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Effect of grass-legume silage on production and milk composition of Friesian cross cows in Imbo region of Burundi

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A B S T R A C T

The study determined the effects of feeding *Cenchrus purpureus*- Velvet bean, or Maize stalk- Velvet bean silage on milk production and quality. The one-way analysis of variance (ANOVA) in R4.4.1 software was used for data analysis. Results from the study showed that there was a significant difference ($P < 0.01$) in milk production among treatments. The mean milk production was different between the blocks ($P < 0.05$). The mean milk production was higher (7.53±1.52 kg) for cows fed on maize stalk-Velvet bean silage than cows fed on *Cenchrus purpureus*-Velvet bean silage (5.36±1.07 kg) and fresh mixed grass-legume (4.29l±1.07 kg). Results also showed a significant difference ($p<0.05$) in milk SNF, lactose and salt, while there were no significant differences ($p>0.05$) on milk fat and protein contents for all the experimental diets. The study concluded that the incorporation of maize stalk: Velvet bean silage ratio (80:20) could prevent the dry season feed scarcity, increase milk production and consequently increase the household income.

Keywords: Feed scarcity, Season, Milk consumption, Quality, Income

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Introduction

The Imbo Plain has an average temperature and annual precipitation of 25°C and about 900 mm/year, respectively. In this region, inadequate and unbalanced feed supplies are the major technical problems faced by farmers, especially during the dry season. Since October 2021, Burundi has adopted the zero-grazing policy. For smallholders with limited capacity, finding enough fodder in the dry season to maintain good milk production is a major problem. In this region, it is observed that there is a decrease in milk production, while milk consumption is associated with an increase in milk price during the dry season. In this place, the main crop production is maize and rice, which are used mainly for human consumption. The use of crop residues is not well adopted. This makes feed scarcity, which causes a decrease in animal production, especially during the dry season. To manage dry season feed scarcity, it is important to improve feed resources by considering the use of crop residues available as animal feed. Cultivation, processing (silage making) and preservation of high-yielding fodder (e.g., *Cenchrus purpureus,* Maize Stalk, Velvet bean) could minimize feed shortage during the dry season period. This study aimed to contribute to sustainable dairy production by improving the nutritive value of available feed and preventing dry season feed scarcity by feeding a mixture of *Cenchrus purpureus* – Velvet bean and Maize Stalk – Velvet bean silage.

Materials and Methods

Study areas

The study covered the Imbo Plaine region of Burundi. The area of the study was the region located between 2°48'30'' and 4°20'43'' latitude south, and 29°93' 63'' longitude East. The ecological region of the Imbo plain of Burundi is characterized by a rainfall of 800 to 1100 mm spread over 7 to 8 months. The average annual temperature was 25°C, with maximum and minimum of 30°C and 15°C, respectively (Ahimpera *et al*., 2024).

Silage preparation

Harvesting

The response to cutting forage plants depends upon its seasonal yield of carbohydrate storage, its growth and the extent of inflorescence development. During the study, *Cenchrus purpureus* was cut at 1m height (before forming internodes), the maize stalk was cut when the grain was at the harvesting maize stage, and the Velvet bean in the early bloom stage. *Cenchrus purpureus* and maize stalks were harvested in the morning and left to wilt in the field for 24 hours, then transported for chopping using a forage chopper machine. The legumes were harvested in the morning and allowed to wilt for 6 hours, and similarly chopped. Harvesting of Napier grass, Maize Stalk, and Velvet bean was done by hand using machetes.

Chopping

Fodder was chopped using a forage chopper machine to lengths smaller than 2.5 cm for stems and much longer for leaves. Legumes (Velvet bean) were also chopped using a forage chopper machine after wilting for 6 hours.

Filling and packing

The forage was harvested by hand and pre-wilted for 1 day before ensiling. On the second day, forages were chopped and immediately transported to the silo. Before the start of filling, a plastic sheet was spread on the outer edges of the silo and the walls and hung over the sides. Legumes were hand mixed with both *Cenchrus purpureus* and Maize stalk. The mixture of grass-legume was 80-20 percent respectively. Once the forage arrived at the silo, it was transferred and packed quickly to exclude oxygen and promote the onset of fermentation. Forage was delivered to the silo immediately after chopping. The dimension of the silo was 1.5 m length x 1.5 m width x 1.5 m depth. The forage was packed until the silo of 3.375 m^3 was full.

Addition of molasses

During compacting, 1.5% molasses was added to the silage. Molasse (5 kg) was diluted into water (10 L) and mixed before it was sprinkled with a watering can to the forage in the silo. This addition of molasses improved the taste and the smell of the silage, which increased the amount of silage eaten. Molasses was available due to the availability of the sugarcane industry in Burundi.

