Mucuna pruriens-based feeds that improve sustainability of communal goat farming during the dry season in semi-arid savannah of southern Africa

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Abstract

The International Livestock Research Institute is promoting cultivation and processing of *Mucuna pruriens* as a climate-smart fodder which can produce cost-effective feed supplements for livestock on communal rangelands in semi-arid Zimbabwe, to de-risk and improve sustainability of livestock production during droughts. Commercial supplements are generally expensive and not readily accessible to agro-pastoralists. Home-mixed Mucuna-based supplements can be nutrient-dense and effective. In a seven-week on-farm trial, Mucuna hay (MH) reduced weight loss in mature Matebele goats, though its effectiveness was inferior to Bambara nut hay and dried groundnut haulms ($P<0.05$). Goats averaging 28.2kg body weight (BW) and grazing solely on rangeland lost -66g head^{-1} day^{-1}, while those fed 1:2 MH: maize stover (MS), 1:2 Bambara nut hay: MS and 1:2 groundnut haulm: MS at 1% body weight during evenings only achieved -5g, 54g and 63g head^{-1} day^{-1} average daily weight gain (ADWG), respectively at the peak of 2022 dry season. This showed that farmers can maintain goats on MH. East Africa-type does (±25kg BW) supplemented with 45g head^{-1} day^{-1} of coarsely ground Mucuna pods (shell + kennel) at night-time during the 2021 dry season gained even more (150-270g head^{-1} day^{-1}), proving that pods are a richer supplement. Efforts were made to combine Mucuna with other local nutrient-dense feeds and forages to diversify the range of supplementary feeds and so improve accessibility. On-farm demonstrations conducted over a six-week period in 2022 showed that home-mixed rations (21.9 and 21.4% CP) of (i) *Mucuna* grain (MG) + *Lablab purpureus* hay (LpH) and (ii) MG + LpH + *Sorghum vulgare* grain fed to Matebele goats at 1% of body weight increased ADWG to 50g and 70g head^{-1} day^{-1}, respectively. These results led ILRI and national partners to officially register three marketable supplements for goats and sheep in April 2024.

Introduction

Maize-mixed farming occupies 32 million hectares (or 19%) of the total cultivated land in East and Southern Africa (ESA) region (Garrity et al. 2012). Maize is a staple crop in ESA and an important source of livelihood. Farmers usually add diversity to maize through cultivation of grain legumes to reduce the risk of total agricultural failure in the event of droughts and other calamities (Sumberg 1998). Legumes normally sown in rotation or through intercropping with maize were listed by Garrity et al. (2012). Grain and residues from these legumes and from tropical forage legumes can be incorporated in supplementary diets of large and small ruminants. Home-mixed supplements containing non-conventional legumes are cost-effective compared to commercial supplements which are formulated using oil-seed cake (Chakoma *et al*. 2016). Feeding non-conventional supplements to livestock grazing communal rangelands can increase productivity and farmers income.

The International Livestock Research Institute (ILRI) is conducting various studies to mitigate drought and de-risk maize-mixed farming systems in ESA. Several on-farm experiments conducted in Zimbabwe during the past two decades demonstrated that it is possible to sustainably integrate livestock production with maize-groundnut and other maize-legume rotations (Chakoma et al. 2016; Gwiriri et al. 2016). In the Ukama Ustawi (U2) and the EU-Funded LIPS-Zim Projects ILRI is promoting ley farming using two climate-smart forage legumes (*Mucuna pruriens* and *Lablab purpureus*) to diversify and sustainably intensify traditional cropping patterns towards livestock production (Matebesi 2024; Siyamachira 2022). As ESA is predicted to be a climate hotspot (Lugoi *et al*. 2023) there is need to promote resilient climate-smart farming practices, which include goat rearing.

The objective of this paper is to show how farmers practising integrated crop-livestock farming can formulate home-mixed feeds to de-risk and sustainably improve goat production on Savanah rangelands.

2. Materials and Methods

2.1 Study sites

Three participatory on-farm experiments were conducted in villages of Buhera (Ward 15) and Beitbridge (Ward 11) districts during the 2021 dry season and Gwanda district (Ward 24), during the 2022 dry season. All districts are in the semi-arid regions (agro-ecological IV and V) where the dry season normally extends from May-November. At all sites host farmer selection was based on (1) willingness (2) availability of goats for the experiments and (3) availability of planted fodders.

2.2 Dietary treatments

In *Experiment 1 (Beitbridge, Fula ward)* 20 Matebele goats at one homestead were randomly assigned to four treatments diets namely, (T_1) rangeland grazing only (i.e. farmer practice); T_2 comprised of velvet bean hay and maize stover (1:2 ratio); T_3 groundnut haulms and maize stover (1:2 ratio); T_4 Bambaranut (Vigna subterranea (L.) Verdc) haulms and maize stover (1:2 ratio). Five goats were assigned to each treatment. All goats grazed Acacia thornveld during daytime. During the evening, those on supplementary feeding were separated, individually penned and fed different supplementary feeds at the rate of 1% body weight. Water was provided *ad-libitum*. The experiment ran for 49 days from October to November 2021.

