerance limit of 27.6°C. As is characteristic of tropical regions, the study area has two main seasons: the rainy season, which lasts from September to February, and the dry season, which lasts from March to August. This study was conducted from July to October 2025.

Experimental design

The research material used in this study consisted of four female Murrah buffaloes, aged between 3 and 5 years, from North Sumatra, raised in Kapau Village, Agam Regency. The livestock were fed a basal ration consisting of pasture grass commonly used by farmers, basic concentrate, and local forage and silage at varying levels for each treatment. This study employed an experimental method with a Latin square design (LSD), comprising four treatments and four replicates (Fig. 1). The treatment arrangement applied was as follows:

- P1= 100% basal feed,
- P2= 90% local forage + 10% silage + concentrate,
- P3= 80% local forage + 20% silage + concentrate,
- P4= 70% local forage + 30% silage + concentrate.

The quality and antinutrients of the feed provided in the study can be seen in Table 1 and 2:

Table 1: Nutritional Content of Feed

| Nutritional Content | P1 | P2 | P3 | P4 |
|---------------------|-------|-------|-------|-------|
| Dry Matter (%) | 13.50 | 16.97 | 16.30 | 18.60 |
| Crude Protein (%) | 7.65 | 13.17 | 12.20 | 13.96 |
| Crude Fiber (%) | 30.22 | 32.24 | 33.31 | 33.68 |

Table 2: Antinutrient content of feed

| Feed Type | Tannin |
|------------------|--------|
| Silage (%) | 1.10 |
| Basal Forage (%) | 3.21 |

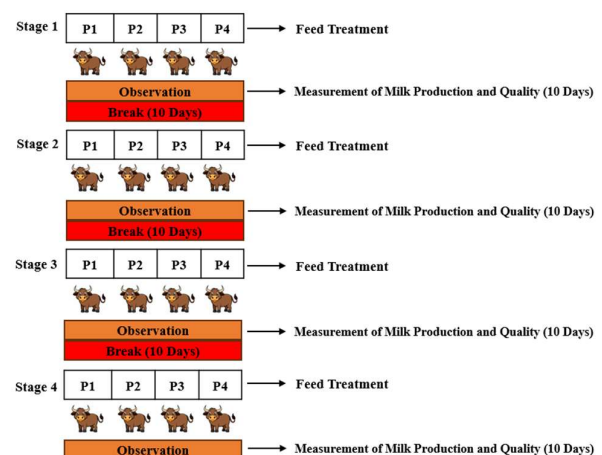


Fig. 1: Research implementation stages.

Parameters

Milk production

Milk production is determined based on the accumulation of morning and evening milking results, which are carried out manually and then expressed in kilograms of milk per head per day (Fig. 1). Additionally, milk production is evaluated based on the total volume of milk produced during the lactation period, measured in liters. To standardize milk production results, a 7% fat-corrected milk (FCM) conversion method is used daily, in accordance with Gaafar et al. (2009) and Roza et al. (2024b). The calculation of 7% fat-corrected milk (7% FCM) production is performed using the following equation: 7% FCM milk production = $(0.265 \times \text{milk production}) + (10.5 \times \text{fat production})$

Note:

FCM = fat-corrected milk

Fat production = percentage of milk fat content \times milk production

Milk quality

Milk quality testing was conducted using a Lactoscan Milk Analyzer Biobase CN (Model: BKMA-MK).

Data Analysis

The data obtained were processed and analyzed using Analysis of Variant (ANOVA). If the treatment showed significantly different results ($F \text{ count} > F \text{ table } 0.05$), then the analysis continued with further tests using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Milk production

The average Murrah buffalo milk production data, using local forage and silage-based feeding, are presented in Table 3.

Table 3: Average Milk Production of Murrah Buffaloes

| Treatment | 7% FCM Milk Production (kg/head/day) |
|-----------|--------------------------------------|
| P1 | 4.12 \pm 0.55 ^a |
| P2 | 4.18 \pm 0.51 ^a |
| P3 | 4.45 \pm 0.71 ^a |
| P4 | 5.46 \pm 0.07 ^b |

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$).

