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Effect of feeding sweet potato vine-based diets as partial milk substitutes for dairy calves in Uganda

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Abstract

A study was conducted to determine the potential of sweet potato vine-based diets as partial milk substitute (PMS) for dairy calves. Twenty five Friesian bull-calves weighing 38.7 ± 4.56 kg were fed composite meals containing 0, 30, 40, 50 and 60% air-dried sweet potato vines (SPV) as partial milk substitutes in a completely randomized design (CRD) over a seventy day period. Dietary treatments were introduced 15 days after calving. Milk offered was reduced by one litre every fortnight until 70 days after birth. Proximate and mineral analyses were carried out for ingredients and dietary treatments. Feed intake (FI), average daily weight gains (ADG), feed: gain ratio and variable cost per unit of gain were computed over the experimental period.

The use of the PMS reduced the amount of milk consumed per calf by 120 litres over the 70-day period. Mean daily intake of dry matter was higher ($p<0.05$) for calves fed PMS (1.09 x10^3 gd^{-1}) than those fed on milk and pastures (912 gd^{-1}). Daily crude protein intake for calves fed PMS (216 g d^{-1}) was comparable to the 220 gd^{-1} among calves fed milk + grazing (M + G) while daily energy intake increased from 9.91 to 11.4 MJ d^{-1} respectively. The ADG of calves were higher ($p<0.05$) among calves fed PMS (299 gd^{-1}) than those fed milk and grazing (175 gd^{-1}). Feed: gain ratio decreased from 21.7 (control) to 10.2 (PMS). Weaning weights were higher among calves fed PMS (64.9 kg) compared to 53.9 kg for the control. Net variable cost per unit of gain was more than halved when the calves were fed PMS comprising 30 - 60% SPV. Farmers can reduce costs of calf rearing and increase their income from sale of milk by using SPV meals as partial milk substitutes.

Key words: *calving, energy intake, livestock, milk replacers, replacement stock, variable cost*

Introduction

An economically viable livestock sub-sector depends on a reliable supply of replacement stock. In this context, the calf is important for viable bovine livestock economy and germplasm conservation (Tiwari et al 2007). Unfortunately, immediate gains from milk often lower the core values of calves in milk and meat value chains to the stimulation of milk let down, hence the calves are underfed (Tiwari et al 2007). Most farmers, therefore, resort to restricted milk feeding and grazing as the only available option for raising female calves. They often cull bull-calves at birth to reduce cost of feeds and feeding. Advanced dairy economies solve this problem by using commercially formulated milk replacers (Frontline 2005; Whitelaw et al 1961). The use of complete milk replacers is untenable in developing countries due to technical and socio-economic reasons (Coleen and Heinrichs 2007). In Uganda, milk production and processing are still lower than the demand for fresh milk. Commercial milk replacers themselves are unavailable and their use would not be economically justified for the majority of our dairy farmers who are predominantly small scale zero-grazers.

The sweet potato vine (SPV) is a widely grown but underutilized feed resource that has attracted interest of researchers as a food-feed crop in developing countries (CIP 1988a; Boy et al 1988; Mackay 1989; Scott 2005). The nutrient value of SPV for young animals compares favourably with milk (Godoy et al 1981; Dominguez 1990; Phuc 2006). The technical merits of partial milk replacers and starters in calf rearing have been demonstrated (Orodho 1990). This study was conducted to determine the potential economic success of utilizing SPV-based diets for feeding calves under smallholder dairy production environment.

Materials and methods

Experimental site, animals and diets

The experiment was conducted at the National Crop Resources Research Institute (NaCRRI) Namulonge, located about 27 km North-East of Kampala (0^0 31'N $32^0$35'E) at an altitude of 1150 m above sea level. The soils are characteristic of the Buganda catena (Yost and Eswaran 1990) with mean annual rainfall of 1170 mm and a bi-model distribution. Experimental animals were pure-bred Friesian bull-calves procured from a private commercial firm after 5 days of colostrum feeding. The treatments in the feeding trial comprised of four formulations (PMS1, PMS2, PMS3 and PMS4) of partial milk substitutes (PMS) compared with farmers practice of calf rearing: milk feeding and grazing (M+G). The PMS formulations had 30, 40, 50 and 60% sweet potato vine (SPV) inclusion supplemented with maize bran (MB), fishmeal and mineral lick (Table 1).

