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Effect of Supplementary Feeding on the Performance of Ankole x Friesian Crossbred Calves Grazed on Natural Pastures

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SK and DM designed the study and wrote the protocol. Author SK managed the experimental process, performed the statistical analyses and wrote the first draft of the manuscript. Author ENS and EW played a supervisory role by visiting experimental sites and participated in dissemination workshops. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the effect of protein supplementation to Ankole x Friesian crossbred calves grazing natural pastures on their growth performance, and the economic viability of supplementation.
Study Design: Randomized Complete Block Design.
Place and Duration of Study: Kiruhura district in Uganda; September to December 2012.
Methodology: Nine weaned crossbred calves aged 5-6 months on each of the five experimental farms were divided into three groups. Each group was randomly assigned one of the three dietary treatments comprising: a control where calves depended solely on pastures, supplementation with homemade concentrate (HMC), or lablab hay (LH). Calves were released daily at 8.00 am to graze

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till 3.00 pm when those on supplementation were returned to their pens for supplementary feeding; meanwhile the control group was left grazing until evening. Body weight (BW) and body condition (BC) of each calf were recorded at three weeks' intervals. Financial efficiency of supplementation was estimated using the ratio of total revenue (TR) to total variable cost (TVC).

Results: The mean total DMI (kg/day) of calves supplemented with HMC (3.28) and LH (2.94) were higher (P < .001) than that of calves on sole grazing (1.90). The mean daily BW gain (g/day) of calves supplemented with HMC (540) was higher (P = .03) than that of calves supplemented with LH (423) and those on sole grazing (357). The BC scores of calves fed HMC and LH were 4.74 and 4.90 respectively, and were higher (P = .04) than that of calves (4.32) on sole grazing. Returns per unit variable cost of production measured by TR/TVC for calves on sole grazing were 1.30 compared to 1.11 and 0.92 for calves fed LH and HMC, respectively.

Conclusion: Supplementing crossbred calves grazing natural pastures with HMC improves their growth performance, but might be uneconomical in the short run due to cost of ingredients.

Keywords: Body weight gain; crossbred calves; dry matter digestibility; dry matter intake; gross margin; homemade concentrate; lablab hay.

1. INTRODUCTION

The increase in land pressure due to the rapidly growing human population and the demand for livestock products especially in the urban areas are changing the life styles of pastoralists. In the rangelands of south-western Uganda, the pastoralists have settled down and pastoralism has been transformed into an agro-pastoral system [1]. In an effort to increase livestock productivity, many agro-pastoralists are crossing their Ankole cattle (*Bos indicus*) with the Holstein-Friesian (*Bos taurus*) to obtain crosses with higher milk production potential. However, nutritional demands of the crosses are higher than those of the indigenous Ankole cattle, and the natural pastures which are the main source of feed may not supply all the needed nutrients throughout the year [2]. The problem of feed is more serious during droughts when the quantity and quality of forage drop significantly [3].

The situation is getting worse due to the impacts of climate change on livestock production and productivity. These include reduction in milk yields and body live weights, changes in availability of forage and water, and increased severity of diseases among others [4]. An accelerated adaptation process to climate change is needed if livestock farmers and their livestock are to survive [5]. Livestock feeding systems in the rangeland areas will have to change so that they are matched with the seasonal changes in the forage availability and quality, and the nutritional requirements of the emerging Ankole x Friesian crossbreed of cattle if better livestock productivity is to be realized.

Long-term sustainability of any dairy production system depends on a sound herd management. As part of herd management, good calf rearing is essential as it ensures availability of future replacement stock. The current calf feeding regimes in the rangelands where tropical grasses constitute the primary diet, makes it unlikely that calves get balanced nutrient supply that meets their nutrient requirements [6]. In practice, calves are allowed to suckle after milking when the udder has been almost emptied. They are then grazed on natural pastures with insufficient forage because farmers lack well established paddocks for calves. All these result in inadequate nutrient intake, which in turn adversely affects the growth rates, age and weight at breeding and calving.

