Research Article

Improving Milk Production and Quality of Murrah Buffalo Trough Local Forage-Based Feeding

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Abstract | The production and quality of Murrah buffalo milk in West Sumatra are still relatively low, and this is due to the feed provided not meeting the production needs of livestock. Hence, milk production and quality still need to be expected. This research aims to get the best forage feed by utilizing local forages (cassava leaves, sweet potato leaves, and Moringa leaves), which are high in nutritional content, to increase the production and quality of Murrah buffalo milk and increase farmers' income. This study used an experimental method with a Latin Square Design (LSD), using four female Murrah buffaloes as research samples with the following feed treatments: P1 = basal forage + concentrate, P2 = P1 + cassava leaves (2 kg), P3 = P1 + sweet potato leaves (2 kg), P4 = P1 + Moringa leaves (2 kg). Parameters observed in this study were milk production, milk protein, milk fat, milk lactose, and Solid Nonfat. The results obtained in the study are as follows: milk production (2.00–3.60 kg/7% FCM), protein (2.27–3.42%), fat (5.86–7.97%), lactose (3.60–5.20%) and solid nonfat (8.11–8.92%). From the results of the study, it can be concluded that feeding local forages (cassava leaves, sweet potato leaves, and Moringa leaves) can increase the production and quality of Murrah buffalo milk so that this forage feed can be recommended to farmers as an alternative feed that is high in nutritional content and readily available in welcoming national milk self-sufficiency.

Keywords | Cassava leaves, Sweet potato leaves, Moringa leaves, Murrah buffalo, Milk production, Milk quality

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INTRODUCTION

Buffalo is a germplasm that needs attention to increase its productivity because buffalo is a typical genetic source of local livestock in Indonesia. Swamp buffalo make up 95% of the local buffalo breeds in Indonesia, while riverine buffalo make up the remaining 5%. Mud buffalo are generally kept as working cattle and meat producers, while Murrah buffalo are milk producers. Buffalo milk has the advantage of having a higher fat content (6-8%) compared to cow's milk (3-4%) (Mihaiue et al., 2011; Roza et al., 2021). River buffalo milk production ranges from 3-8 liters/head/day, which is higher when compared to mud buffalo milk production, which averages 1.5-2.0 liters/head/day (Roza, 2013). However, Murrah buffaloes raised in Nagari Kapau West Sumatra have not shown this because the feed provided has yet to meet the needs in terms of quality and quantity. Feed is one of the most critical factors affecting the success of the livestock business, because animal husbandry's most significant production cost is feed, either forage or concentrate, is about 70% of the total cost. In addition, converting forage land into residential areas significantly impacts the reduction of forage for livestock. Therefore, finding local forage feed sources with high production and good nutritional quality, including cassava (*Manihot utilissima*) leaves, sweet potato (*Ipomoea batatas*) leaves, and Moringa (*Moringa oleifera*) leaves, is necessary. Cassava leaves are widely available in rural environments.

Dried cassava leaves (hay) are a source of protein and can be utilized as a nutritional supplement for ruminants, especially in dairy cows, broilers, and buffaloes (Khang et al., 2005). Cassava leaves contain protein 19.5% dry matter and condensed tannins 4.0% dry matter. Its administration can be directly as a feed supplement and as a source of protein in concentrates (Hong et al., 2003) or as a cassava peels with *Gliricidia sepium* fodder (Adegun et al., 2023). Giving cassava leaves as a feed supplement as much as 1.5 kg/day gives performance in milk production and quality by increasing hemoglobin levels and the amount of buffalo blood protein; the increase in hemoglobin levels is due to cassava leaves having high protein and Fe content, Hemoglobin is a combination of heme and globin. Heme is formed from Fe in the mitochondria, while globin is formed from protein (Roza et al., 2015). Roza et al. (2021) added that cassava leaf feeding can improve hematology in swamp buffaloes. Roza, (2013) added that giving 1.5 kg/day of dried cassava leaves to buffaloes can increase milk production by 1.67 liters/head/day. This is due to the condensed tannin content (5%), which can increase protein bypass in buffalo.

