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Effect of Dietary Inclusion of Discarded Beetroot and Potato Hash Silage on Growth Performance and Digestibility in South African Dorper Lambs

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Abstract: Experiment was conducted to study the effect of dietary inclusion of Discarded Beetroot (DB) and Potato Hash Silage (PHS) on the growth performance of South African Dorper lambs. Potato hash silage was produced in 210*l* drums for 3 months and its fermentation characteristics were determined. Diets that contained no agro-industrial by-product (T_1), DB (T_2) or DB in combination with PHS (T_3) were formulated and fed to 24 lambs of 24.5±0.275 kg body weight (8 per treatment). The PHS was poorly fermented as indicated by lower concentrations of lactic acid, higher butyric and ammonia-N. Higher ($p<0.05$) Dry Matter Intake (DMI) was obtained in T_1 diet compared to the others. Lambs on diet T_3 had lower ($p<0.05$) ADG than those fed the other diets. Improved ($p<0.05$) digestibility of CP was obtained in T_1 and T_2. It was concluded that dietary addition of poorly fermented potato hash silage resulted in lower ADG. Further research on the effect of dietary inclusion of high quality potato hash silage on ruminant performance is needed.

Key words: Agro-industrial by-products, discarded beetroot, fermentation, lambs, potato hash

INTRODUCTION

A major constraint to a profitable livestock production under resource poor farmers in South Africa is the scarcity and fluctuating quantity and quality of the year-round feed supply (Nsahlai and Sedumedi, 2000). Providing adequate good quality feed to livestock to raise and maintain their productivity is still a challenge faced by these farmers. Furthermore, the country is experiencing a rapid increase in human population, which will lead to an enormous increase in demand for animal products (Stroebel *et al*., 2003). Future hopes of feeding the millions and safeguarding their food security will depend on the enhanced and efficient utilization of alternative feed resources that cannot be used as food for humans. Fortunately, South Africa is endowed with an abundant variety of agro-industrial by-products that derived from the food processing industries, which are not effectively utilized. These resources have the potential to be used in animal rations, especially for ruminants due to their ability to digest fibre (Boucque and Fiems, 1988). Interest in utilizing by-products in animal nutrition to reduce feed costs is steadily increasing. The regular use of market wastes as animal feed under resource poor farmer livestock keeping systems, where there is insufficient or no herbage grown for feeding livestock may reduce the problems of waste disposal faced by the food producing factories. Discarded Beetroot (DB) (*Beta vulgaris var. esculenta*) and potato (*Solanum tuberosum*) hash are amongst the food by-products that are available and under-utilized in South Africa (Nkosi *et al*., 2007, 2009a). Beetroot has a high Metabolizable Energy (ME), highly digestible and can be offered to stock as a supplementary feed (Clark *et al*., 1987; Sabri and Roberts, 1988). In addition, studies of Roberts (1987) and Fisher *et al*. (1994) reported that feeding fodder beet with *ad libitum* good quality silage improved milk fat and yield constituents in dairy cows. Feeding a total mixed potato hash silage to lambs resulted in improved Dry Matter Intake (DMI) (Nkosi *et al*., 2009a). However, research that determines the effects of dietary inclusion of DB and potato hash silage on the growth performance and nutrient digestibility in lambs is scarce. The objectives of this study were therefore to evaluate the nutritional value of DB and PHS and their effects on the growth performance of lambs.

MATERIALS AND METHODS

Batches of Discarded Beetroot (DB) were collected from the Tshwane Fresh Produce Market in Pretoria and brought to the ARC-Irene Institute, South Africa (longitude 28°13'S: latitude 25°55'E, altitude 1524 m) for chemical analysis and animal feeding experiments. The DB were chaffed into pieces using a butcher knife and sun-dried until a constant mass was achieved and analysed for chemical compositions. Potato Hash Silage (PHS) was produced by mixing 80% potato hash with 20%

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Eragrostis curvula hay (on as is basis) and ensiled in 210/drums for 90 days. After 90 days of ensiling, drums were opened and samples were collected and analysed for pH, Lactic Acid (LA), Acetic Acid (AA) and Ammonia-N (NH_3-N) as described by Nkosi *et al.* (2009b). Furthermore, samples of DB and PHS were analysed for Dry Matter (DM), Organic Matter (OM), Ether Extract (EE), Metabolizable Energy (ME), *In vitro* Organic Matter Digestibility (IVOMD), Crude Fibre (CF) and Crude Protein (CP) following standard methods (Table 1). Diets that contained either DB or the combination of DB and PHS were formulated (Table 2). The diets were: control (T_1), DB (T_2) and DB and PHS (T_3).