A number of technologies have been demonstrated which can improve the growth performance of calves. Studies carried out elsewhere have shown that growth rates of calves supplemented with protein-rich forages are higher compared to those of calves without supplementation [7,8]. Trials carried out in Kiruhura district located in the rangelands of Uganda showed that oversowing of natural pastures with forage legumes improves pasture productivity, persistence during drought and milk productivity [9]. However, pastoralists have not adopted the forage legumes for reasons which are not yet well established. One possible explanation for not adopting such technologies could be that they are not economically viable, or are too expensive for the farmers. Thus, this study was intended to demonstrate to farmers that productivity can be improved using these technologies. In addition, no comprehensive on-farm studies have been conducted to evaluate the effects of protein supplementation on the performance of Ankole x Friesian crossbred calves maintained on natural pastures. The study also assessed the cost-effectiveness (profitability) of providing the Ankole x Friesian calves grazed on natural pastures with protein-rich supplements.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in Kazo county, Kiruhura district located in the south-western rangelands of Uganda. The major town in the area is called Kazo and is located at 0°03'10.0"S, 30°45'25.0"E (Latitude:- 0.052778; Longitude: 30.756944) [10]. The area lies in a low rainfall belt (around 900 mm annually) with bimodal pattern. The first rains fall from March to May, and second rains occur from September to November [11]. The average temperature of the area is about 27.5°C with daily variations ranging from 21.5 to 34.0°C. The mean monthly rainfall and temperature patterns during the period of study are shown in Fig. 1. The droughts greatly reduce the quantity and quality of forage in the pastures, and consequently the productivity of livestock that depend on these pastures.

2.2 Lablab Hay Production and Establishment of Calf Paddocks

Half an acre of land on each of the participating farms was prepared and then planted with lablab (*Lablab purpureus*) forage legume in March 2012. Each of the plots received 25 kg of single super phosphate fertilizer before planting to improve phosphorus content of soils. After three months of growth, lablab herbage was harvested by cutting whole plants (stems and leaves) at 30 cm above the ground, chopped into pieces and then dried under shade. The chopped material was continuously turned using a rake to enhance drying. The dried material (lablab hay (LH)) was sampled, baled using a wooden baling box, the bales tied with sisal strings and stored. Each farm produced and used its own LH. Each of the participating farmers provided one hectare of pasture which was fenced and turned into calf paddock. Fencing was carried out in March 2012, followed by weeding of pastures. This was the paddock where the calves were grazed daily throughout the study.