Sweet potato leaves contain mineral salts such as calcium, magnesium, iron, and phosphorus, phenolic compounds such as caffeic acid, chlorogenic acid, 3,5 di-caffeoylquinic acid, and 3,4 di-caffeoylquinic acid, antioxidant compounds, and several vitamins (Truong et al., 2007). Sweet potato leaves contain high crude protein, 26-35%, with good mineral content and vitamins A, B2, and C (Adewolu, 2008). Sweet potato leaves also contain anti-nutrients, namely tannins. Tannins can be used as a defaunation agent to reduce protozoan populations and suppress the rumen's methane emissions (Makkar, 2003). In addition, tannins can also protect the protein from rumen microorganisms, making the protein in sweet potato leaves bypass and absorbed directly by the livestock body. According to Baba et al. (2011) mentioned that based on the experience of farmers, the provision of sweet potato and cassava can increase milk production and diversification products compared to only bran feed.

Moringa leaves have a relatively high nutritional value: protein 29.61%, metabolic energy 1318.29 kcal/kg, fat 7.48%, fiber 8.98%, and ash content 10.13% (Masitlha et al., 2024). Moringa leaves are classified as leguminous and serve as a protein feed source for livestock growth. The use of fresh Moringa leaves as feed intake of 8 to 12 kg in dairy cows can increase cow's milk production compared to those only fed with grass (Sanchez et al., 2005). From the description above, the local feed has good potential to be used as Murrah buffalo feed, so the existence of Murrah buffalo as one of the local livestock resources must be considered, especially in the production and quality of milk produced. The research results by Soetanto and Firsoni (2008) stated that milk production in dairy cows can increase by up to 15% by supplementing moringa leaf flour in molasses blocks. Research by Mathius et al. (2002) added that giving moringa leaves to dairy goats as much as 0.5–1.5 kg of fresh moringa leaves/head/day can spur growth between 60–87 g/head/day and milk production up to 0.5 liters/head/day. This study aims to determine the impact of local forage on Murrah buffalo milk production and quality.

MATERIALS AND METHODS

Etichal Approval

The implementation of this study refers to the ethics of research using experimental animals based on the government law of the Republic of Indonesia (Number 18 of 2009 article 66), which discusses the maintenance of animals, killing, treatment, and reasonable care.

Experimental Site

This research was conducted on the Murrah buffalo farm, Nagari Kapau (Figure 1), Agam Regency, West Sumatra Province, Indonesia, with an altitude of 500–1000 meters above sea level; with this altitude, the temperature in the Nagari Kapau has a cool temperature ranging from 21–25°C. With this temperature, the Kapau area has excellent potential for developing Murrah buffalo.

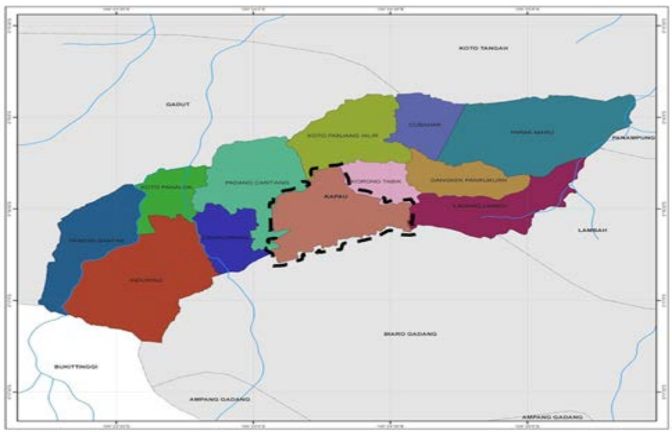

Figure 1: Map of Kapau Village

The Kapau village area boasts 303.86 hectares of agricultural land, rich with potential agricultural by-products like cassava leaves, sweet potato leaves, and Moringa leaves, ideal as forage feed for Murrah buffalo cattle. The Kapau area has two seasons: dry and rainy, where the rainy season lasts from September to February, and the hot season lasts from March to August. This research was conducted from June to September 2023.