Compacting and covering

During the silo filling, forage was compacted by trampling with legs to get out the air as much as possible. Compacting silage was done layer by layer using legs. The silo was covered immediately after completing the filling and compacting. Dry fodder was added to the silage before covering, and then a plastic sheet was used to cover. Finally, soil was heaped on the plastic sheet to hold it in place.

Silage sampling and assessment

After eight months of ensiling, the silos were opened one by one for evaluation of physical properties of the silage (color, aroma, mold appearance…). Samples were taken to the laboratory for analysis of dry matter, crude protein, crude fiber and ash content.

Experimental design

Nine lactating Friesian cross cows 400 kg (±100 kg), in second or third parity within the early to mid-lactation (about 5-8 weeks after calving) period, were selected based on their average milk production. In a randomized complete block design (RCBD), the cows were grouped into three uniform blocks of three animals each according to weight and milk production. Cows were housed in individual pens in a common house. They were treated for internal and external parasites. Within a block, animals were randomly allotted to one of the three dietary treatments each. Cottonseed cake, palm seed cake, rice bran and wheat bran were used as protein and energy supplements. The cows were fed three meals per day, at 07:00 AM, 1:00 PM, and 5:00 PM for 28 days after 14 days of adaptation. The experimental diets were Maize Stalk -*M. pruriens* silage(T1), *Cenchrus purpureus*- *M. pruriens* (T2), Fresh Napier grass and Fresh mixed grass-legume forage (control T3). During milking, 2 kg/cow of concentrate was fed at each milking time (8:00

AM and 4:00 PM). The milk yield of each cow was recorded twice per day. Daily milk yields of each cow were measured and recorded at each milking time (8:00 AM and 4:00 PM). All cows had free access to drinking water. The study consisted of an adaptation period of 14 days followed by a 28-day experimental period during which cows were fed their experimental diets.

Data collection and analysis

Silage samples were collected immediately when filling the silo and after the fermentation process was completed (after 45 days). Silage samples were stored immediately at -8°C. Fresh and ensiled samples were analyzed for dry matter, crude protein, ash, crude fiber, and crude fat. Milk samples were taken at the beginning and at the end of the study for milk composition analysis. Milk samples were put in a clean cup and then placed in the icebox and analyzed for Protein, Fat, SNF and Lactose using a lactoscan (milk analyzer). Milk yield was immediately recorded at each milking time and during the entire experimental period. Milk samples were collected at the beginning of the experiment (before the adaptation period) and on the 25th day of the experiment.

The analysis of feed was done in the Laboratory of Soil Analysis and Food products (LASPA). The proximate analyses were done using the Association of Official Analytical Chemists (AOAC, 1990) procedures. The DM, CP- Kjeldahl method, Ash and crude fat content were determined using methods (930.15), (984.13), (942.05), and (920.29), respectively.

Statistical analysis

The analysis of variance (ANOVA) for a randomized complete block design (RCBD) was done using the R4.4.1 software. The one way of variance (ANOVA1) in R was used to compare if the means of the dry matter, crude protein, ash, crude fiber, and crude fat were equal in the freshly mixed *Cenchrus purpureus: Mucuna pruriens* or Maize Stalk: *M. pruriens*. The effect of the incorporation of *Cenchrus purpureus*: Velvet bean and maize stalk: Velvet bean silage was also determined. The means of milk production and milk composition between the blocks were tested and also compared to determine if there was a significant difference by incorporating *Cenchrus purpureus*: Velvet bean and maize stalk: vervet bean silage ration.

The significant difference was determined at $P<0.05$ level. Significantly different means were separated for linear expressions following the models described by Snedecor and Cochran (1989):

Milk yield (Y_{ijkl}) = $\mu + cov_i + T_i + B_j + Sk + Fl + eijkl$

Where,

Y_{ijkl} = Milk yield
μ = General mean.
cov_i = the covariate measure for cow
T_i = The effect of the treatment.
B_j = The effect of the block
Sk = The effect of the stage of lactation.
Fl = Effect of the interaction (Tix Bj)
E_{ijkl} = random error term.

Results

Nutrient composition of the mixture of grass-legumes

Crude fiber content of ensiled grass-legumes was 28.1% for *Cenchrus purpureus*-Velvet bean, while it was 24.8% for maize stalk-Velvet bean silage. Laboratory results showed the lowest content of crude protein (CP) in Maize stalk-Velvet bean silage (5.37%) and the highest in *Cenchrus purpureus*-Velvet bean silage (7.07%).

Table 1. Nutrient composition of the mixture of grass-legumes.