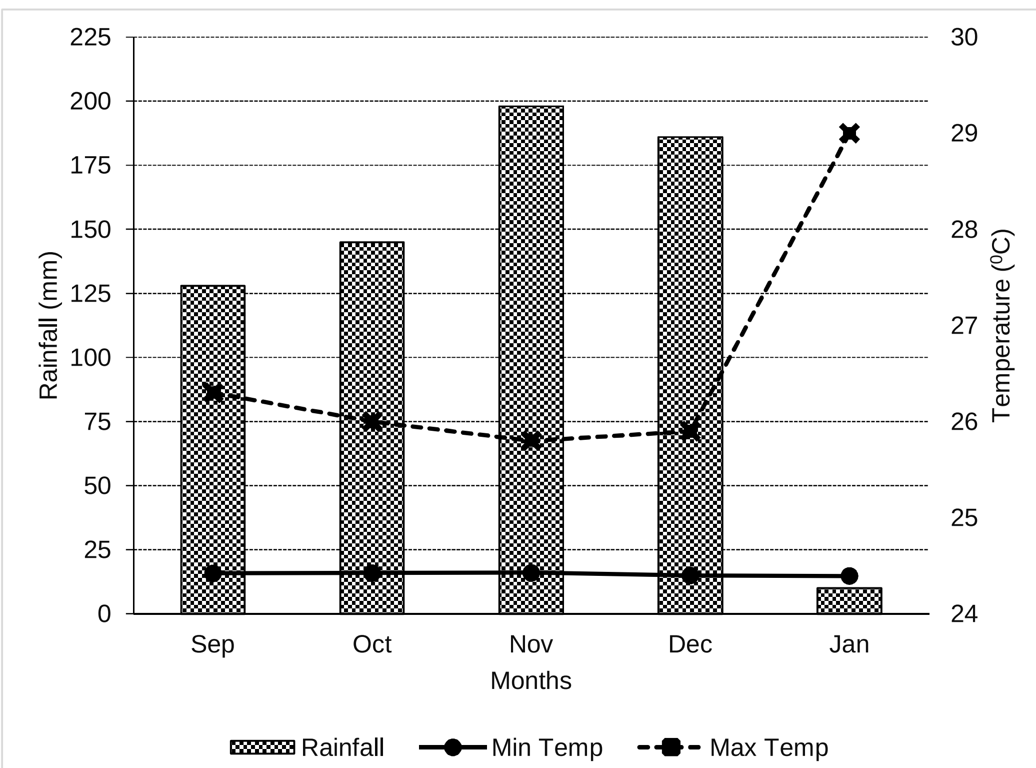

Fig. 1. Mean monthly rainfall and minimum and maximum temperatures of the study area, September 2012-January 2013

2.3 Experimental Animals, Treatment Diets and Experimental Design

A total of 45 weaned crossbred calves, aged 6-7 months from 5 farms were used in the study. Nine calves on each farm were randomly divided into 3 groups, while making sure that the total body weights of calves in all the three groups are almost equal. Each group of calves was randomly assigned one of the three dietary treatments which comprised: (i) a control where no supplement was fed to calves (farmers' practice), (ii) a homemade concentrate (HMC) supplement containing 17% CP, and (iii) lablab hay (LH) supplement. Both supplements (HMC and LH) were formulated to have similar concentrations of digestible energy. During grazing time, all calves had free access to mineral blocks (5.54% P, 26.54% Na, 3.31% K, 14.38% Ca, 0.23% Mg, 719 ppm Fe, 1087 ppm Mn, 2178 ppm Cu and 2377 ppm Zn). The main ingredients of HMC were maize bran (82.2%), cotton seedcake (15.3%) and premix (2.5%). Maize bran and cotton seed cake were sampled for proximate chemical analysis before mixing to form the concentrate mixture. The premix contained 4.3% Zn, 4.3% Mn, 7800 mg/kg Cu, 830 mg/kg I, 320 mg/kg Co, 220 mg/kg Se, 5500000 IU/kg vitamin A, 1375000 IU/kg vitamin D and 18700 IU/kg vitamin E). The farms were taken as blocks, thus giving a Randomized Complete Block Design.

2.4 Feeding Management

The nine calves on each farm were released every morning (8.00-9.00 am) to graze in the calf paddock. At 3.00 pm, they were taken to the water source to drink. Thereafter, the 3 calves on the control treatment were returned to the paddock to graze till evening (7.00 pm) while those to be supplemented were returned to their pens for supplementary feeding. They were housed in separate pens and fed individually. The supplements (HMC and LH) were provided to the calves once a day *ad libitum* after grazing. The HMC was made every two weeks on one of the farms to ensure that the composition is similar for all the calves, sampled and then distributed to other farms. The study lasted for 90 days, from 10th September to 12th December 2012.

2.5 Measurements and Data Collection

2.5.1 Body weight changes and feed intake

On the commencement of the study, the body weights (BW) of calves were taken using an electronic scale. The body condition (BC) was visually assessed and scored by two people throughout the experimental period following the nine-point scale, where 1–3 denoted thin condition, 4 border line, 5–7 optimum condition, while 8–9 denoted fat condition [12]. The BC scores were based on the observable changes in the rear and side parts of the calf's body. Thereafter, calf BW measurements and BC scoring were carried out at three weeks' intervals in the morning before allowing calves to graze or drink water to assess changes in BW and BC. The amounts of supplements offered and refused (only for LH) were weighed daily and recorded for each calf to determine daily dry matter intake (DMI). Refusal samples of LH collected for each calf were pooled, mixed thoroughly and a composite sample drawn for chemical analysis. Refusals from HMC were negligible and were not recorded or sampled.