In *Experiment 2 (Buhera - Mutunha Vidco)* 30 East Africa-type goats from two villages (15 from each village) were assigned to three supplementary diets namely, (Ti) rangeland grazing only, (T_2) 75 grams of crushed velvet pods (unshelled); (T_3) 280g of a velvet bean-based ration. Five goats from each village were assigned to each treatment. Feeding management was the same as in *Experiment 1*. The experiment ran for 42 days from September to October 2021.

In *Experiment 3 (Gwanda, Ward 24*) 15 Matebele goats were used in the trial. Five goats were allocated to each treatment. Goats across all treatments grazed Acacia thornveld during daytime. Supplementary feed was only provided to goats in Treatment 2 and 3 at the rate of 1% of BW, during the evening. Composition of feed supplements for Treatments 2 and 3 is shown in Table 1.

Table 1: Composition of treatment diets for the goat feeding experiment conducted in Gwanda during the 2022 dry season.

Diet ingredient	Proportion (%) in diet on DM basis	
	Diet 2	**Diet 3**
Lablab purpureus hay	25.80	25.80
Mucunapruriens grain	58.70	48.30
Molasses	12.10	12.10
Sorghum grain (crushed)	0	10.30
Monocalcium phosphate	0.61	0.65
Limestone flour	1.31	1.36
Coarse salt	1.08	1.05
Ammonium Chloride	0.22	0.22
Vitamin-Mineral Premix	0.21	0.21

Feeding management was the same as in *Experiment 1*. The experiment ran for 41 days from October to November 2022.

2.3 Preparation of experimental animals

All experiments were set out to determine voluntary feed intake (VFI) and live weight changes of goats fed different diets. Goats with average live weights of 26 kg - 32 kg were used in *Experiment 1 and 3* and average ± 25 kg in *Experiment 2*. Experimental animals were vaccinated for Pulpy Kidney (PK), dipped and dewormed (i.e for ecto and endo parasites) prior to trials. Goats were ear-tagged for identification and initial weights were recorded. Fourteen days were permitted for feed induction in all experiments. Animals were weighed once a week. The amount of feed supplied to the goats was adjusted weekly on the basis of their body weight changes. Animal husbandry practices were similar across all treatment groups.

2.5. Laboratory analyses.

Samples of all supplementary feeds were ground through a 1mm screen and dry matter (DM) was determined by oven drying at 70^0C for 48 hrs. Crude protein was determined following the standard Kjeldhal method (AOAC, 1991), ether extract was determined using the Soxhlet apparatus while neutral detergent fibre (NDF) and acid detergent fibre (ADF) were assessed using the methods proposed by Van Soest et al. (1991).

2.6. Statistical design and analysis

In Experiment 1 and 3 dietary treatments were tested using a randomized complete block design (RCBD) with initial weights and sex used as blocking factors. Statistical analyses were conducted using the General Statistical Package software (Genstat 14th Edition, 2017). Data were tested for normality using the Shapiro-Wilk. Daily weight gain and VFI were analysed following a General linear model procedure (GLM). Data were fitted to test the effect of feeding regimes on daily weight gain and feed intake. Differences of means were tested using Least Significant Difference (LSD) *post hoc* test at 5 % level of significance.

In Experiment 2 a RCBD was used to test three dietary treatments with age and breed as blocking factors. Collected data was tested for normality using the Kolmogorov-Smirnov test in SPSS software. PROC GLM procedure of SAS was used to analyse treatments effects on dependent variables.

3. Results

3.1 Experiment 1

Daily liveweight gains were significantly ($P<0.05$) higher in goats fed supplements containing Bambara nut haulms (BNH) and groundnut haulms (GNH) compared to Mucuna hay (MH), even though MH had relatively higher crude protein (CP) content (Table 2). There were no significant differences on NDF content. Heaviest losses (-66g head^{-1} day^{-1}) were observed in unsupplemented goats while MH caused lower weight losses (-5g head^{-1} day^{-1}).

3.2 Experiment 2

There were no significant differences ($P<0.05$) between does on supplements derived from unshelled Mucuna pods (UMP) and the Mucuna-based supplement (MBS). These East Africa-type does gained live weight at 42.9 and 28.6 g $^{-1}$ day^{-1}, respectively during the dry season, whereas those on rangeland grazing only lost weight at -95.2 g $^{-1}$ day^{-1} ($P<0.05$).

