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Effect of feeding cactus-legume silages on nitrogen retention, digestibility and microbial protein synthesis in goats

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ABSTRACT

The effect of co-ensiling *Opuntia ficus indica* with dry forage legumes on dry matter intake, digestibility, nitrogen retention and overall performance of kapaters was investigated. The treatment diets were Cactus-*Acacia angusitissima* silage (CAAS), Cactus-*Leuceana leucocephala* silage (CLLS), Cactus-*Calliandra calothyrsus* silage (CCCS), Cactus-*Macroptilium atropuprium* silage (CMAS) and a negative control of *Pennisetum purpureum* (PP) hay which was also fed as a basal diet to all other animals. Thirty, one-year old kapaters of mean (±SD) weight of 22.6 kg (±5.41) were assigned to the five treatments in a completely randomised design. The goats were individually housed in metabolism cages for a period of twenty-one days adaptation and seven-days of total urine and faecal collection. The results showed a significantly ($P<0.05$) higher dry matter intake (DMI), organic matter intake and digestibility of organic matter (DOM) in goats fed cactus-forage legume silages diets than those fed *Pennisetum purpureum* hay alone. Mixed silages DMI ranged from 0.72 to 0.81 kg/day and 0.42 to 0.50 DOM. The calculated microbial protein yield was highest in the CLLS group and lowest in the PP group. These trends are also reflected in the nitrogen intake (NI) and retention with CLLS (NI = 16 g/day, N retained = 13.54 g/day) showing the highest values and CMAS (NI = 9.02 g/day, N retained = 6.11 g/day) having the least among the silage supplemented goats. The PP fed goats had the least intake and a marginally negative nitrogen balance. Daily live weight gain was low (<100 g/day) for all the diets. The *Pennisetum purpureum* group had a negative weight gain throughout the period. The resultant silages can improve animal performance especially during times of nutritional stress. We concluded that mixed cactus legumes silage can be used as supplements in periods of feed deficits to improve goat performance and communal livelihood.

Abbreviations: ADFom, ash-free acid detergent fibre; CLLS, Cactus-*Leucaena leucocephala* silage; CAAS, Cactus-*Acacia angusitissima* silage; CCCS, Cactus-*Calliandra calothyrsus* silage; CMAS, Cactus-*Macroptilium atropurpureum* silage; DM, dry matter; NDFom, ash-free neutral detergent fibre; OM, organic matter; DOMR, digestible organic matter in the rumen; PP, *Pennisetum purpureum*; N, Nitrogen; NI, nitrogen intake; FCR, feed conversion ratio.

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1. Introduction

Opuntia ficus indica has potential for use in feeding ruminants in dry areas because of its high fresh biomass yield, relative abundance, low cost and ease of cultivation and high palatability (De Kock (2001); Nefzaoui, 2010). Furthermore, the evergreen habit, drought resistance and adaptability to a wide range of soils are useful attributes in dry areas (Azócar, 2001; Felker, 2001; Nobel, 2001; Guevara et al., 2009). Guevara et al. (2009) reported that the crassulacean acid metabolism (CAM) of cacti makes them more water-use efficient compared to C3 and C4 plants. Ben Salem (2012) considers *Opuntia* cultivation and use as forage as one of the simple and effective options for adaptation to climate change. *Opuntia ficus indica* has been considered as an alternative feed ingredient in arid and semi-arid rangelands (Teklehaimanot and Tritschler, 2010; Andrade-Montemayor et al., 2011) and its utilisation in livestock feeding is an old practice in Brazil, Chile, South Africa, Tunisia and many other countries (Tegegne, 2001; Guevara et al., 2009). However, its use is limited by high water content which results in high ruminal degradability and laxative effects. Cactus cladodes have high water content which results in high ruminal degradability and laxative effects when fed alone (Ben Salem et al. (2004); Souza et al., 2009; Santos et al., 2010). In addition, *Opuntia ficus indica* cladodes are not nutritionally balanced as it is low in crude protein, fibre, phosphorus and sodium (Souza et al., 2009; Nefzaoui, 2010,). The low crude protein content may affect its use as a complete feed as it may cause protein malnutrition in livestock. Ensiling it with dried forage legumes could increase the dry matter content making it suitable for ruminant feeding.

