# PERFORMANCE OF MASHONA COWS REARED ON NATURAL RANGELANDS WITH NON-CONVENTIONAL PROTEIN SUPPLEMENTATION IN THE DRY SEASON, ZIMBABWE

# [DESEMPEÑO DE VACAS MASHONA CRIADAS EN PRADERAS NATIVAS CON SUPLEMENTOS PROTEICOS NO CONVENCIONALES DURANTE EL PERÍODO DE SEQUÍA EN ZIMBABWE]

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## SUMMARY

Performance of animals in smallholder farming systems is hindered by feed availability and feed costs that make up 60-70% of total variable cost in a farming system. The use of non-conventional feedstuffs is an alternative which can be adopted to minimize feeding costs. The study was conducted to evaluate performance of animals fed with supplements formulated on-farm in comparison with a commercial prepared supplement. Thirty Mashona cows were grouped according to age and subjected to five treatments, given twice a week from the 1st of September until 31st December for three subsequent years. The five treatment diets, beef survival meal (BSM), urea treated maize stover (UTS), *Leucaena leucocephala* meal (LLM), mixed forage meal (MFM) and natural pastures (NP) were randomly assigned to cows in a complete randomised design (CRD). Average weight gains were determined. Performance in the first year was not significantly different across treatments. In the subsequent years, performance remained low in the NP. Average weight gains increased in the second and third years and was significantly different across treatments ($P<0.05$). Performance of animals supplemented with non-conventional feed was comparable to those offered commercial BFM; hence LLM and UTS can be used as alternative protein supplements especially in resource-constrained farming systems.

**Key words:** Resource-constrained farming systems; protein supplements; non-conventional protein sources.

## RESUMEN

El desempeño de los animales en sistemas de producción de pequeña escala es limitado por la disponibilidad de alimento y precio que pueden representar hasta 60-70% de los costos variables de producción del sistema. El uso de alimentos no convencionales es una alternativa que puede ser adoptada para minimizar los costos de alimentación. Este estudio comparó el desempeño de los animales alimentados con suplementos formulados en la granja en relación a los alimentos comerciales disponibles en la región. Se emplearon 30 vacas Mashona agrupadas por edad y se les distribuyo empleando un diseño completamente aleatorizado en 5 tratamientos proporcionados 2 veces por semana durante 3 años. Alimento de mantenimiento bovino (BSM), rastrojo de maíz tratado con urea (UTS), harina de *Leucaena leucocephala* (LLM), harina de forraje mixto (MFM) y pastura natural (NP). Se evaluó ganancia de peso. El desempeño del primer año no fue diferente entre tratamientos y en los años subsecuentes el desempeño se mantuvo bajo para NP. La ganancia de peso se incrementó significativamente y el desempeño de los animales con las dietas no convencionales fue similar al obtenido con el alimento comercial (BSM). Se concluye que LLM y UTS pueden ser empleados con suplementos proteicos alternativos especialmente en sistemas de producción con limitaciones en la disponibilidad de recursos.

**Palabras clave:** Sistemas de producción limitados por recursos; suplementos proteicos; fuentes proteicas no convencionales.

## INTRODUCTION

In Zimbabwe, communal livestock is a source of livelihoods for rural population (Sibanda and Khombe, 2006). However, livestock performance is constrained by inadequate nutrition (Gusha *et al.,* 2014; Zvinorova *et al.*, 2013). There is perennial feed deficit, both in quantity and quality during the April to November dry period in Zimbabwe. During this dry period most animals become thin and unable to conceive. More frequently, some die in large numbers during a cold spell that is experienced with some October rain showers. Due to the fact that the animals will be in poor body condition, any risk factors predispose to the animals may negatively affect them because of a weakened immunity system. Farmers experience very high animal mortality ranging 10% to 50% annually (Mavedzenge *et al.,* 2005; Gusha *et al.*, 2013a). Most communal farmers cannot afford high quality conventional supplements hence very few farmers supplement their cattle during the dry season (Ngongoni *et al.,* 2006). Animals that are reared in such management system fail to conceive annually and might have three or more years calving interval and calves born in those conditions take longer to reach puberty due to very slow growth rates. Animals reach slaughter weights after four to six years. The capacity of farmers to generate income from livestock production is compromised due low productivity of animals.

