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Short communication

Evaluation of potential and effective rumen digestion of mistletoe species and woody species browsed by goats in a semi-arid savanna, southwest Zimbabwe

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ABSTRACT

The potential and effective rumen digestion 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 was determined *in vitro* with or without including polyethylene glycol (PEG). The *in vitro* gas production (IVGP) (74.6 *vs.* 63.1 ml), gas production rate (0.05/h *vs.* 0.035/h) and effective degradability (46.7 *vs.* 35.3 ml) were higher in mistletoe than acacia ($P<0.01$). For mistletoe species, *P. kalachariensis* had the highest IVGP, potential gas production (*b*), gas production rate (*c*) and effective degradability (ED) than *E. ngamicum* and *V. verrucosum* ($P<0.01$). In acacia species, IVGP and potential gas production (*b*) were higher in *A. karroo* whilst *A. gerrardii* had the greatest gas production rate (*c*) than the other acacia species. In all browse species, addition of PEG, which minimised the inhibitory effects of tannin on microbial fermentation, resulted in an increase in gas production parameters except in *P. kalachariensis* ($P<0.01$). The effect of PEG on fermentation and degradability was greater in acacia foliage than in mistletoe foliage (IVGP, 19 *vs.* 41%; potential gas production, 11 *vs.* 16%; effective degradability, 13 *vs.* 42%), which suggested that the tannin in acacia was more biologically active than that in mistletoe. In both mistletoe and acacia species, there was an interaction between species and PEG for IVGP and effective degradability. This result suggested that the effects of PEG on fermentation parameters were species-specific as species responded differently to the addition of PEG. The increase in fermentation parameters due to the addition of PEG varied widely amongst the acacia species (range: 10–114%) and mistletoe species (range: 7–49%). Thus, the inclusion of PEG to neutralise or reduce the effects of tannins should consider the species were its use would be more beneficial, such as in *A. gerrardii*, *A. robusta*, and *E. ngamicum* in this study. In conclusion, mistletoe species show a high nutritive value with large potential for feeding goats in the semi-arid savanna due to the higher values of IVGP, gas production rate, potential gas production, and effective degradation than those for acacia species. In addition, our results support the use of PEG to neutralise tannins in tannin-rich forages.

Abbreviations: ADF, acid detergent fibre; ADL, acid detergent lignin; CP, crude protein; CT, condensed tannins; DM, dry matter; ED, effective degradability; GLM, general linear model; IVGP, *in vitro* gas production; NDF, neutral detergent fibre; PEG, polyethylene glycol.

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1. Introduction

In the semi-arid savanna, to supplement their diet, goats depend on browse especially during drought periods when grass is quantitatively low and of poor quality. In addition to woody browse, goats have also been observed to eat mistletoe (Madibela et al., 2002; Ndagurwa and Dube, 2013). Mistletoe species that commonly infect trees in the semi-arid savanna southwest of Zimbabwe include *Erianthemum ngamicum* (Sprague) Danser (Loranthaceae), *Plicosepalus kalachariensis* (Schinz) Danser (Loranthaceae) and *Viscum verrucosum* Harv. (Viscaceae) (Mapaura and Timberlake, 2004). Although lower nutrient concentration in mistletoe than hosts have been reported elsewhere (Madibela et al., 2004), the foliar nutrient concentrations of mistletoe are usually greater than those of their hosts (Marshall et al., 1994). Thus, mistletoe species are a potential source of quality browse for goats when alternative sources of dietary protein are limited. Additionally, the host plant buffers the parasite against large-scale fluctuations in resource availability (Ehleringer and Marshall, 1995). For example, the parasite is less affected by seasonal changes in water availability due to the hosts' ability to access a lower water table because of a deep root system. The consequence of this is that parasitic plants are able to maintain their water status and nutritive value during the dry season, and thus they may be an important browse supplement in dry areas.