2.5.2 Sampling forage in calf paddocks and estimation of forage yields

Forage in calf paddocks was sampled at three weeks' intervals for dry matter (DM) yield and nutritive value determination using a 1.5 m^2 metallic quadrat, which was thrown randomly in each paddock following a zig-zag pattern to get the sampling points. Forage within the quadrat that could be grazed was cut using a panga (machete), placed in a polythene bag, weighed to determine its fresh weight and then the bag labelled. Five samples were collected from each calf paddock at each round of sampling, mixed thoroughly and then two composite samples, each weighing about 400 g taken, weighed and labelled. All the samples collected were dried in the oven at 60℃ for 48 hours to determine their DM weights. The DM weights of composite samples were then used to determine the total forage DM yield per hectare in each calf paddock available for grazing.

2.5.3 Collection of fecal samples

Fecal samples of about 100 g each were collected from calves by rectal palpation in the morning (8.00-9.00 am) after every three weeks and stored in plastic bags [13]. They were dried in the oven at 60℃ for 48 hours.

2.6 Chemical Analysis of Feedstuffs and Feces

Dry samples of forage, LH and its refusals were ground to pass through a 1 mm sieve, and together with the HMC and its ingredients (maize bran and cotton seed cake) were analyzed for crude protein (CP) [14], acid insoluble ash (AIA) [13] and neutral detergent fibre (NDF) [15]. The calcium (Ca), phosphorus (P) and potassium (K) contents of forage, LH, maize bran and cotton seed cake were determined by first digesting the samples with a tri-acid mixture of sulphuric, perchloric and nitric acids (1.5:2:3) [16]. Then Ca and K contents were determined using the flame photometer (Model PFP7, Jenway Co. Ltd), while P content was determined using the colorimeter (Model CO 7000). Fecal samples were also ground to pass through a 1 mm sieve and analyzed for AIA [13].

2.7 Estimation of Dry Matter Digestibility and Dry Matter Intake of Calves

Dry matter digestibility (DMD) of calves under each treatment was determined using percentages of AIA in feed (Md) and feces (Mf) as internal marker by using the following equation [17].

DMD, % = 100 – 100 x (Md/Mf). Forage DMI was calculated using the following prediction equation developed by Hoffman et al. [18]: $\text{DMI (kg/d)} = 13.48 \times [1 - e^{(-0.00271 \times BW)}] - 0.0824 \times NDFdv$

where $NDFdv = (\text{dietary NDF as a \% of DM}) - \{23.11 + [0.07968 \times BW] - [0.00006252 \times (BW)^2]\}$; e = 2.71828 (Mathematical constant that is the base of natural logarithm) and BW = calf body weight (kg).

Total DMI was then determined by addition of forage DMI and DM of supplement (HMC or LH) consumed by the calf.

2.8 Gross Margin Analysis

Gross margin (GM) was taken as the gross income less variable costs [19], and can be represented by the equation as: $GM = \Sigma (yi*py_i) - \Sigma (x_i*px_i)$, where $\Sigma (yi*py_i)$ = gross income, y_i = calves used in the study, py_i = respective estimated market prices of calves, $\Sigma (x_i*px_i)$ = total variable costs, x_i = quantities of materials used including calves, and px_i = respective prices.

The gross income (total revenue) was computed as estimated sales from calves at the end of the study valued at market prices. Variable costs included estimated cost price of calves at the onset of the study, management costs, costs of veterinary services and feeds. Costs that were incurred in fencing calf paddocks and constructing housing structures for the study were regarded as fixed costs, thus were not included in the gross margin analysis. Management costs were computed based on the number of personnel employed and their respective wages for the three months of the study. Cost of veterinary services was computed as the sum of the cost of spraying calves with the acaricide and deworming. Feed costs comprised the cost plus transport of feedstuffs used to formulate the concentrate. However, gross margin could not reflect the real economic performance of calves under supplementary feeding. Thus, we considered Total Revenue (TR) in relation to Total Variable Cost (TVC) in order to establish financial efficiency of supplementation. Financial efficiency was estimated using the TR/TVC ratio, which shows the returns (revenue) per unit variable cost of production.