It is therefore imperative that research should evaluate any potential affordable supplements in order to drive farmers out of this predicament. Browse and forage legumes have been recommended from *in vitro* and *in vivo* studies potential supplements (Matenga *et al.,* 2003; Baloyi *et al.,* 2009; Gusha *et al.,* 2013b). Farmers use different form of supplements available at farm level and the optimum feeding levels that are sustainable according to level of production are yet to be evaluated or need further evaluation. This study was designed to evaluate performance of animals fed on supplements formulated on-farm. The study also aimed at comparing a commercial supplement to cheap farm-based resources.

## MATERIAL AND METHODS

### Study site

The experiment was conducted at Makoholi Research Institute located 32 km north of Masvingo town on 19$^{o}$50’ S, 30$^{o}$47’E and altitude of 1 200 m. The area is characterised by erratic rainfall both within and between seasons; annual mean rainfall is 565 mm with a range of 133 to 1 155 mm. The granite-derived soils consist of 96% sand, 2% silt and 2% clay are inherently infertile and plant growth is severely limited by the unavailability of nitrogen and phosphorus.

### Experimental diets

*Leucaena leucocephala* herbage was harvested from the trees that were grown around the farm. The herbage was harvested by cutting the trees at 30cm above the ground and then removed the twigs and leaves in October, February and in April. The harvested material was air dried under shade for at least a week. *M. atropurpureum* herbage was harvested at flowering stage and air-dried under shade after which it was milled prior to feeding. Maize stover was collected after harvesting and milled before treatment with dissolved urea fertiliser containing 46% nitrogen. Fifty kilograms of urea fertiliser was dissolved in 200 litres of water to produce 25%w/v. The solution was sprinkled over 1000 kg milled maize stover and stored in a pit silo covered with plastic and soil for six weeks to create anaerobic conditions after which the treated stover was sun-dried for three days prior to feeding. Mixed forage meal (MFM) was produced mixing a third of each of *L. Leucocephala, M. atropurpureum* and urea-treated maize stover. The experimental diets fed to experimental animals were as follows; beef survival meal (BSM), Urea treated maize stover (UTS), *L. Leucocephala* meal (LLM), Mixed forage meal (MFM) and those on natural pastures (NP) without feed supplement.

### Animals feeding and experimental design

Thirty calf nursing cows were grouped according to age and randomly allocated to five treatments in a complete randomised design (CRD). Each animal was an experimental unit and was individually fed the experimental diets on Monday and Friday every week from the 1$^{st}$ of September until 31$^{st}$ December for three years. All experimental animals were dosed with a commercial dosing drug at the beginning of feeding experiment, in February and May each year. The feed was mixed with 100g of molasses to improve palatability. Table 1 shows the feeding procedure that was followed during the first year while Table 2 shows the procedure for year 2 and year 3. Initial weights of the animals were taken at the beginning of the trial and every fortnight for 4 months.

Table 1. Quantities of experimental diets offered to experimental animal in year 1

| Treatment | Quantity offered | | |
|---|---|---|---|
| | Monday | Wednesday | Friday |
| Beef survival meal (BSM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Urea-treated Stover (UTS) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| *L. Leucocephala* meal (LLM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Mixed forage meal (MFM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Natural pasture (NP) | 100 grams molasses | 100g salt | 100g molasses |

Table 2. Quantities of experimental diets offered during year 2 and year 3

| Treatment | Quantity offered | | |
|---|---|---|---|
| | Monday | Wednesday | Friday |
| Beef survival meal (BSM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Urea-treated Stover (UTS) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| *L. Leucocephala* meal (LLM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Mixed forage meal (MFM) | 3.5kg + 100g molasses | 100g salt | 3.5kg + 100g molasses |
| Natural pasture (NP) | | | |

**Chemical analysis**

Feeds were dried in a forced air oven at 60ºC for 48 hours to determine DM. Nitrogen content in the feed and in the residues was analysed by Kjeldahl method (A.O.A.C, 1990). Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were analysed according to Goering and van Soest (1970). Total ash was obtained by igniting a dried sample in a muffle furnace at 600ºC for 24 hours, calcium and phosphorous were determined by the EDTA (Kaur, 2007) and spectrophotometer (Danovaro, 2009) methods, respectively.

