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Nutritive value and digestibility of mistletoes and woody species browsed by goats in a semi-arid savanna, southwest Zimbabwe

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ABSTRACT

The study examined the nutritive value of three mistletoe species (*Erianthemum ngamicum*, *Plicosepalus kalachariensis* and *Viscum verrucosum*) and four Acacia species (*Acacia gerrardii*, *Acacia karroo*, *Acacia nilotica* and *Acacia robusta*) browsed by goats in the semi-arid savanna in Zimbabwe. All were analysed for crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total phenolics (TP), condensed tannin (CT) and *in vitro* dry matter digestibility (IVDMD). *In vitro* gas production (IVGP) was measured with and without the addition of polyethylene glycol (PEG). *In vitro* metabolizable energy (IVME) was estimated from CP and IVGP. Acacia foliage contained more CP (120.9 vs. 109.5 g/kg DM) and ADF (219.1 vs.161.1 g/kg DM) content than mistletoe foliage. However, the content of ADL, TP, CT and IVDMD did not differ ($P>0.05$) between the two plant groups. *In vitro* dry matter digestibility differed significantly ($P<0.01$) among species within both mistletoe and acacia foliage, and the differences reflected variation in their chemical composition. The IVDMD for *E. ngamicum*, *P. kalachariensis* and *V. verrucosum* was 563.3, 537.3, and 339.2 g/kg DM, respectively. In acacia species, the respective IVDMD for *A. gerrardii*, *A. karroo*, *A. nilotica*, and *A. robusta* was 604.2, 317.7, 509.1, and 479.6 g/kg DM. Mistletoe foliage had higher *in vitro* ruminal fermentation parameters (i.e., IVGP and IVME) than acacia foliage. The IVGP without and with the addition of PEG was 62.2 and 68.5 ml/300 mg DM and 32.9 and 54.1 ml/300 mg DM in mistletoe and acacia foliage, respectively. The respective IVME in mistletoe foliage was 16.9 and 17.8 MJ/kg DM and in acacia foliage, 13.6 and 16.4 MJ/kg DM. The inclusion of PEG in the fermentation experiment increased IVGP and IVME in all acacia species and two mistletoe species (*E. ngamicum* and *V. verrucosum*). However, in *P. kalachariensis* inclusion of PEG caused a significant reduction in IVGP (−15.6%, $P<0.001$) and IVME (−9%, $P<0.001$). Overall, the inclusion of PEG caused a greater change in IVGP (64.4 vs. 10.1%), and IVME (20.6 vs. 5.3%) in acacia foliage than in mistletoe foliage. *In vitro* dry matter digestibility and fermentation parameters (i.e., IVGP and IVME) had inverse relationships with ADF, ADL, CT, and TP. In conclusion, the mistletoe species were of good fermentation quality than acacia species due to low ADF content and tannin activity. In this regard, mistletoe species show potential as alternative browse for goats in the semi-arid savanna.

1. Introduction

In the semi-arid savanna, due to nutrient poor basal feeds, goats are considerably constrained by inadequate nutrition.

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They rely on woody species, many of them being Acacia species, to improve their nutritional status especially during the dry season (Smith et al., 2005). In addition to eating browse as a supplement, goats have been observed to eat mistletoe. Mistletoes are aerial parasitic plants that depend on host trees for nutrients and water (Kuijt, 1969). The pathway underlying the acquisition of nutrients enables them to accumulate greater nutrient concentrations than their hosts (Ehleringer et al., 1986; Marshall et al., 1994). Therefore, the foliage of mistletoes may be important in providing quality fodder to goats in dry areas. In addition, due to low amounts of chlorophyll–protein complexes, mistletoes have a low capacity for photosynthesis enabling them to adapt to drought conditions (Turquet and Salle, 1996). Thus, mistletoes are valuable, as they remain available when there are few alternative sources of dietary protein. Mistletoes can have leaves with similar morphology to their hosts (mimic) or have leaf morphology different from their host (non-mimics). According to Bannister (1989), non-mimic mistletoes generally have lower N concentrations than their host plants while mimic contain higher levels of N than their hosts do. This strategy ensures that mimic mistletoes, by not appearing distinct from their host, gain a selective advantage aimed at reducing herbivory. Conversely, non-mimics contain lower levels of N than their hosts contain, and hence benefit by advertising the fact that their N level is low (Press, 1995).