2.9 Statistical Analysis

The General Linear Model (GLM) procedures of SAS [20] was used in the analysis of growth rates and BC scores of calves, with Least Square Means to test the significance of all differences evaluated. The statistical model used was: $Y_{ijkn} = \mu + F_i + X_j + S_k + FS_{ik} + e_{ijkn}$ where Y_{ijkn} is the growth rate of n^{th} calf on the i^{th} farm, j^{th} calf sex and k^{th} calf diet; μ is the general mean; F_i is the fixed effect of farm (i = 1, 2,3, 4, 5); X_j is the fixed effect of sex of calf (j = 1, 2); S_k is the fixed effect of calf diet (k = 1, 2, 3); FS_{ik} is the interaction between F_i and S_k; e_{ijkn} is the random residual effect. The initial BW and BC measurements were used as covariates in the analysis to adjust for differences in BW and BC of calves. When treatment effects were found to be significant, comparison between treatment means was undertaken by Tukey's pairwise procedure to determine whether the changes in body weights and BC scores from the first recording to that performed at the end of the study were significant.

3. RESULTS

3.1 Feed Composition

The mean CP content in forage from calf paddocks (67.2 g/kg DM) was lower than those of the supplements (HMC and LH), and also contained higher amounts of NDF (635.1 g/kg DM) than the supplements (Table 1). Lablab hay and cotton seed cake contained high amounts of Ca and P respectively, while all the feedstuffs had relatively same amounts of K.

3.2 Variations in Forage Yields and Quality in the Calf Paddocks

The mean forage DM yields (herbage mass) in the calf paddocks gradually increased from September as the rainfall intensified and reached the peak (2.4 ton DM/ha) in October, and thereafter declined to 1.9 ton DM/ha by December (Fig. 2). Within the same period, the mean CP content in forage ranged between 5.0 and 7.5% (Fig. 2).

3.3 Intake and Digestibility of Dry Matter

Supplementation significantly (*P* = .04) increased the mean forage DMI when compared with the control (sole grazing), but there were no significant differences within the supplemented (LH and HMC) treatments (Table 2). The mean total DMI was significantly (*P* < .001) higher for calves supplemented with HMC and LH when compared with that of calves maintained on sole grazing. Also, the mean total DMI of calves supplemented with HMC was significantly (*P* = .03) higher than that of calves that were supplemented with LH. However, supplementation did not improve the DMD of forage (Table 2).

3.4 Body Weight Gain and Body Condition of Calves

The mean daily BW gain of calves supplemented with HMC was significantly (*P* = .03) higher than that of calves that were supplemented with LH and those that depended entirely on grazing. In addition, supplementation significantly (*P* = .04) improved the BC of calves when compared with that of calves on sole grazing, but there were no significant differences within the supplemented (LH and HMC) treatments (Table 2).

Table 1. Chemical composition of forage, lablab hay and ingredients of homemade concentrate

Item (g/kg DM)	Forage	Lablab hay	Homemade concentrate	
			Cotton seed cake	Maize bran
Dry matter (as fed)	229.0	889.7	903.3	860.2
Organic matter	912.5	926.0	929.5	924.8
Crude protein	67.2	191.3	425.1	122.6
Neutral detergent fibre	653.1	472.6	255.7	240.0
Ash	87.5	74.5	70.5	75.2
Calcium	5.4	14.2	2.1	4.9
Phosphorus	2.2	2.7	14.1	1.8
Potassium	16.4	19.2	17.2	10.2

Table 2. Mean dry matter intake and digestibility, daily body weight gain and body condition of calves as influenced by protein supplementation

Item	Treatment			$LSD_{(0.05)}$
	Sole grazing (Control)	Lablab hay supplement	Homemade concentrate supplement	
DMI (kg/day)				
Forage	1.90^{b}	2.30^{a}	2.22^{a}	0.19
Supplement	---	0.64	1.07	---
Total DMI	1.90^{c}	2.94^{b}	3.28^{a}	0.18
DMD (g/kg)	595.8	586.0	621.6	87.8 (ns)
Calf body weights (kg)				
Initial weight	129.9	165.3	149.9	
Final weight	162.1	204.4	198.5	
Wait gain	32.2	38.1	48.6	
Daily BW gain (g/day)	357.3^{b}	423.2^{b}	539.6^{a}	87.5
Body condition score				
Initial mean score	4.27	4.80	4.55	
Final mean score	4.13	5.00	4.85	
Overall mean score	4.32^{b}	4.90^{a}	4.74^{a}	0.37