**Statistical analysis**

The data was analysed using the general linear models (GLM) procedure for repeated measures of SAS (SAS, 2010). Means were separated with the adjusted Tukey methods. The following model was used:

$$Y_{jk} = \mu + T_k + \varepsilon_{jk}$$

Where:
$Y_{jk}$ was response variable being (Weight gain/loss);
μ was overall mean common to all observations;
$T_k$ is effect of the $k^{th}$ treatment (k=1, 2, 3, 4, 5);
$\varepsilon_{jk}$ are the random residuals with a distribution of $N \sim (0; \sigma^2_E)$.

## RESULTS

**Chemical composition**

The nutritional composition of supplements and rangeland biomass is presented in Table 3. The diets were significantly different on crude protein content as well as acid detergent fibre. BSM had higher total digestible nutrient (TDN) compared to other farm based feed supplements. Forage supplements had higher calcium and phosphorus content compared to BSM and urea-treated maize stover.

Table 3. Chemical composition of experimental diets

| Experimental diet | % nutrient composition | | | | | | |
|---|---|---|---|---|---|---|---|
| | DM | CP | ADF | NDF | P | Ca | Ash |
| Beef survival meal (BSM) | 88.0 | 11.0 | ND | ND | 0.5 | 0.85 | ND |
| Urea-treated Stover (UTS) | 95.7 | 15.7 | 42.7 | 71.8 | 0.3 | 0.6 | 9.7 |
| *L. Leucocephala* meal (LLM) | 90.3 | 21.7 | 29.6 | 33.2 | 0.7 | 2.1 | 8.1 |
| Mixed forage meal (MFM) | 96.3 | 13.3 | 31.5 | 43.1 | 1.1 | 0.8 | 7.5 |
| Natural pasture (NP) | 97.6 | 3.2 | 48.2 | 76.2 | 0.6 | 0.3 | 8.6 |

**Calving rates and weight changes trends**

The trend in weight changes is presented in Tables 4, 5 and 6. In year one there was no significant weight loss in all the treatment groups. All cows maintained weight during the period. However, significant ($P<0.05$) weight loss was observed in animals that were not supplemented. It was also observed that animals with non-conventional protein and non-nitrogen supplement compared well with animal supplemented with commercial diet BSM. It was also observed that animals supplement with BSM and LLM had 83.3% calving rate compared to 66.7% for UTS and MFM whilst animals that were not supplement had 50% calving rate during the study period. No animal loses were recorded during the three year study period though it was observed that animal loss weight as from April but stabilises with the weaning period in June and then start losing weights in August up to the beginning of rain season.

## DISCUSSION

In the first year of the experiment the least significant mean weight for experimental animals were not significantly different. The animals in the natural pasture NP were receiving molasses and salt at the same level as those on LLM, UTS, MFM and BSM. Therefore, there was no significant mean weight differences observed. Molasses can be used as an energy source for livestock, particularly in situations where grains are unavailable (Chaudhary *et al.*, 2001). Moreover, it is a rich source of calcium (about 0.9 % DM) due to the addition of calcium hydroxide during processing (Blair, 2007). Studies showed equal or greater animal performance when molasses was substituted for maize grain (Morales *et al.*, 1989). Hence in low amounts of molasses in a roughage-based diet NP stimulate rumen fermentation and the rumen cellulolytic potential is maintained or improved with low quality forage diets. However, molasses fed in large amounts is toxic to livestock (Pérez, 1995; Mesfin and Ledin, 2004). Sodium in the salt improve herbage digestibility and promoted growth of bacteria that digest fibres in the rumen. An increase in sodium recycling in the saliva reduces rumen acidity, the cow will spend more time ruminating. Consequently, if there is enough herbage on the farm animals consuming salt will be able to perform well during the dry season.

Ruminants consuming low-quality forage during the dry period (NP) deficient in CP encounter the problem of inadequate ruminal N that hinders microbial growth and as a result, decreases ruminal fermentation and the quantity of potentially absorbable N presented to the small intestine (Bohnert *et al.*, 2002a; Mupenze *et al.*, 2009). The dry season causes nutritional stress (Matenga *et al.*, 2003; Ngongoni *et al.*, 2007) and consequently decreases animal productivity (Souza *et al.*, 2010; Allam *et al.*, 2012). The decline in growth rates of cattle in dry season delays the attainment of slaughter weight and adversely affects the quality and quantity of beef (Muchenje *et al.*, 2008). Supplemental degradable intake protein (LLM, UTS, MFM and BSM) provides the main source of N for the growth of ruminal microorganisms.