Table 1: Composition of dietary treatments

Inclusion level (%)	PMS1	PMS2	PMS3	PMS4	Control
Sweet potato vine (SPV)	30.0	40.0	50.0	60.0	-
Maize bran (MB)	60.0	50.0	40.0	30.0	-
Fish meal (FM)	9.00	9.00	9.00	9.0	-
Dairy Mineral Lick[1]	1.00	1.00	1.00	1.00	-
Whole milk + Grazing	-	-	-	-	100
Total	**100**	**100**	**100**	**100**	**100**

[1] Composition (%): Calcium (17), Magnesium (2.49); Sodium (12.7); Iron (0.35); Chlorine (19.7); Iodine (0.031); Manganese (0.15); Zinc (0.23); Copper (0.2); Cobalt (0.015); Sulphur (0.25); Phosphorus (8.5). Manufactured by Pharma and Horticultural Inputs Limited, Nairobi Kenya.

Feeding trial

The calves were delivered in batches of five; randomly allocated to the five treatments; fed individually in pens supplied with clean grass bedding; water given *ad-libitum*. Each calf received 4 litres of milk per day until treatment diets were introduced at day 15. Thereafter the offers of milk to calves on PMS treatments were reduced by one litre every fortnight until weaning at 10 weeks of feeding. A known weight of PMS was offered daily to replace the milk reduction. The calves on control treatment received 4 litres milk per day with access to pastures for 60 days followed by a reduction to 2 litres per day for the last 10 days. The PMS were offered as composite marsh. A single dose of Sulfamide bolus was given to each calf two weeks after introduction of the PMS to prevent nutritional scours.

Data collection

Body weights and condition scores on 9-point scale (Croxton et al 1976; Henneke et al 2000) were recorded for all calves at the beginning of the experiment, and weekly (body weight) or fortnightly (body condition scores) intervals. Growth rate (gd^{-1}) was estimated by regression of the weekly body weights on the days of feeding. Daily feed offers and refusals were weighed and recorded. Intake of pastures was estimated by indirect means using the double indicator. Chromium and lignin were used as external and internal indicators respectively. Faecal samples were taken from grazing calves at 0, 12, 15, 18, 21, 24, 27, 36, 42, 48, 60, 72, and 84 hrs. All samples except milk were analysed for dry matter (DM), crude protein (CP), ether extract (EE), organic matter (OM), calcium (Ca) and phosphorus (P) in accordance with procedures of AOAC (1990). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analysed according to Van Soest and Robertson (1985). Milk intakes (kg) were computed as a factor of density (1.01kg l^{-1}) on volume. Nutrient intakes from PMS were computed as the respective differences between offers and refusals corrected for dry matter contents. Nutrient intakes from pastures were computed using double indicator method (Crampton 1969). Energy values (MJ) were estimated from chemical assays according to MAFF (1984).

Statistical analyses

Least cost analysis was analysed using variable costs (Doll and Orazem 1984). Data on feed intake, mean daily gains and variable cost per unit of gain were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedures of Statistical Analysis System (SAS

2001). The differences between means were separated using Least Significant Difference at 5% significant level.

Results and discussion

Proximate, mineral and energy compositions of PMS

The progressive increase in the level of inclusion of SPV from 30 to 60% resulted in an increase in the protein and fibre contents of the PMS (Table 2). These increases could be attributed to the relatively higher protein and fibre content of SPV compared to maize bran which it substituted in the PMS formulae. This agrees with earlier reports by Dominguez (1990) who reported that the use of SPV in animal feeds is advantageous in providing additional proteins for the less protein rich diets in livestock nutrition. The maximum protein content of 13.8% observed at the highest level of inclusion of SPV was still much below the recommended 18% for a calf starter diet (Schingoethe and Alvaro 2001) but much higher than the protein content of whole milk (3.2%). Increasing SPV content of the PMS from 30 to 60% did not yield major changes in mineral composition of the PMS formulae. This was because SPV had lower mineral content and therefore, the mineral composition of the PMS formulae was much more influenced by the mineral powder and fish meal whose levels were kept constant at 1% and 9% respectively (Table 1).