3.3 Experiment 3

Efforts were made to incorporate local nutrient-dense feeds and forages to diversify the range ingredients and so improve accessibility (Table 1). Results showed that home-mixed rations (21.9 and 21.4% CP) of (i) *Mucuna* grain (MG) + *Lablab purpureus* hay (LpH) and (ii) MG + LpH + *Sorghum vulgare* increased ADWG to 50g and 70g head^{-1} day^{-1}, respectively in Matebele goats (Fig. 1).

4 Discussion

Traditional dry season goat management practices in Buhera, Beitbridge and Gwanda consist largely of semi-extensive rangeland grazing during the day and overnight penning with limited supplementation. Results from all experiments show that rangeland grazing alone is not sufficient to meet nutritional needs of all classes of goats and may culminate in poverty deaths. This resonates with Charambira *et al*. (2021) who indicated that smallholder farmers ought to adopt practices such as forage conservation, utilization of crop residue and use of cultivated fodder crops.

Supplementary feeds based on MG and GNH or BNH could be a powerful alternative to conventional feeds, judging from the higher levels of live weight gains (54.5 – 71g^{-1} day^{-1}) recorded in Experiments 1 and 3. This collaborates findings by Chakoma *et al*. (2016) and Gwiriri *et al*. (2016) who recommended the same for beef and dairy cattle, respectively. These results led ILRI and national partners to officially register three marketable supplements for goats and sheep in April 2024 under the Ukama Ustawi Project.

Experiment 3 findings suggest that increasing energy to legume-only supplements improves gut fermentation, evidenced by an increase in liveweight gains from 40 g^{-1}day^{-1} on T_2 to 69 g^{-1}day^{-1} on T_3, turning them into effective supplements for maintenance or grower rations. Farmers could feed up to 1.5% of body weight before goats start suffering from antinutritional or depressants factors.

Performance variations in Experiments 1 and 3 are attributable to breed factor (Matebele vs East Africa type) and nature of biomes. Rate of weight loss in unsupplemented goats from Buhera seemed to be higher (-95.2 $g^{-1}day^{-1}$) compared to Gwanda (66.4 $g^{-1}day^{-1}$), during October and November. The nutritive quality of rangelands deteriorates more in sour veld of Buhera compared to the sweet veld of Beitbridge. Therefore, it is more imperative for Buhera farmers to provide supplementary feeding to goats. It would also be even more beneficial is the feeding starts in July or August, especially for young goats.

Fig 1: Average daily weight gain Gwanda district

5 Conclusion

It is not sufficient for ESA farmers to rely on communal rangeland grazing only for subsistence or commercial goat production. These farmers can improve their livelihoods and incomes through goat farming by diversifying and de-risking maize-mixed farming systems through incorporation of *M. pruriens* and *L. purpureus* leys to supply grain and hay, respectively which will be mixed with residues of common grain legumes to improve quality and cost-effectiveness of dry season feeds. Adoption of this technology will be easier when farmers can access appropriate machinery to process the ingredients.

Table 2: Performance of goats fed different types of forage-based supplements and nutritional composition of the formulated supplements.

District	Treatment	Average daily gain (g/day)	#Daily suppleme nt-ary feed intake (g/day)	CP (%)	ADF (%)	NDF (%)	DM (%)
Experiment 1							
Beitbridge	T_1 (*Farmer practice*)	-66.4^{a}	0	n/a	-	n/a	n/a
	T_2 (*VBH + MS*)	-4.9^{b}	280	10.76	-	33.79	91.60
	T_3 (*GNH + MS*)	54.5^{bc}	280	7.98	-	33.48	91.32
	T_4 (*BNH + MS*)	63.2^{c}	280	7.78	-	33.74	91.49
Experiment 2							
Buhera	T_1 (Farmer practice)	-95.2^{c}	0				
	T_2 (MBS)	42.9^{a}	280^{a}	21.86	33.35	48.02	92.42
	T_3 (UMP)	28.6^{b}	75^{b}	21.14	37.63	65.58	92.90
Experiment 3							
Gwanda	T_1 (Farmer Practice)	-8.0^{b}	0				
	T_2 (MG + LpH)	40.0^{ab}	280	21.86	33.35	48.02	92.42
	T_3 (MG + LpH + SGM)	69.0^{a}	240	21.14	37.63	65.58	92.90

#DFI refers to daily intake of supplementary feed.

Experiment 1: VBH = Velvet bean hay, GNH = Groundnut haulms BNH =Bambaranut haulms.

Experiment 2: MBS = Mucuna-based supplement, UMP = Unshelled Mucuna pods)

Experiment 3: MG = Mucuna Grain, LpH = Lablab hay, SG = Sorghum grain meal

*Within an Experiment site, the same superscripts in same column denote no significant differences between treatments at $P<0.05$

[1] Experiment 3 Gwanda ADG statistics: P-value = 0.037 and s.e.d = 0.026 and Beitbridge ADG statistics: P-value 0.005 and s.e.d. = 0.024.

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