Table 4. Least square mean weight for experimental animals during the first year feeding period in kilograms (mean ±se)

| Year 1 | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | NP | LLM | UTS | MFM | BSM | LSD |
| Weight 1 | 243.2a±13.2 | 239.0a±13.2 | 244.6a±13.2 | 244.3a±13.2 | 250.2a±13.2 | 54.8 |
| Weight 2 | 247.0a±13.1 | 246.7a±13.1 | 249.5a±13.1 | 248.5a±13.1 | 257.7a±13.1 | 54.5 |
| Weight 3 | 250.5a±12.9 | 253.5a±12.9 | 252.8a±12.9 | 252.8a±12.9 | 267.3a±12.9 | 53.9 |
| Weight 4 | 252.7a±12.8 | 261.3a±12.8 | 261.5a±12.8 | 258.8a±12.8 | 274.0a±12.8 | 53.3 |
| Weight 5 | 255.5a±12.3 | 267.7a±12.3 | 268.0a±12.3 | 264.8a±12.3 | 278.3a±12.3 | 51.5 |
| Weight 6 | 261.0a±11.9 | 275.8a±11.9 | 274.2a±11.9 | 271.2a±11.9 | 285.2a±11.9 | 49.6 |
| Weight 7 | 268.3a±11.4 | 281.2a±11.4 | 279.7a±11.4 | 276.2a±11.4 | 293.2a±11.4 | 47.3 |
| Weight 8 | 278.7a±11.5 | 287.8a±11.5 | 284.7a±11.5 | 278.2a±11.5 | 298.7a±11.5 | 47.7 |
| Weight 9 | 286.3a±10.5 | 294.3a±10.5 | 291.5a±10.5 | 286.7a±10.5 | 305.0a±10.5 | 43.5 |
| Lactating cows | 6 | 6 | 6 | 6 | 6 | |
| Number of calves | 6 | 6 | 6 | 6 | 6 | |

Different lower case letters in the same row indicate significant different at $P<0.05$

Table 5. Least square mean weight for experimental animals during the year 2 feeding period in kilograms (mean ±se)

| Year 2 | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | NP | LLM | UTS | MFM | BSM | LSD |
| Weight 1 | 261.2b±15.9 | 320.3ab±15.9 | 268.7ab±15.9 | 301.0ab±15.9 | 328.7a±15.9 | 65.9 |
| Weight 2 | 244.8c±14.8 | 317.2ab±14.8 | 265.2bc±14.8 | 297.5abc±14.8 | 343.2a±14.8 | 61.5 |
| Weight 3 | 239.0c±14.1 | 310.3ab±14.1 | 267.2bc±14.1 | 286.8abc±14.1 | 333.8a±14.1 | 58.5 |
| Weight 4 | 232.3c±13.5 | 305.0ab±13.5 | 257.0bc±13.5 | 284.0abc±13.5 | 336.0a±13.5 | 56.0 |
| Weight 5 | 231.5c±12.8 | 310.2ab±12.8 | 263.3bc±12.8 | 280.7bc±12.8 | 335.7a±12.8 | 53.3 |
| Weight 6 | 233.5c±13.9 | 308.3ab±13.9 | 272.8bc±13.9 | 304.3ab±13.9 | 340.3a±13.9 | 57.9 |
| Weight 7 | 247.0c±13.4 | 324.5ab±13.4 | 291.2bc±13.4 | 309.0b±13.4 | 365.5a±13.4 | 55.7 |
| Weight 8 | 267.7c±13.9 | 340.5ab±13.9 | 300.7bc±13.9 | 335.7ab±13.9 | 375.8a±13.9 | 57.5 |
| Weight 9 | 284.8c±13.9 | 349.3ab±13.9 | 314.0bc±13.9 | 340.8abc±13.9 | 388.2a±13.9 | 57.5 |
| Lactating cows | 3 | 5 | 4 | 4 | 5 | |
| % calving rate | 50 | 83.3 | 66.7 | 66.7 | 83.3 | |

Different lower case letters in the same row indicate significant different at P<0.05