Based on Table 3, the average milk production of Murrah buffaloes, expressed as 7% Fat-Corrected Milk (FCM), showed a significant difference ($P < 0.05$) between treatments. Treatment P4 produced the highest milk production, namely 5.46 \pm 0.07 kg/head/day, and was significantly different from treatments P1, P2, and P3, which produced milk production of 4.12 \pm 0.55, 4.18 \pm 0.51, and 4.45 \pm 0.71 kg/head/day, respectively. The increase in milk production in treatment P4 indicates that the combination of rations given was able to enhance the efficiency of nutrient utilization, particularly feed energy and protein (Table 1), which play a crucial role in milk synthesis. The use of local forage and processed feed such as silage and protein-based supplements is known to increase the availability of digestible nutrients in the rumen, thereby positively impacting milk production in

ruminants (Kung et al. 2018; Tudisco et al. 2021). Feeding high-protein diets can increase metabolic rate and support the ability of rumen microbes to degrade feed materials (Arief et al. 2018). Feed protein acts as a source of ammonia (NH_3) in the rumen, which is then utilized as a source of nitrogen for the growth and activity of rumen microorganisms, thereby maintaining microbial balance and performance (Roza et al. 2021). Ammonia available in the rumen also plays a role in the fermentation of polysaccharides, which produces volatile fatty acids (VFA). VFA is used as the primary energy source for livestock, supporting the production process. Increased VFA production will provide more energy for buffaloes, thereby positively impacting productivity, as reflected in increased milk production.

In addition, the presence of phytochemical compounds, specifically tannins, contained in local forage plays a role in protecting feed proteins from degradation in the rumen through the formation of protein-tannin complexes, allowing these proteins to function as bypass proteins. Tannins can bind with proteins, cellulose, and hemicellulose, which can reduce the activity of protease and cellulase enzymes. As a result, not all feed proteins are degraded in the rumen, but can pass through to the small intestine to be absorbed and utilized more efficiently by the livestock's body to support physiological needs and milk production (Huang et al. 2018; Roza et al. 2021). The provision of local forage, such as cassava leaves, in addition to tannins, also contains steroid compounds that play a role in stimulating the prolactin reflex and alveolar activity in milk production, while also stimulating the hormone oxytocin, which functions in the milk ejection process (Roza et al. 2021). Additionally, these steroid compounds are believed to influence the increase in estrogen hormones, thereby contributing to increased milk production. Furthermore, the presence of essential minerals in the ration, such as zinc (Zn), cobalt (Co), copper (Cu), and iron (Fe), also plays a role in supporting increased milk production in Murrah buffaloes.

The quality of murrah buffalo milk

The average data on the quality of Murrah buffalo milk fed local forage-based feed and silage are presented in Table 4 and 5.

Table 4: Average Protein and Fat Content of Murrah Buffalo Milk

| Treatment | Protein Content (%) | Fat Content (%) |
|-----------|------------------------------|------------------------------|
| P1 | 3.22 \pm 0.15 ^a | 6.36 \pm 1.45 ^a |
| P2 | 3.19 \pm 0.12 ^a | 6.79 \pm 1.62 ^a |
| P3 | 4.03 \pm 0.53 ^b | 7.27 \pm 1.29 ^a |
| P4 | 5.23 \pm 0.31 ^c | 8.92 \pm 1.00 ^b |

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$).

Table 5: Average levels of solid nonfat and total solids in Murrah buffalo milk

| Treatment | solid nonfat (%) | total solids (%) |
|-----------|------------------------------|-------------------------------|
| P1 | 7.01 \pm 0.59 ^a | 13.37 \pm 1.40 ^a |
| P2 | 7.19 \pm 0.93 ^a | 13.97 \pm 0.96 ^a |
| P3 | 7.82 \pm 0.49 ^a | 15.09 \pm 1.47 ^a |
| P4 | 8.57 \pm 0.96 ^b | 17.49 \pm 1.11 ^b |

Note: Different superscripts on the same line indicate significant differences ($P < 0.05$).