^{abc}*Within a row, means with different superscript letters differ (P < .05). DMI = dry matter intake, DMD = dry matter digestibility, BW = body weight, ns = not significant*

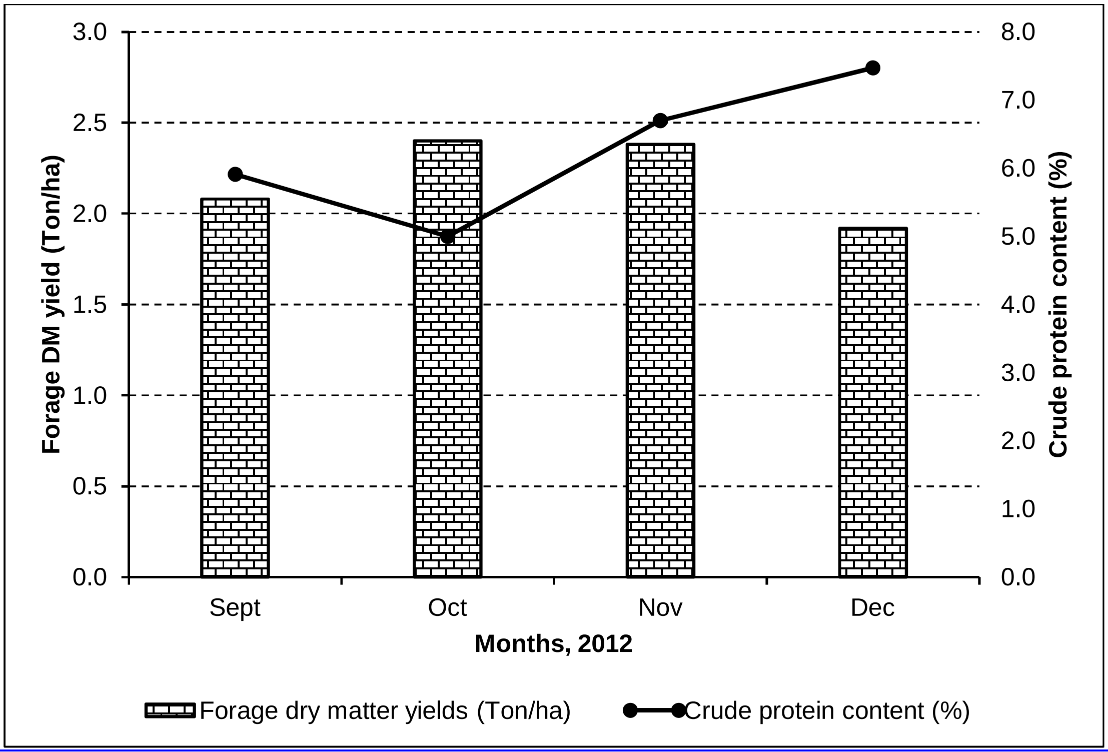

Fig. 2. Changes in forage quantity and quality in the calf paddocks during Sep. – Dec. 2012 period

3.5 Profitability of Protein Supplementation to the Ankole x Friesian Crossbred Calves Grazing Natural Pastures

The economic viability/profitability of providing the Ankole x Friesian crossbred calves grazed on natural pastures with protein-rich supplements (LH or HMC) was assessed (Table 3). The output (total returns) comprised estimated calf sales at the end of the study, while the major input costs of supplementary feeding were the production of lablab and the purchase of ingredients for making HMC. Production of LH for each calf contributed 13.9% while providing HMC to each calf contributed 33.6% of the total variable costs. The mean monthly gross margin from calves solely grazing natural pastures was Ug. Shs 56,638 (1 USD = Ug. Shs 2,480) compared to (Ug. Shs 30,644 and –24,776 for calves supplemented with LH and HMC, respectively. Also, the returns (revenue) per unit variable cost of production (financial efficiency) measured by TR/TVC ratio for calves maintained solely on natural pastures were 1.30 compared to 1.11 and 0.92 for calves supplemented with LH and HMC, respectively (Table 3).