Experimental Design

This research material is 4 Murrah buffaloes that are lactating at 3-4 years old with a body weight ranging from 400-450kg, which is kept in Nagari Kapau, Agam Regency, West Sumatra, Indonesia. Before starting the research, Murrah buffaloes were separated, placed in the prepared research cages, and given deworming drugs to make the results more accurate. The research method used is the experimental method using the Latin Square Design (LSD), with the mathematical model is as follows: $Yijk = \mu + {}_{i} + ß_{j} + \gamma_{k} + \varepsilon_{ijk}$ (Steel and Torrie, 1995), which consists of four treatments and four replicates. The treatments given were basal forage feed, basal concentrate, cassava leaves, sweet potato leaves, and moringa leaves with different percentages, namely:

P1= Basal forage feed + concentrate
P2= P1 + Cassava Leaves (2 kg)
P3= P1 + Sweet Potato Leaves (2 kg)
P4= P1 + Moringa Leaves (2 kg)

The nutritional content of the above treatments is presented in Table 1.

Table 1: Composition of ration of Murrah Buffalo

No	Chemical Content*	P1	P2	P3	P4
1	Dry matter (%)	75.00	89.20	88.19	89.03
2	Crude Protein (%)	6.12	10.89	10.20	10.15
3	Crude Fiber (%)	20.21	20.68	20.12	19.13
4	Crude Fat (%)	1.01	2.40	2.77	3.49

* Research Feed Analysis (2023)

Parameter

Milk Production

Milk production seen from the total milk production in the morning and evening with a hand milking system, known as milk kg/head/day. Milk production was also determined by the volume secreted during the lactation period in liters. The production was regulated with the conversion method (7% FCM/days) (Gaafar et al., 2009).

Milk production 7% FCM = (0.265 x milk production) + (10.5 x fat production).

Note:
FCM= Fat-Corrected Milk
Fat production = fat content % x milk productions
Milk Quality (Protein, Lactose, Fat and Solid Nonfat)
Milk quality testing (protein, lactose, fat, and solid nonfat) was done using the Lactoscan Milk Analyzer Biobase CN (Model: BKMA-MK; Figure 2) as per the operating manual of machine manufacturer.

Figure 2: Lactoscan Milk Analyzer Biobase CN (Model: BKMA-MK)

Data Analysis

The data obtained were processed and analyzed using Analysis of Variant (ANOVA) with the Minitap14 application.

RESULT AND DISCUSSION

Milk Production

The average milk production of Murrah buffaloes fed with local forage is shown in Table 2.

Table 2: Milk Production of Murrah buffaloes.

Treatment	Average (Kg) (7% FCM)
P1	2.00 ± 0.09^{a}
P2	3.60 ± 0.16^{d}
P3	2.73 ± 0.11^{b}
P4	3.23 ± 0.31^{c}

Note: ^{abcd} Different superscripts indicate significant difference ($P<0.05$)
P1= Basal forage feed + concentrate; P2= P1 + Cassava Leaves (2 kg); P3= P1 + Sweet Potato Leaves (2 kg); P4= P1 + Moringa Leaves (2 kg)