Despite the high calcium content of mineral powder (17%) and the equally high potassium content of fish meal (17%), all the PMS formulae had low content of both calcium (maximum, 0.02%) and phosphorus (maximum, 1.56%), attributable to the low level of inclusion of both ingredients in the PMS. The calcium concentrations in all the PMS and control diets were lower than the recommended 0.70% of DM by the NRC (Schingoethe and Alvaro 2001). However, phosphorus concentration in the PMS was higher than both the concentration in normal Holstein whole milk (0.11% of DM) and the recommended 0.45% of DM by the NRC.

Table 2: Proximate, mineral and energy compositions (% of DM) of PMS

Parameter	**PMS1**	**PMS2**	**PMS3**	**PMS4**
SPV (%)	**30**	**40**	**50**	**60**
DM	91.0 ± 3.36	92.0 ± 2.43	91.2 ± 2.05	90.2 ± 2.44
CP	12.8 ± 0.91	12.8 ± 0.73	13.7 ± 0.42	13.8 ± 0.79
EE	5.42 ± 0.34	5.29 ± 0.41	3.45 ± 0.22	3.88 ± 0.25
NDF	38.9 ± 1.01	40.0 ± 1.11	40.2 ± 1.34	40.7 ± 1.53
ADF	12.0 ± 0.82	14.0 ± 0.56	23.0 ± 0.93	20.0 ± 0.76
Ca	0.01 ± 0.002	0.02 ± 0.002	0.02 ± 0.001	0.02 ± 0.002
P	1.56 ± 0.03	1.04 ± 0.01	0.78 ± 0.01	1.04 ± 0.02
ME (MJ/Kg)*	11.2 ± 0.22	11.0 ± 0.38	10.8 ± 0.41	10.8 ± 0.18

** Calculated from chemical assay (MAFF 1984)*

Feed intake

The daily dry matter (DM), crude protein (CP) and energy (MJ) intake of Friesian bull-calves fed sweet potato-vine based PMS and the control treatments are shown in Table 3.

Table 3: Means of DM, CP and energy (ME) voluntary intake of dietary treatments

Parameter	Treatments					SEM	LSD	P-value
	PMS1	PMS2	PMS3	PMS4	Control			
DM (g/d) (10^3)	1.05[c]	1.07[b]	1.07[b]	1.15[a]	0.912[d]	29.1	3.19	<.0001
CP (g/d)	207[d]	211[c]	218[b]	229[a]	220[b]	13.1	3.49	<.0001
ME (MJ/d) [1]	11.2[b]	11.2[b]	11.1[b]	12.2[a]	9.91[c]	1.29	0.224	<.0001

[abcd] *Means within rows sharing a common superscript are not different at P<0.05.*
[1]*Values calculated from chemical assay (MAFF 1984)*

The lowest DM intake was observed among calves fed whole milk + grazing (control). This could have been due to the lower DM content of milk (2.01%) and pasture (23%), which comprised the control diet compared to the higher DM content (90% - 92%) of the PMS formulae (Table 2). Mean daily DM intake increased with increase in proportion of SPV in the diet, being highest at 60% level of inclusion. This was probably due to increased palatability and high fibre digestibility of SPV (Dominguez 1992; Giang et al 2004). The reduction in bulkiness of the SPV due to air drying; incorporation with maize bran, fish meal and mineral powder probably contributed to the higher intake compared to the control treatment, further confirming the findings and recommendations by Dominguez (1990) and Devendra (1992).

Growth characteristics

The control treatment resulted in average daily gain of 0.175g/day which was significantly lower (p<0.05) than all the PMS 1 - 4 (Table 4). The growth trend was typical of dairy production systems characterized by restricted milk feeding without supplementation for the calf to compensate for the reduced milk intake (Orodho et al 1993). The lower growth rate exhibited among calves fed the control treatment was because the restricted milk and pasture alone did not provide adequate nutrients for growth as the calves increased in body weight. The higher feed to gain ratio for the calves on the control diet (21.7) compared to PMS diets (9.45-11.3) could be attributed to the effect of low total DM and thus low nutrient intake from a combination of milk and fresh pasture. Calves receiving the PMS treatments exhibited higher (p<0.05) performance on all growth parameters compared to the control treatment. The higher growth rates recorded among calves receiving PMS showed that the PMS were able to provide the nutritional requirements for growth of the calves compared to the control treatment.