4. DISCUSSION

4.1 Feed Composition

Forage in the calf paddocks was a low-quality feed with CP content less than 70 g/kg DM, which is the minimum requirement of rumen microbes. Crude protein content of feed and digestibility of DM have been emphasized as the main determinants of forage quality [21]. Forage quality refers to the capacity of forage to provide the required nutrients to livestock [22]. Forage quality is important because it influences the performance and health of livestock [23]. Failure to meet minimum nutritional requirements of livestock, as is usually the case in the rangelands during drought leads to a reduction in their productivity such as milk, weight gain and reproductive rates, and to susceptibility to diseases [2,3]. Therefore, providing livestock grazing natural pastures with supplementary feeds is essential in order to achieve satisfactory production.

Table 3. Gross margin analysis (Ug. Shs) of protein supplementation to the crossbred calves grazing natural pastures

Item	Mean values (Ug. Shs) for supplementation		
	Lablab hay	**Homemade concentrate**	**No supplement**
Outputs (Total returns)(TR)			
Market value per calf at the end of study	922,134	886,894	730,896
Inputs			
a) Market value of calf at the start of study	642,852	582,961	505,181
b) Labour for feeding and grazing each calf	53,300	53,300	53,300
c) Lablab hay production for each calf	115,150	0	0
d) HMC fed each calf	0	322,460	0
e) Bags for hay storage	16,400	0	0
f) Veterinary services	2,500	2,500	2,500
Total variable costs (TVC)	**830,202**	**961,221**	**560,981**
Gross margin (benefit) per calf	91,932	-74,327	169,915
Mean monthly gross margin (benefit) per calf	30,644	-24,776	56,638
TR/TVC Ratio	**1.11**	**0.92**	**1.30**

4.2 Variations in Forage Yields and Quality in the Calf Paddocks

The quality of forage changes from season to season based on the type of vegetation cover [24], and the variation in forage quality and quantity leads to variation in the performance of livestock. Generally, the quantities of forage (1.92-2.40 ton/ha) and quality (5.00-7.47% CP) on the calf paddocks were low due to the semi-arid conditions of the area. The problem of forage scarcity is more serious during drought when the quantity and quality of forage drop significantly [25]. However in Uganda, this semi-arid area supports a high number of livestock, as is the case in other semi-arid rangelands found in Africa [26,27]. A deficiency in protein intake limits DMI and utilization. The level of protein in the diet of calves is critical because excessively low CP content can affect the growth rate of calves, while overfeeding of nutrients increases feed costs, and can result in excessive excretion of nutrients into the environment [28]. A study carried out in the same area by Johansson et al. [29] also revealed low mean CP and energy contents of the pasture biomass with a large variation between farms, and the levels were low both during periods when there was pasture shortage (during droughts) and periods when pasture availability was higher (during rainy seasons). The study further revealed that CP content was the only pasture variable that had a significant effect on calf growth, with daily weight gain of calves aged 6-9 months increasing by 81 g/day for each additional percentage of CP.

4.3 Intake and Digestibility of Dry Matter

Dry matter intake is fundamentally important in nutrition because it establishes the amount of nutrients available to an animal for health and production. The increase in forage DMI with supplementation was attributed to higher CP (N) content that was availed to the rumen microbes by the protein-rich supplements [30]. Umunna et al. [31] observed that when supplied with sufficient amounts of N, the rumen microbial population increased thus enabling them to speed up the rates of DM degradation and clearance of feed from the rumen. In this study, therefore, higher rates of feed degradation and clearance from the rumen could have created room for more feed to be consumed. Van Soest [32] also reported that low quality livestock feeds generally exhibit low digestibility because they provide insufficient degradable and fermentable N to sustain optimum digestion of fibre by rumen microbes. Depression in intake is associated with forages and feeds with CP contents of less than 7%, and the result is a depression in digestibility. Therefore, under such circumstances there is need to manipulate and control the rumen ecology in order to enhance the utilization of low quality feeds by ruminants. It has been reported that LH can serve as one of the sources of fermentable N and thus increase voluntary intake and digestibility of low quality forages and feeds [30].