Nutrient /Parameter	DM %	CP %	CF %	Ash%	Crude fat%
Fresh *Cenchrus purpureus*-Velvet bean	45.1	9.76	29.4	12.00	1.78
Fresh mays stalk-Velvet bean	22.7	11.60	24.8	7.19	1.34
Ensiled *Cenchrus purpureus*-Velvet bean	30.1	7.07	28.1	7.20	1.99
Ensiled maize stalk-Velvet bean	17.6	5.37	33.9	12.60	2.51
F value	3.811	4.254	0.99	0.013	2.646
Pr(>F)	0.19	0.175	0.425	0.921	0.245

DM: Dry Matter; CP: Crude protein; CF: Crude Fiber

Table 2. Statistical description of the forage composition.

Nutrients	Min.	Median	Mean ± SD	Max.
DM	17.600	26.400	28.880 ±11.972290	45.100
CP	5.370	8.415	8.450 ± 2.770644	11.600
CF	24.800	28.750	29.050 ± 3.768731	33.900
Ash	7.190	9.600	9.748 ± 2.957537	12.600
Fat	1.340	1.885	1.905 ± 0.485833	2.5100

The result showed that the mean milk production was different between the blocks (P < 0.05). The mean of milk production for cows fed on maize stalk-Velvet bean silage is greater (7.53±1.52l) than for cows fed on *Cenchrus purpureus*-Velvet bean silage (5.36±1.07l) and fresh mixed grass-legume (4.29l±1.07l) feed.

Table 3. Means and standard deviations of milk production and milk composition depending on the diet.

Diet	Milk (kg/d)	FAT, %	Protein, %	SNF, %	Lactose, %	SALT, %
maize stalks-Velvet bean silage	7.53±1.52	4.62± 4.82	3.26± 0.51	8.94±0.15	4.88± 0.16	0.76±0.001
Cenchrus purpureus- Velvet bean silage	5.36±1.07	7.85± 1.28	3.22± 0.51	8.04±0.21	4.35± 0.11	0.62±0.002
Fresh mixed fodder	4.29±1.07	6.67±4.06	3.24±0.16	8.77±0.43	4.85±0.23	0.73±0.003
F test	234.213	0.58	0.016	8.10	7.99	2.52
P-value		0.58	0.98	0.019	0.020	0.0007

There was no difference between the means of milk components such as Fat and Protein. There was significant difference in milk composition for the component SNF(P-value=0.019), Lactose (P- value= 0.020) and Salt(P-value=0.0007). The SNF 8.94±0.15, Lactose 4.88± 0.16 and Salt 0.76±0.001 was high for cows fed on Maize stalk-Velvet bean silage compared to cows fed on *Cenchrus purpureus*-Velvet bean silage (SNF 8.04±0.21, Lactose 4.35± 0.11and Salt 0.62±0.002 and fresh mixed fodder (SNF 8.77±0.43, Lactose 4.85±0.23 and Salt 0.73±0.003).

Discussion

Chemical composition of *Cenchrus Purpureus*- *Mucuna Pruriens* or Maize Stalk- *Mucuna pruriens* silage

There was no significant difference between *Cenchrus purpureus* -Velvet bean silage and Maize stalk-Velvet bean silage composition. In both dry matter and crude protein, values decreased when fresh samples were compared to ensiled samples. Several factors influence the chemical composition of feeds including variety, environment, and post-harvest handling. The crude fiber and Ash content decreased in the mixture of *Cenchrus purpureum* -Velvet bean silage, while they increased in maize- Velvet bean silage. This difference could be explained based on the quality of the forage used which was highly variable with the forage species, variety, and stage of harvest. A decrease in crude fiber may indicate that microbial enzymes hydrolyze crude fiber into glucose. The percentage of dry matter and crude protein was recorded with Fresh *Cenchrus purpureus*-Velvet bean silage (DM=30.1, CP=7.07, Ash=7.20) was higher than Maize- Velvet bean silage (DM=17.6, CP=5.37, Ash=12.6), respectively. The value of DM (30.1) in *Cenchrus purpureus*-Velvet bean was almost similar to the level reported by Zhao *et al.* (2007) in maize at the dough stage(DM=30.38). The crude protein in this study was close to 6.58 (Zhao *et al.*, 2007). In contrast, the crude fiber, crude fat and ash were higher in maize stalk-Velvet bean silage than *Cenchrus purpureus*-Velvet bean silage.