The statistical analysis showed that the provision of local forage in Murrah buffalo cattle significantly affected Murrah buffalo milk production ($P<0.05$). Where the highest milk production was obtained in the P2 treatment (3.60 kg/head/day) followed by P4 (3.23 kg/head/day), P3 (2.74 kg/head/day) and P1 (2.00 kg/head/day). Giving local forage in cassava leaves, sweet potato leaves, and moringa leaves showed significant results compared to the P1 treatment in the form of field grass alone due to the high protein content in local forage. Here, it is clear that the treatment given to cassava leaves gets the highest milk production results. Milk production in Murrah buffaloes is strongly influenced by the quality of feed provided; good quality feed will increase milk production by livestock, where the protein content of P2 feed has a high percentage of 10.89%. Feed protein content is a precursor in the formation of NH_3 in the rumen of livestock (Arief et al., 2020). NH_3 is utilized as a source of nitrogen for the growth of microorganisms so that the activity of microorganisms in the rumen in fermenting polysaccharides into volatile fatty acids (VFA) increases; VFA is used as a source of energy by livestock for growth and reproduction activities as well as milk production (Roza, 2013). With higher VFA production, buffalo cattle get a more significant energy source, so their productivity improves, characterized by higher milk production.

The high milk production in the P2, P4, and P3 treatments compared to the P1 control was due to the phytochemical content in the form of tannin (+) contained in local forages, which also made a determining factor in the formation of by-pass proteins in the rumen. The tannin content in cassava leaves, according to several studies, is 1.17% (Hawashi et al., 2019), sweet potato leaves 0.32% (Akpe et al., 2021) and Moringa leaves 0.89% (Mohammed and Manan, 2015). Tannins in forage feed can protect proteins from rumen degradation by forming protein-tannin complex bonds so that proteins are not degraded in the rumen. However, these proteins will reach the intestines so that the body can efficiently utilize them for life's basic needs and production. The presence of tannin in forage feed can protect the protein so that it can directly undergo the process of enzymatic digestion in the abomasum and intestine (Henson et al., 1997). Feeding with protein content that is not degraded in the rumen can increase the amount of protein and amino acids to be digested and absorbed in the small intestine, which can ultimately increase the synthesis of body protein, which is a precursor in the formation of milk protein (Rizqan, 2018). In addition, feed protein content is a source of carbon skeleton that stimulates the growth of cellulolytic bacteria, thereby increasing carbohydrate digestibility. Microorganisms will break down carbohydrates into VFA, including propionic, acetic, and butyric acids (Rizqan et al., 2023). Acetic and butyric acids are ketogenic energy sources, while propionate is a glucogenic energy source used for gluconeogenesis. Acetic, propionic, and butyric acids are precursors of milk formation in dairy cattle. Acetic and butyric acids will be converted into long-chain fats in the secretory cells of the udder (Mutamimah et al., 2013), while propionic acid increases milk production in the udder gland. Roza, (2013) state that giving 1.5 kg/day of dried cassava leaves to buffaloes can increase milk production by 1.67 liters/head/day, this is due to the condensed tannin content, which can increase protein bypass in buffalo.

Milk Quality

The average milk quality (protein, fat, lactose and solid nonfat) of Murrah buffaloes fed local forage is shown in Table 3.

The results of statistical analysis showed that the provision of local forage in Murrah buffalo cattle has a significant effect ($P <0.05$) on the quality of milk produced (protein, fat, lactose, and solid nonfat content) where the highest average milk protein was obtained in the P4 treatment (3.42%), P3 (3.27%), P2 (3.14%), P1 (2.27). Fat content P4 (7.97%), P3 (7.42%), P2 (7.22%), P1 (5.86%). Lactose content P4 (5.20%), P3 (4.75%), P2 (4.82%), P1 (3.60%), and solid nonfat content P4 (8.92%), P2 (8.77%), P2 (8.76%), P1 (8.11%). The increase in milk quality compared to the control (P1) is due to the high content of nutrients (crude protein, crude fiber, crude fat) found in cassava leaves, sweet potato leaves, and moringa leaves compared to the provision of field grass. Given good quality feed, Murrah buffaloes will have a good effect on the quality of milk produced (protein, fat, lactose, and solid nonfat). This is the opinion of McCullough (1973), who states that quality forage feed can improve the milk produced by dairy cattle.