4.4 Body Weight Gain and Body Condition of Calves

The observed improvement in BW gain of calves supplemented with HMC could be attributed to the ability of the supplement to provide more N to the rumen microbes. This in turn enabled the supplemented calves to utilize low quality forage more efficiently. Results of protein supplementation with protein rich forages and formulated concentrate rations improving the rate of daily weight gain of calves have been reported by other researchers [7,8].

At the onset of the experiment, the BC of calves on all the treatments were not significantly different but by the end of the experimental period, calves on supplementation had better BC than calves that depended solely on grazing. Crude protein that was supplied by the supplements resulted in higher total DMI, and hence the increase in BW gain and BC of supplemented calves. The BC is a reflection of the nutritional status of livestock, which in turn reflects the quality and quantity of the pasture [33]. Mugasi et al. [33] observed that cattle grazed on farms which had been cleared of bushes and weeds had a higher mean BC score (5.8) than those grazed on bushy farms (4.2). They attributed the difference in BC to availability of more herbage on cleared farms, which in turn led to higher DMI. Also, due to better nutrition, heifers grazed on cleared farms reached puberty earlier and calved relatively earlier (12-30 months) as opposed to 24-36 months on bushy farms. Thus, if pasture conditions are poor, supplementing calves with additional protein can help improve their growth rates and BC, which will in turn improve their overall reproductive performance and health.

4.5 Profitability of Protein Supplementation to the Ankole x Friesian Crossbred Calves Grazing Natural Pastures

The financial efficiency (monthly benefit per calf) for calves maintained solely on natural pastures (1.30) was higher because there were no expenses incurred in feeding these calves, other than labour for grazing and spraying to control ticks. Supplementation with HMC resulted in the least financial efficiency (0.92) due to costs incurred in the purchase of ingredients, especially cotton seed cake which were not available in the study area. Labour costs for looking after the calves were uniform across all treatments since the same labourer took care of all the experimental calves on the farm. But most of the daily activities involved in looking after these calves were on the management of calves under supplementation, and they included releasing calves to graze in the paddock, cleaning the calf pens, watering the calves and providing supplements to the calves. A study conducted by Ocaido et al. [34] revealed that the cattle pastoral system was labour intensive, and herding was the major labour cost contributing 93% of total labour costs. Pastoralists hire causal labourers to supplement family labour. Job seekers from other areas move to pastoral areas looking for casual jobs like herding, milking, watering animals, weeding/shrub control in pastures and spraying of animals.

The results indicated that the cost of producing lablab on-farm was lower than that of purchasing ingredients for making HMC and distributing it to the farms. Thus, supplementation using LH produced on-farm proved cheaper than use of HMC which was formulated using ingredients purchased outside the study area. This confirms the observation of Mugisa et al. [35] that forage legumes are more economical and on-farm produced supplements than the purchased protein-rich concentrates, especially under smallholder dairy production systems. However, pastoralists still find it expensive to invest in simple technologies like oversowing forage legumes in natural pastures, weeding and controlling shrubs in pastures, and growing fodder legumes [9]. This could be attributed to problems they encounter in the marketing of animal products especially live animals at the onset of drought [36], and as a result they usually find themselves with little or no funds to invest in such technologies.

5. CONCLUSION

Forage found on farms in the rangeland areas of Uganda is of low quality due to low CP and high fibre contents, thus does not satisfy the nutritional (protein) requirements of crossbred calves solely depending on this forage. Supplementation with protein-rich concentrates like HMC is essential in order to improve feed intake and in turn the growth rates and body condition of crossbred calves. However, the cost involved is a hindrance to the adoption of supplementation since farmers may not afford, and also the benefits cannot be realized within a short period. Supplementation with LH which is produced on-farm and proved to be cheaper than the use of HMC may be the next best alternative for adoption.

ETHICAL STANDARDS

Authors declare that experimental protocol was approved by the graduate research and ethics committee of Makerere University, and the study was performed with the consent of farmers. All handling of animals in connection with registrations and management was performed, taking animal welfare into consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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