Based on Table 4, the feed treatment given had a significant effect ($P < 0.05$) on the protein and fat content of Murrah buffalo milk. The highest milk protein content was obtained in treatment P4, which was $5.23 \pm 0.31\%$, which was significantly different when compared to treatments P1, P2, and P3. Meanwhile, treatments P1 and P2 produced relatively lower milk protein levels and were not significantly different from each other. In contrast, P3 showed an increase in protein levels, although it was still lower than P4. The increase in milk protein levels in treatment P4 indicates that the feed provided was able to supply a more optimal source of protein and nitrogen for the cattle (Table 1). The increased availability of feed protein as the amount of feed given increases (P4) will also have a significant impact on microbial protein synthesis in the rumen, which in turn contributes to an increase in the supply of amino acids absorbed in the small intestine. These amino acids play a crucial role in milk protein formation, thereby directly influencing the increase in milk protein content produced (Patra and Saxena 2021; Saleem et al. 2024).

The milk fat content obtained in the P4 treatment also showed the highest value, namely $8.92 \pm 1.00\%$, and was significantly different from treatments P1, P2, and P3, which had relatively lower fat contents. There was no significant difference in milk fat content between P1, P2, and P3, indicating that a significant increase in milk fat only occurred in treatment P4, which had better quality and nutrient balance compared to the other treatments (Table 1). The high milk fat content in treatment P4 was influenced by local forage in the form of cassava leaves, which served as a source of soluble carbohydrates and undegradable protein. Feed carbohydrates serve as precursors in the formation of glucose during fermentation by rumen microbes, which ultimately produce volatile fatty acids (VFAs), including acetic acid and butyric acid. Acetic acid and butyric acid are the primary components of long-chain fatty acids in milk. The higher the crude fiber content of the feed, the higher the acetic acid content in the rumen, resulting from rumen microbial degradation (Suhendra et al. 2015). Acetic acid and butyric acid enter the bloodstream and are transported to the liver, where they are converted into fatty acids. These fatty acids then enter the secretory cells of the mammary glands for milk fat synthesis (Mutamimah et al. 2013). Additionally, feed with balanced fiber content (Table 1), supported by adequate forage quality, can increase rumen fermentation activity, thereby optimizing milk fat production (Gaafar et al. 2009; Thomas et al. 2022).

Based on Table 5, the treatments had a significant effect ($P < 0.05$) on the nonfat solids and total solids content of Murrah buffalo milk. Treatment P4 produced the highest nonfat solids content, namely $8.57 \pm 0.96\%$, and was significantly different from treatment P1, while treatments P2 and P3 showed values that were not significantly different from each other. The increase in nonfat solids content in treatment P4 indicates an improvement in milk solids fractions other than fat, which include protein, lactose, and minerals. The nonfat solids content is significantly influenced by the adequacy of feed nutrients, particularly protein (Table 1). Well-digested feed protein increases the supply of amino acids to the mammary gland, while energy availability supports lactose synthesis, which

is the main component of milk nonfat solids (Walstra et al. 2019; Thomas et al. 2022).

The total solid content of treatment P4 also showed the highest value of $17.49 \pm 1.11\%$, and was significantly different from treatments P1, P2, and P3. Total solids are an overview of the total milk solids content, which consists of fat and nonfat solids. The increase in total solids in treatment P4 indicates that this treatment not only increases one component of milk but also improves the overall quality of milk, including the protein and fat produced (Table 4). The high total solids content of milk in treatment P4 is due to increased rumen fermentation activity, which produces volatile fatty acids (VFA), particularly acetate and propionate. Acetate serves as the primary precursor for milk fat synthesis. At the same time, propionate acts as a source of glucose through the process of gluconeogenesis, which is then utilized in the formation of lactose. The balance of VFA production contributes to an increase in milk fat, protein, and lactose content, resulting in higher total milk solids (Van Soest, 1994; Patra and Saxena 2021).

Conclusions

Based on the research results, it can be concluded that feed based on local forage and silage in treatment P4 can increase the production and quality of Murrah buffalo milk. Therefore, the feed treatment P4 can be applied to Murrah buffalo farms in West Sumatra, in particular, and can be adopted for other regions with the same formulation.

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