Table 6: Least square mean weight for experimental animals during the year 3 feeding period in kilograms (means ±se)

| Year 3 | Treatment | | | | | LSD |
|---|---|---|---|---|---|---|
| | NP | LLM | UTS | MFM | BSM | |
| Weight 1 | 276.3a±13.8 | 304.2a±13.8 | 286.0a±13.8 | 294.5a±13.8 | 307.8a±13.8 | 57.3 |
| Weight 2 | 268.0a±14.0 | 290.7a±14.0 | 280.8a±14.0 | 294.3a±14.0 | 307.0a±14.0 | 57.9 |
| Weight 3 | 264.8a±14.2 | 283.5a±14.2 | 274.2a±14.2 | 287.3a±14.2 | 292.8a±14.2 | 58.8 |
| Weight 4 | 247.7a±10.8 | 289.2a±10.8 | 265.5a±10.8 | 283.0a±10.8 | 270.3a±10.8 | 44.9 |
| Weight 5 | 231.2c±8.8 | 304.8a±8.8 | 281.2ab±8.8 | 274.8ab±8.8 | 266.3bc±8.8 | 36.7 |
| Weight 6 | 240.7c±9.1 | 321.7a±9.1 | 291.5ab±9.1 | 297.0ab±9.1 | 272.0bc±9.1 | 37.9 |
| Weight 7 | 260.0b±8.7 | 330.0a±8.7 | 299.7a±8.7 | 304.8a±8.7 | 313.3a±8.7 | 36.1 |
| Weight 8 | 274.2b±9.3 | 348.0a±9.3 | 320.2a±9.3 | 324.3a±9.3 | 329.5a±9.3 | 38.4 |
| Weight 9 | 286.3b±9.3 | 358.3a±9.3 | 331.3a±9.3 | 337.0a±9.3 | 339.2a±9.3 | 38.4 |
| Lactating cows | 3 | 4 | 4 | 4 | 4 | |
| % calving rate | 50 | 66.7 | 66.7 | 66.7 | 66.7 | |

Different lower case letters in the same row indicate significant different at P<0.05

Leucaena is rich in protein, minerals and vitamin content and it enhances voluntary feed intake, nutrient digestibility, rumen fermentation and microorganisms (Lazzarini *et al.,* 2010; Kang *et al.,* 2012). Protein level ranges around 292 g/kg CP in the leaf meal and 220.3 g/kg CP in forage (Garcia *et al.,* 1996; Gusha *et al.,* 2013; Chakoma, 2012). Moreover, it contains condensed tannin content of 10.1–10.5 g/kg that can protect protein from rumen microbial degradation and reduce methane production (Kang *et al.,* 2012). The effect of supplementing with LLM was the same as using the conventional BSM in the study. Therefore, Leucaena can be used as a substitute to beef survival meal to supplement ruminants in the dry period because it is a low-cost technology.

The animals were only supplemented 2 days a week and a significant difference was noted because decreasing the frequency of protein supplementation to ruminants consuming low-quality forage has been shown to result in acceptable levels of performance with only minimal impacts on nutrient intake and digestibility (Bohnert *et al.,* 2002b). Legume supplements supply ruminal microorganisms with a readily available source of nitrogen (N) that enables them to breakdown basal diets efficiently (Edwards *et al.,* 2012). Therefore, animals supplemented on LLM and MFM treatments performed better than the animals on the natural pasture (NP) alone in the second and third year. UTS supply a readily degradable source of N to rumen microbes resulting in increased fermentation and hence increased utilization of the basal diet (Lazzarini *et al.,* 2010;

Yousuf *et al.*, 2007). The UTS provides the capacity to maintain N efficiency which is a consequence of the N recycling ability of ruminants (Mahesh and Mohini, 2013; Mesfin and Kebede, 2011).

Calving rates were significantly different despite weight changes being not significantly different in year one. This indicates that molasses and salt alone cannot stimulate oestrus cycle hence low conception rate. Animals on NP had fewer calves born over the three year, which shows the low productivity of animal without supplements due to non availability of supplements or high cost of supplements. All the non-conventional and non-nitrogen supplements used demonstrated their potential in addressing nutritional changes in resources constrained framers.

## CONCLUSION

An average weight gain in the first year was lowest in the group fed on pasture, though they were not significantly different to those in supplemented groups. However, in the subsequent years the performance of the animals improved greatly. The performance in all the different supplementation diets was comparable to the commercial beef meal; hence the adoption and use of the non-conventional feed supplements such as Leucaena and urea-treated stover can be promoted in periods of feed deficit.

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