Effect of feeding grass-legume silage on milk production

The mean milk production for cows fed on maize stalk-Velvet bean silage was higher (7.53±1.521/d) than for cows fed on *Cenchrus purpureus*-Velvet bean silage (5.36±1.07l/d) and fresh mixed grass-legume (4.29l±1.07l/d). This may be due to the difference in dry matter intake from maize stalk silage, which could have a major influence on feed digestibility. Some researchers found that the increase in milk production could be due to the distribution of high-quality feed, which improves rumen function and efficiency of milk production synthesis (Liu *et al.*, 2016). According to Terefe *et al.* (2021), the dry matter yield of the cow was significantly affected (P<0.01) by the dietary treatments, with cows receiving the silage-based (50% Maize stalk silage, 50% Concentrate mixture) diet producing better daily milk than cows on the control diet. In his study, the means of milk production for T2 (70% Maize stalk silage: 30% Concentrate mixture) were almost comparable with this study (9.46 l/d). The reason is that the mixture of Maize stalk-Velvet bean was near the ratio (80%-20%) and concentrate was added during the feeding period (2 kg of concentrate/cow/day). This result could be due to the higher palatability and good fermentation characteristics of feed, which made cows consume more amounts of Maize stalk -Velvet bean silage. Also, diets based on legume silage, maize silage, or the mixture of the two led to high milk production. However, according to Dewhurst (2013), grass and legumes tend to contain adequate levels of crude protein. The Increase in milk production for all experimental cows may result in an increase in milking frequency. According to some researchers, milking twice a day yields at least 40% more milk than once a day. The most likely reason for increasing milk production when increased milking frequency could be the lower intramammary pression generated with frequency of milk, an increase of stimulation of hormone activity of milk production, and the less negative feedback on the secretary cells due to the accumulation of milk components (Vijayakumar *et al.*, 2017).

There were significant changes observed with milk production (P < 0.05) in milk among treatments for the entire experimental period. The milk production was higher for the Block 1 (7.53±1.521/day) than Block 2 (5.36±1.071/day) and Block 3(4.29±1.071/day). This could be attributed to the availability of glucose and amino acids in the feeds, as well as the productivity of ruminants, which is influenced primarily by feed intake, which in turn determines the digestibility and capacity of the diet to supply the nutrients required. The increase of mammary gland activity may also induce the increase of milk production.

Effect of feeding grass-legume silage on milk composition

For cows on T1, the respective amounts of fat and protein were 7.85±1.28 and 3.22±0.51. The amount on fat and protein content in milk for cows in T2 were 4.62±4.82 and 3.26±0.51 while they were 6.67±4.06 and 3.24±0.16 for cows in T3. Our result showed that there were no significant differences (P>0.05) found in milk fat and protein contents. These results differed from Agbo *et al.* (2023) found a significant difference in fat and protein content. This difference could result from the presence of fatty acids from diets, adipose tissue or synthetized novo in the gland. A decrease in rumen acetate and butyrate also limits milk fat synthesis, as cited by Bauman and Griinari (2003). Legume silages have often led to reductions in milk fat concentration and/or milk protein concentration. The reduction in milk fat concentration with silage is most consistent with the reduction in milk protein concentration. Often small and occasional significant increases in milk protein concentration occur when clover silages with exceptionally high intake characteristics were fed (Dewhurst, 2013). Milk fat content may also be induced by the type of breed and the stage of lactation. Our result differed from the result found by Budimir *et al.* (2011) where they assumed that the Holstein Friesian breed had an average milk fat content range of 3,61 %- 3,80 %. The decrease of milk fat and protein may also be induced by the stage of lactation in cows.

There was a significant difference (p<0.05) in SNF, lactose, and milk salt for different treatments. The SNF content of the animals in T1 (8.95±0.15) was higher than that of the animals in T2 (8.04±0.21) and T3 (8.77±0.43). The lactose content found in this study was 4.88 ±0.16, 4.35 ±0.11, and 4.85± 0.23, and milk salt was 0.76±0.001; 0.62±0.002; and 0.73±0.003, respectively, in T1, T2 and T3. The SNF content in milk for all experimental cows is close to the results found by other researchers. These results also close to the standard fixed by the Food Safety and Standards Authority of India (FSSAI). These standards fix that the percentage SNF in raw milk for cow range to 8.5 to 9.0 (Garg *et al.*, 2016).

The salt value of the milk of the animals was 0.76±0.001%, 0.62±0.002%, and 0.73±0.003%, respectively, in T1, T2 and T3. The change in milk composition could be due to the supplementation with lick block, as found by Agbo *et al.* (2023) in Benin when evaluating the nutritional quality of low milk for dairy cows supplemented with lick block.

The lick block was also used during our experimental feeding. Generally, more factors induce milk composition. Include in the intrinsic factors that are related to animals, such as the age of the animal, health, breed, parity, and the stage of lactation. Other factors affecting milk composition are related to extrinsic factors, which are related to environmental factors such as housing factors, nutritional factors, climate, hygiene (especially during milking), and the milking operation.

Conclusion

The increase in milk production and quality depends on the improvement of the nutritive value of the feed. Since *Zea mays* is the main crop established in the Imbo plain, it is important to increase the use of maize stalk as animal feed. This could help to prevent the dry season feed scarcity in the Imbo plain of Burundi. Farmers are also encouraged to improve the nutritive value of *Cenchrus purpureus* by mixing it with the protein-rich feed sources, such as legume, during feeding.

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