Microbial enzymes proteolyze the protein content of the feed in the rumen into oligopeptides and amino acids. Some amino acids are degraded into NH3 and then used for microbial protein synthesis, and amino acids are also utilized in milk protein formation through udder secretory cells (Utari et al., 2012). Protein in feed is also a source of carbon skeleton that stimulates the growth of cellulolytic bacteria to increase carbohydrate digestibility. Microorganisms will break down carbohydrates into VFA, including propionic acid, acetic acid, and butyric acid. Acetic acid and butyrate will be absorbed by the body and enter through the bloodstream, becoming a precursor in forming fatty acids, then entering the udder's secretory cells and becoming milk fat (Rizqan et al., 2023).

Meanwhile, after being absorbed from the rumen, propionic acid will be converted into glucose in the liver. This glucose is partially converted into glycogen and stored in the liver or into α-glycerol phosphate and used to synthesize triglycerides. The remaining glucose will be carried through the blood circulation to various body tissues to be used as a source of energy, co-enzymes, a reducer in the synthesis of fatty acids and muscle glycogen (Riis, 1983). Adequate protein and energy in the feed will stimulate rumen microbial activity to produce more propionic acid, increasing milk lactose levels. According to Bergman et al. (1966) and Leng et al. (1967), 50-54% of propionic acid is used as the primary precursor in the formation of milk lactose.

In addition to the high nutritional content of local forages, the phytochemical content in the form of tannin (+) has a beneficial effect on livestock, which can protect some feed proteins from degradation by microorganisms in the rumen. According to Widyobroto et al. (2007) Tannins are antinutritional compounds that have phenol groups and

Table 3: Milk Quality of Murrah Buffalo with Local Forage Feeding

Treatment	Protein (%)	Fat (%)	Lactose (%)	Solid Nonfat (%)
P1	2.27 ± 0.05[a]	5.86 ± 0.75[a]	3.60 ± 0.44[a]	8.11 ± 0.99[a]
P2	3.14 ± 0.11[b]	7.22 ± 0.55[b]	4.82 ± 0.26[b]	8.77 ± 0.49[b]
P3	3.27 ± 0.12[b]	7.42 ± 0.26[b]	4.75 ± 0.34[b]	8.76 ± 0.69[b]
P4	3.42 ± 0.14[b]	7.97 ± 0.66[b]	5.20 ± 0.89[b]	8.92 ± 0.36[b]

Note: [ab] Different superscripts indicate significant difference (P<0.05)

P1= Basal forage feed + concentrate; P2= P1 + Cassava Leaves (2 kg); P3= P1 + Sweet Potato Leaves (2 kg); P4= P1 + Moringa Leaves (2 kg)

are colloidal; tannins form complex bonds with proteins, carbohydrates (cellulose, hemicellulose, and pectin), minerals, vitamins, and microbial enzymes in the rumen. The complex bond of tannins with proteins will be released at low pH in the abomasum of ruminants so that proteins can be degraded by the enzyme pepsin and the amino acids they contain can be utilized by the livestock body optimally (Jayanegara et al., 2009). Therefore, tannin can increase protein by passing in the rumen, improving milk quality in Murrah buffalo. Improving the quality of milk, particularly enhancing protein and lactose levels, will elevate the yield of solid nonfat milk. According to Suhendra et al. (2015) and Zurriyanti et al. (2011), solid nonfat milk consists primarily of milk protein and lactose.

CONCLUSION

From the results of the study, it can be concluded that feeding local forages (cassava leaves, sweet potato leaves, and Moringa leaves) can increase the production and quality of Murrah buffalo milk so that this local forage feed can be recommended to farmers as an alternative feed that is high in nutritional content and readily available in welcoming national milk self-sufficiency.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

NOVELTY STATEMENT

The novelty of this study is to get the best feed from local forages (cassava leaves, sweet potato leaves, and Moringa leaves) to increase the production and quality of Murrah buffalo milk in West Sumatra. Also, this local forage feed can be recommended to farmers.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the manuscript.

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