The rate and extent of fermentation of browse in the rumen are very important determinants for the nutrients absorbed by ruminants. Fermentation can be determined using *in vitro* gas production (IVGP), which is relatively simple to use and allows the processing of a large number of samples in a short time (Menke and Steingass, 1988). The IVGP is also efficient in evaluating the effects of condensed tannins (CT) on rumen fermentation (Menke and Steingass, 1988). Tannins have been shown to decrease digestibility (Degen et al., 1998; Dube et al., 2001) and fermentation (Makkar et al., 1995; Getachew et al., 2001) thereby affecting the availability of nutrients in browse. The incorporation of polyethylene glycol (PEG), as a CT-complexing agent, in IVGP reduces or neutralises effects of tannins enabling the assessment of the biological activity of tannin (Makkar et al., 1995). Polyethylene glycol has a high affinity for phenolic compounds, especially tannins, and thus prevents the formation of potentially indigestible tannin–protein complexes (Makkar, 2003). Increase in degradability due to the addition of PEG has been reported in other studies (Makkar et al., 1995; Getachew et al., 2001; Makkar, 2003).

The degradation rate of browse forages needs to be evaluated to predict nutritional value since it is related to voluntary feed intake. Therefore, the objective of the present study was to evaluate, in the presence and absence of PEG, the potential and effective rumen digestion of three mistletoe species (*E. ngamicum*, *P. kalachariensis* and *V. verrucosum*) and four *Acacia* species (*Acacia gerrardii*, *Acacia karroo*, *Acacia nilotica* and *Acacia robusta*) browsed by goats in the semi-arid savanna in Zimbabwe.

2. Materials and methods

The study was carried out at Matopos Research Station (20°22′60 S, 28°31′0 E) situated in southwest Zimbabwe. Mean annual rainfall averages 600 mm and the rainy season is from November to March. The mean annual temperature is 23.6 °C. Lower temperatures are observed in July and October is the hottest month characterised by low humidity and high temperatures 29 °C (Dye and Walker, 1987). The vegetation on predominantly red soils 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).

Fresh foliage was collected from five randomly selected representative plants of each species during October 2011. However, *V. verrucosum* does not have leaves; twigs < 2 mm in diameter forming the shoot apex were collected. 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. The samples were dried and ground in a Wiley mill to pass through a 1 mm sieve for *in vitro* assays. For the *in vitro* analyses, rumen liquor was withdrawn from four Matebele goats fitted with permanent rumen fistula at 0800 h, and kept in a flask at 37 °C. The goats were fed a supplement (200 g/animal/day) of the study species (*E. ngamicum*, *P. kalachariensis*, *V. verrucosum*, *A. gerrardii*, *A. karroo*, *A. nilotica* and *A. robusta*, in equal proportions). Standing grass hay was offered at the rate of 600 g/animal/day as a basal diet and drinking water was available throughout the experiment. *In vitro* gas production was determined following the procedure of Menke and Steingass (1988). Gas production was measured at 3, 6, 12, 24, 36, 48, 72 and 96 h of incubation, and corrected for gas production due to rumen fluid alone. The samples were analysed with and without including 300 mg of polyethylene glycol (PEG 4000MW, Sigma®).

The non-linear equation $y = b(1 - e^{-ct})$ was fitted to gas production data using the PROC NLIN procedures of the SAS 9.2 (SAS, 2009) based on the understanding that no gas is produced from unfermented feed (Siaw et al., 1993) where, y = the gas produced (ml) at time t, b = the potential gas production (ml), c = the gas production rate constant and t = the incubation time (h). Effective degradability (ED) was calculated using the equation $ED = (bc/(c + k))$, where k is the outflow rate from the rumen assumed to be either 0.03 or 0.05/h. Data on *in vitro* gas production ($IVGP_{48}$) and fermentation parameters were analysed as factorial experiments, (i) for foliage types (2 foliage types × 2 treatments (*i.e.*, with or without PEG)), (ii) for mistletoe (3 mistletoe species × 2 treatments (*i.e.*, with or without PEG)) and (iii) for acacia (4 acacia species × 2 treatments (*i.e.*, with or without PEG)) with 5 replicates according to the model: $Yijk = \mu + Fi + Pj + (FP)ij + \varepsilon ijk$, where *Yijk* is the response variable; μ is the overall mean; *Fi* the effect of foliage species; *Pj* the effect of PEG; $(FP)ij$ is the interaction effect; εijk the residual error using the GLM procedure in SAS 9.2 (SAS, 2009). Where *F* tests showed significant differences, means were