Experimental diets were fed to 24 South African Dorper lambs that were housed in individual metabolic crates (2.2 m^2) in an insulated well-ventilated barn. The lambs weighed 24.5±0.275 kg and were divided into three groups of equal initial Body Weight (BW). Each group was randomly assigned to one of the three treatments, with 8 lambs per treatment. Lambs were fed once daily and feed intake was measured. An adaptation period of 14 days was offered and the study lasted 63 days. The amount of forage offered was always 100 g kg^{-1} higher than the previous intake to ensure *ad libitum* intake. Lambs were weighed at the start of the trial and continued at weekly intervals until the end of the trial.

A 7 days faecal collection period was conducted during the last week of the growth study. Lambs were fitted with leather harnesses and canvass bags attached to the back of each lamb 3 days before the digestion trial started. Daily feed intake and faeces were collected. Faeces accumulated for the 7 days period were pooled per lamb and sub-samples were collected for laboratory analyses.

The DM of diets, by-product and silage was determined by drying the samples at 65°C until a constant mass was achieved, following the procedure of AOAC (1991). After drying, the samples were ground through a 1 mm screen (Wiley mill, Standard Model 3, Arthur H. Thomas Co., Philadelphia, PA, USA) for chemical analyses. The CP, OM and EE were determined according to the procedure of AOAC (1991). The IVOMD was determined by the method of Tilley and Terry (1963). The ME was determined by using the gas production technique of Pienaar and Van Ryssen (1997), GE was determined with a bomb calorimeter and CF was determined by the method of Van Soest *et al.* (1991).

Differences between treatment means on the chemical composition, lamb growth performance and digestibility were analysed in a completely randomized design by the Analysis of Variance (ANOVA) using Genstat. Significant statistical differences between the means were declared when probabilities (p) were >0.05.

Table 1: Chemical composition of Discarded Beetroot (DB) and PHS ($g\ kg^{-1}$ DM, unless otherwise stated)

Composition	DB	PHS
DM	141.5	320
OM	903.1	939.6
CP	149	79
CF	80.9	275
EE	6.8	71.3
ME MJ kg^{-1} DM	12.77	11.01
IVOMD	874.5	596.2
Fermentation characteristics		
pH	-	4.2
Water soluble carbohydrates	-	16.5
Lactic acid	-	47.5
Acetic acid	-	21.0
Propionic acid	-	6.7
Butyric acid	-	0.52
NH_3-N	-	1.15

*Was done only in the PHS, DM: Dry Matter; OM: Organic Matter; CP: Crude Protein, CF: Crude Fibre, EE: Ether Extract; ME: Metabolizable Energy; IVOMD, *In vitro* Organic Matter Digestibility

Table 2: Ingredients and chemical composition of experimental diets

Ingredients (%)	Control (T_1)	DB (T_2)	DB+PHS (T_3)
Maize meal	54.5	41	41
Wheaten bran	12	10	10
Molasses meal	10	10	8
DB	0	15	9
PHS	0	0	22.5
Eragrostis curvula hay	15	8	0
Cotton oil cake	5	14	6.4
Feedlime	1.5	1.	1.3
Ammonium sulphate	0.5	0.6	0.5
Urea	0.5	0.2	0.3
Salt	0.5	0.5	0.5
*Vitamin/mineral premix	0.5	0.7	0.5
Chemical composition ($g\ kg^{-1}$ DM, unless stated otherwise)			
DM	803.9	796.5	752.2
OM	723.5	716.9	676.9
CP	126	119	106
CF	92	143	200
GEMJ kg^{-1} DM	15.71	15.21	14.79

*DM base: selenium 10 mg kg^{-1}, potassium 215 mg kg^{-1}, iron 50 mg kg^{-1}, cobalt 20 mg kg^{-1}, zinc 50 mg kg^{-1}, manganese 1600 mg kg^{-1}, copper 300 mg kg^{-1}, iodine 70 mg kg^{-1}, calcium 220 mg kg^{-1}, phosphorus 280 mg kg^{-1}, sulphur 30 g kg^{-1}, salt 950 g kg^{-1}. DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; CF: Crude Fibre, GE: Gross Energy

The means were compared by the Fisher's Protected Least Significance Difference (LSD) with the model:

$$Y_{ij} = \mu + t_i + \beta_j + \varepsilon_{ij}$$

Where:

- Y_{ij} = The individual observations of the i-th treatment and the j-th replicate
- μ = The general effect
- t_i = The effect of the i-th treatment
- β_j = The effect of the j-th replicate
- ε_{ij} = The random variation or residual error

RESULTS AND DISCUSSION

The chemical composition of the by-products is shown in Table 1. Fisher *et al.* (1994) reported 169, 905 g kg^{-1} DM and 13.8 MJ kg^{-1} DM of DM, OM and ME

Table 3: Mean values for the growth performance and apparent digestibility (%) of experimental diets fed to sheep (n = 8)

	Treatments				
Parameters	T_1	T_2	T_3	P	SEM
Growth performance					
IBW (kg)	24.7	24.6	24.1	0.102	0.88
FBW (kg)	38.4^a	34.7^a	29.7^b	0.001	3.94
DMI g day^{-1}	1492.5^a	1281.3^b	1036.3^c	0.001	0.29
ADG g day^{-1}	245.0^a	181.3^a	101.3^b	0.004	0.02
FCR kg kg^{-1}	6.1^b	7.1^b	10.2^a	0.028	1.88
Digestibility co-efficient (%)					
DMD	94.5	90.1	87.9	0.091	6.89
OMD	94.3	90.8	87.5	0.067	7.78
CPD	91.4^a	87.8^a	81.8^b	0.001	2.24
CFD	89.5	81.6	84.2	0.161	2.55

$^{a-c}$Means of the same row with different superscript differ significantly ($p<0.05$). IBW: Initial Body Weight; FBW: Final Body Weight; DMI: Dry Matter Intake; ADG: Average Daily Gain; FCR: Feed Conversion Ratio; DMD: Dry Matter Digestibility; OMD: Organic Matter Digestibility; CPD: Crude Protein Digestibility; CFD: Crude Fibre Digestibility

from fodder beet, which is comparable to that of the present study. According to De Brouwer *et al.* (1991) a well preserved silage is characterized by a lactic acid concentration that ranged from 80-120 g kg^{-1} DM lactic acid. Moreover, a silage with a pH in the range of 3.8-4.2 is considered well preserved (McDonald *et al.*, 1991). Although, the PHS had an acceptable pH of 4.2 for good fermentation, it had lactic acid concentration of 47.5 g kg^{-1} DM, which indicated that it was poorly fermented. Furthermore, a butyric acid concentration of <0.1 g kg^{-1} DM is usually found in well-preserved silages (Kung and Shaver, 2001) and the PHS had higher (0.5 g kg^{-1} DM) concentration of butyric acid than required.

The chemical compositions of the diets (Table 2) showed that T_1 had higher DM and CF contents than the other diets. The T_2 diet had higher CP content compared to the other diets. Data on the growth performance and nutrient digestibility in lambs is shown in Table 3.

Higher ($p<0.05$) DMI occurred in T_1 compared to the other diets. Mustafa *et al.* (2008) reported lower DMI in lambs that were fed silage compared to those fed concentrate diet. The improved DMI in T_1 might be attributed to the differences in the composition of the diets, since it contained higher DM and lower CF contents compared to the other diets. Hussain *et al.* (1996) obtained DMI of 1320 g day^{-1} in lactating goats that were fed on poor quality silage supplemented with 100 g concentrate, which is higher than the 1036 g day^{-1} obtained with T_3. This might be attributed to differences in chemical composition of the diets between the two studies.

Furthermore, lambs fed diet T_1 and T_2 had higher ADG and lower FCR compared to those fed diet T_3. This supported the research of Mustafa *et al.* (2008) and Petit and Catonguay (1994) when silage diets were compared with concentrate diets on lamb performance. According to Marley *et al.* (2007) and Savage *et al.* (2008) a lamb growth rate of above 150 g day^{-1} is desirable and feeding lambs on silage without supplementation resulted in a growth rate of 50 g day^{-1} (Speijers *et al.*, 2005).

Lambs fed T_3 obtained ADG of 101 g day^{-1}, which suggested that the diet was of poor quality and may take a longer period to fatten the lambs. The digestibility of DM, OM and fibre did not differ ($p>0.05$) but that of CP was improved ($p<0.05$) in T_1 and T_2 compared to T_3. It is assumed that the improved digestibility of CP in T_1 and T_2 might have contributed to an improved ADG in lambs fed these diets compared to T_3.

CONCLUSION

The dietary addition of poorly fermented potato hash silage resulted in lower daily gains in lambs. However, dietary inclusion of DB did not cause any deleterious effect on lamb performance. Further research on the effect of dietary inclusion of high quality potato hash silage on ruminant performance is needed.

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