In addition to high fibrous material, the use of tree foliage is constrained by their secondary compounds, notably tannins, which may interfere with digestion or have direct toxic effects on the animal (Owen-Smith, 1993). Chemical composition can be considered a useful indicator for the evaluation of nutritive value of browse forages (Van Soest, 1983). However, chemical analysis is of limited use to evaluate the nutritive value of plants, especially those containing secondary compounds (El Hassan et al., 2000). In this regard, degradation studies, which are sufficient indicators of processes that occur in the rumen, have gained wide acceptance in research on the nutritional evaluation of animal feeds. The *in vitro* gas production (IVGP) technique has been used to evaluate the nutritional value of browse, especially those containing tannins (Menke and Steingass, 1988). Tannin is the most important anti-nutritional factor, which has been shown to decrease digestibility in browse foliages (Ammar et al., 2005; Mokoboki et al., 2005). Condensed tannins (CT) are flavonoid polymers found in many plant species consumed by goats. They possess high molecular weights (500–3000) that cause them to precipitate with proteins resulting in the formation of indigestible complexes (Makkar et al., 1995). Incorporation of polyethylene glycol (PEG) in IVGP technique reduces or neutralizes effects of tannins and enables the assessment of the biological activity of tannin (Makkar, 2003).

In the semi-arid areas of Zimbabwe, information available on the comparative assessment and nutritional value of mistletoes and indigenous browse foliages is still very scant. The objective of this study was to determine the nutritive value of three aerial parasitic plants, *Erianthemum ngamicum* (Sprague) Danser (Loranthaceae), *Plicosepalus kalachariensis* (Schinz) Danser (Loranthaceae) and *Viscum verrucosum* Harv. (Viscaceae) (Mapaura and Timberlake, 2004) and four Acacia species, *Acacia gerrardii* Benth., *Acacia karroo* Hayne., *Acacia nilotica* (L.) Willd ex Del. and *Acacia robusta* Burch. (Timberlake et al., 1999). These species were chosen because goats have been observed to eat them in semi-arid areas of Zimbabwe. The species were analysed for crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), condensed tannins (CT) and total phenolics (TP), *in vitro* dry matter digestibility (IVDMD) and *in vitro* gas production (IVGP) with and without polyethylene glycol (PEG). *In vitro* metabolizable energy (IVME) was estimated from CP and IVGP using Menke and Steingass (1988) prediction equation. We tested the following hypotheses: (1) Mistletoe and acacia species have similar CP, NDF, ADF, CT, TP, IVDMD, IVGP and IVME contents. (2) Mistletoe and acacia species respond similarly to the addition of PEG in *in vitro* experiments.

2. Materials and methods

2.1. Study site description

Matopos Research Station (20°23′S 28°28′E) is located 30 km southwest of Bulawayo at an elevation of 1340 m. Mean annual rainfall averages 600 mm and rainy season is from November to March. The mean annual temperature is 23.6 °C (Dye and Walker, 1987). The soils are predominantly medium textured red clay soils of moderately high fertility (Dye, 1983) prone to surface crusting which results in bare patches (Ward et al., 1979). Vegetation has been described as an Acacia tree-bush savanna of varying density, dominated by *A. karroo*, *A. nilotica*, *A. gerrardii*, *Acacia rehmanniana*, *Acacia nigrescens* and *Maytenus senegalensis* (Rattray, 1957). The dominant grasses in the understorey vegetation include *Heteropogon contortus*, *Themeda triandra* and *Cymbopogon plurinodes* (Dye, 1983).

2.2. Study plants

Three mistletoe species (i.e., *E. ngamicum*, *P. kalachariensis* and *V. verrucosum*) and four browse species (i.e., *A. gerrardii*, *A. karroo*, *A. nilotica* and *A. robusta*) that grow in semi-arid southwest of Zimbabwe were used. Leaf samples were obtained from five ($n=5$) randomly selected and tagged representative plants of each species during October 2011. However, *V. verrucosum* does not have leaves (Pope et al., 2006); twigs <2 mm in diameter forming the shoot apex were collected. The host trees were the Acacia trees used in this study. The foliage was harvested from the part of the canopy accessible to goats (between 0.5 and 1.0 m in height), and plants growing near termite mounds were avoided.

2.3. Chemical analyses

The samples were dried and ground in a Wiley mill to pass through a 1 mm sieve for chemical analyses and *in vitro* assays. The leaf samples were analysed for dry