On the other hand, browse legumes have demonstrated in *in vitro* and *in vivo* degradability and digestibility studies that they can be used as protein supplements (Masama et al., 1997; Chakoma et al., 1999; Gusha et al., 2013). *Acacia angusitissima, Leuceana leucocephala, and Calliandra calothyrsus* are browse legumes, while *Macroptilium atropuprium* is a forage legume that have been extensively promoted for use in small scale dairying and communal livestock production (Masama et al., 1997; Ngongoni et al., 2006; Baloyi et al., 2009; Chakoma, 2012; Zvinorova et al., 2013). These legume forages have high crude protein and minerals especially calcium and phosphorus (Gusha et al., 2014). However, these forages have a significant amount of anti-nutritional factors which sometimes limit their utilisation (Masama et al., 1997; Baloyi et al., 2009). Therefore, complementary benefits should be realised when cactus and forage legumes are combined to form a supplement. Ben Salem et al. (2002) reported that combining straw with *Opuntia* led to increased straw intake and consequently better growth performance in lambs. Therefore, ensiling high moisture cactus cladodes with dried hays from forage and browse trees should improve the dry matter content of the feed and at the same time balancing the noted deficiencies in the used ingredients. Silage feed is easily consumed especially in areas with some water shortages thus improving the voluntary feed intake of livestock. Also heat generated during the incubation period of the silage was reported to reduce the effects of tannins and thus improving the rate of degradation in the rumen (Makkar, 2003; Waghorn, 2008).

It is, therefore, necessary that research should come up with feed ingredients which can be mixed with cactus to improve its use as animal feed. Combining cactus which is high in soluble sugars but low in crude protein and dry matter, with high crude protein ingredients could compliment each other's weaknesses and form a balanced diet. The objective of this study was therefore; to evaluate the effects of feeding cactus co-ensiled with various locally available forage legumes on the nitrogen retention, digestibility, microbial protein synthesis and growth in goats.

2. Materials and method

2.1. Study site

The experiment was conducted at Makoholi Research Institute located 32 km north of Masvingo town on 19°50′ S, 30°47′ E and altitude of 1200 m. The area is characterised by erratic rainfall both within and between seasons; annual mean rainfall is 565 mm with a range of 133–1155 mm. The rainy season starts end of November and ends mid March to early April while the dry season starts in April and end in November. The granite-derived soils consist of 96% sand, 2% silt and 2% clay and are inherently infertile and plant growth is severely limited by the unavailability of nitrogen and phosphorus (Department of Research and Specialist Services, 2013).

2.2. Treatment diets and silage production

Pennisetum purpureum was harvested at 10 weeks interval during the rainy season. No fertiliser application was done to the grass fields and there was no irrigation applied. The harvested biomass was chopped using machetes to 10 cm pieces before air drying under shade. The biomass was dried for a week before being packed in hessian bags and stored in the feed store room at ambient temperatures. It was then milled using a hammer mill without a screen or sieve. The browse legume shrubs with an average height of 2 m were cut at 30 cm above ground during the rainy season and the leaves were dried under shade for one week before being stored in hessian bags in feed storage room. Fresh cladodes were harvested from wild cactus in rangelands and singed on an open fire to remove spines. The cladodes were then chopped using machetes to 5 cm pieces before ensiling. Five dietary treatments were fed. These were *Pennisetum purpureum* hay alone to mimic dry season conditions in dry areas, then the following mixed silages; cactus-*Acacia angusitissima* (CAAS), cactus-*Leucaena leucocephala* (CLLS), cactus-*Calliandra calothyrsus* (CCCS) and cactus-*Macroptilium atropurpureum* (CMAS) fed as supplements to a basal diet of *Pennisetum purpureum* hay. The silages were prepared from a mixture of 67% fresh cactus and 37% browse meal