Table 4: Average daily gain, feed/gain ratio, live weight gain, weaning weight and body condition scores after 70 days

Parameter	Treatments					SEM	LSD	P-value
	PMS1	PMS2	PMS3	PMS4	Control			
ADG (kg/d)	0.272[d]	0.293[c]	0.304[b]	0.326[a]	0.175[e]	0.052	0.0035	<.0001
F:G ratio	11.3[b]	10.0[c]	9.99[c]	9.45[d]	21.7[a]	2.10	0.247	<.0001
LWG (kg)	19.0[d]	20.5[c]	21.3[b]	22.9[a]	12.3[e]	3.62	0.309	<.0001
WW (kg)	67.7[a]	65.6[b]	61.5[d]	64.7[c]	53.9[e]	5.47	0.385	<.0001
BCS (1-9)	6.2[b]	6.50[ab]	6.70[a]	6.60[a]	5.8[c]	0.363	0.336	0.0009

[abcd] *Means within the same row sharing a common superscript are not different at p<0.05 ADG, average daily gains; LWG, live weight gain; WW, weaning weight; F:G, feed to gain; BCS, body condition scores; SEM, standard error of means*

Least cost analysis

The results of least cost analysis based on variable costs of utilizing SPV partial milk substitute formulae for feeding Friesian bull-calves are shown in Table 5. The results of least cost analysis clearly pointed to the implications of restricted milk feeding often used by most farmers with the hope of saving costs. In reality, more milk was fed to the control (260 litres) compared to 140 litres fed to each calf receiving the PMS. As a result, the Total Variable Cost (TVC) for the control did not differ from the variable cost for PMS 4 i.e. at higher levels of SPV inclusion (60%). The higher AVC recorded for the control treatment was because milk intake supplemented with grazing resulted in lower live-weight gains among calves fed the control treatment.

Table 5: Variable costs and cost per unit of live-weight gain/calf for 70 days (Uganda shillings)

Parameter (10^3)	**PMS1**	**PMS2**	**PMS3**	**PMS4**	**Control**	**SEM**	**LSD**	**P-value**
VC_1 (*k*)	58.4	58.4	58.4	58.4	58.4	0.00	0.364	1.00
VC_2	48.1^a	48.1^a	48.1^a	48.1^a	23.8^b	0.00	0.297	<.0001
VC_3	98.3^e	102^d	116^b	112^c	133^a	3.04	2.94	<.0001
TVC	205^c	208^c	223^a	218^b	215^b	3.04	3.64	<.0001
AVC	10.7^b	10.1^c	10.5^b	9.57^d	17.5^a	0.907	0.295	<.0001
NVC_g	8.03^b	7.27^c	7.94^b	7.09^d	17.5^a	1.61	0.166	<.0001

$VC_1(k)$, variable cost constant = (cost of a calf + cost of transport + treatment); VC_2 = total cost of labour/calf; VC_3 = total cost of feed/calf; TVC = total variable cost/calf ($VC_1+VC_2+VC_3$); AVC = TVC /LWG; NVCg = net variable cost

Conclusions

- The SPV-based PMS provide sufficient nutrients to supplement traditional milk + grazing calf management system for maintenance and growth but it is inadequate as a sole source of nutrients for the Friesian bull-calf.

- Increasing the amount of SPV in the PMS led to increased feed intake and growth (ADG = 70%) but not indefinitely as it also increased the cost of feeding the Friesian calves compared to using restricted milk and grazing alone.

- The SPV-based partial milk substitutes can be used to reduce the net variable cost of feeding the Friesian bull-calf by more than 50%.

- The most appropriate SPV inclusion level in the PMS given the ingredients in this study is at 40% (PMS 2) of total dry matter.

- There is need for on-farm trials to verify these results in real farm situations, tailored to investigations into appropriate technologies for conservation, processing and value addition to the SPV. Such a study should provide opportunities for assessment of the long-term effect of the technology on herd-performance and a comprehensive cost analysis of the technology for worthiness.

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