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Short communication

Intake, digestibility and milk yield in goats fed *Flemingia macrophylla* with or without polyethylene glycol

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ABSTRACT

High quality forage proteins for tropical goat dairy feeds are often difficult to find and many perennials contain condensed tannins (CT) that may not always benefit production. The objective of this study was to evaluate milk yield, apparent digestibility of nutrients and intake of crossbred dairy goats fed Tifton 85 (*Cynodon* spp. hybrid) grass replaced by the leguminous shrub flemingia (*Flemingia macrophylla*) with or without polyethylene glycol (PEG) to neutralize CT which were present at 105 g/kg DM. Treatments consisted of six diets containing 0%, 12.5% and 25% flemingia with or without PEG. Adding flemingia increased ($P \leq 0.05$) dietary concentrations of CT, lignin, protein and rapidly degradable polysaccharides ($A + B1$). The digestibility of nutrients at 12.5% of flemingia inclusion did not differ ($P > 0.05$) from the legume-free diet; however, levels of 25% negatively influenced ($P \leq 0.05$) intake of hemicellulose and dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF) and total carbohydrate digestibility, but this was neutralized when PEG was added. Histochemical tests on the leaf midrib, petiole and petiolule indicated the presence of idioblasts with phenolic compounds in trichome, collenchyma and parenchyma cells. We conclude that flemingia leaves can replace Tifton 85 grass as a supplement in low quality diets of dairy goats.

1. Introduction

Tropical legumes generally are important sources of protein for small ruminants but their high levels of secondary metabolites, including CT, and their lignin contents are considered factors that limit their use in goat dairy production (Ben Salem et al., 2005). These CT are widely distributed in gymnosperms and angiosperms, especially in woody plants. They are found in many species of legumes that are little known and exploited, and have the ability to form a complex with protein, carbohydrates and other constituents. Nevertheless, in recent years, they have been recognized as useful phytochemicals for beneficially modifying rumen microbial fermentation, leading to an increased metabolizable protein supply, from the protein binding action of CT, resulting in greater animal performance (Patra and Saxena, 2011).

Polyethylene glycol (PEG) is used to assess CT effects in ruminant feed because it is a synthetic polymer capable of complexing with CT without interfering with animal digestion (Vasta et al., 2008). This is because it contains a sufficient number of oxygen molecules to form strong bonds with the hydroxyl phenolic groups of CT, thus resulting in greater PEG affinity to CT vis-á-vis dietary proteins.

Flemingia is a drought-tolerant, tropical multipurpose shrub legume and, due to its high protein concentrations in leaves, is especially suited to low-input smallholder production systems as a dry season forage supplement (Andersson et al., 2006). We hypothesize that

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Table 1
Chemical composition of experimental feeds (g/kg DM).

Feed	Plant family	DM	OM	NDF	ADF	ADL	EE	CP
Forage								
Flemingia macrophylla	Fabaceae	844	944	562	319	140	19	191
Cynodon spp (Tifton 85)	Poaceae	840	933	717	322	52	13	119
Concentrates								
Diet 1		843	976	207	39	11	29	181
Diet 2		849	979	207	34	10	36	155
Diet 3		818	979	228	34	9	33	143

ADF, acid detergent fiber; ADL, acid detergent lignin; CP, crude protein; DM, dry matter; EE, ether extract; NDF, neutral detergent fiber; OM, organic matter.

supplementing milk goats eating low-quality Tifton 85 hay diets with moderate amounts of CT contained in flemingia will not negatively affect feed intake, milk production, or digestibility of the total diet. Our study evaluated milk yield, apparent digestibility of nutrients and feed intake of crossbred dairy goats fed different levels of flemingia hay replacing Tifton 85 hay with or without PEG to neutralize CT. The latter was important to determine the effect of CT independently of other factors introduced with the flemingia.

2. Materials and methods

2.1. Experiment area

The experiments were conducted in September–November 2010, in the goat sector of the Instituto de Zootecnia (animal science), Universidade Federal Rural of Rio de Janeiro, located in the district of Seropédica, State of Rio de Janeiro, Brazil.

2.2. Legume material

Forage material was obtained from shrubs growing at Embrapa Agrobiologia in the municipality of Seropédica, Rio de Janeiro, Brazil. Forage was harvested to a height of 1.20 m, at 90 days regrowth, on 23 July, 2010 and separated into leaves and stems. The leaves were used for the production of hay by air drying under shade for 72 h and then storing in bags.

2.3. Animals, experimental diets and management

Six crossbred dairy goats (Saanen × Boer; body weight, 52 ± 1.4 kg BW) in early-lactation and with an average milk yield of 2 kg were obtained from university Goat Sector. They were randomly allocated to individual wooden feeding crates in which feed and water were provided. Goats were milked daily at approximately 07:00 and 15:00 h. Diets consisted of total mixed ration based on 50% concentrate and 50% Tifton 85 grass hay (Table 1). Tifton 85 hay was replaced by flemingia leaf hay at 0%, 12.5% and 25% substitution rates. Half the diets were supplemented with PEG (molecular weight of 4000) added to the concentrate (60 g per animal daily).

Diets were formulated to be isonitrogenous at 14% CP. Tifton 85 hay was used as the basal forage in all dietary treatments. The concentrates used consisted of ground maize (*Zea mays*) and soybean (*Glycine max*) meal. The trial lasted for 54 days, with each experimental period lasting 9 days (5 days for adjustment (Putrino et al., 2007) and 4 days for sample collection). The experimental design was a 6 × 6 Latin square with 3 × 2 factorial arrangement of treatments.

2.4. Chemical analysis

Diets, refusals and fecal samples were analyzed for DM, ash, and ether extract (EE) (AOAC, 1998) concentration. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) concentration in feed samples were estimated according to Van Soest et al. (1991). Crude protein concentration was determined according to a Kjeldahl N concentration method using a conversion factor of 6.25 (AOAC, 1998). Fractions of N compounds were determined according to the protocol described by Malafaia and Vieira (1997). Concentrations of extractable, protein-bound, fiber-bound, and total CT were determined using the HCl–butanol method based on photospectrometric measurement as described by Terrill et al. (1992).

2.5. Histochemical tests

Leaf midrib, petiole and petiolule were sectioned transversally with a rotary microtome and used to prepare semi-permanent slides. The evaluation was made on fresh material with acidified phloroglucin (Sass, 1951) for lignin detection; 10% potassium dichromate (Gabe, 1968) and Hoepfner-Vorsatz for phenolic compounds (Reeve, 1951); 0.5% vanillin and 9% hydrochloric acid (Mace and Howell, 1974) for CT; and ruthenium red (Johansen, 1940) for pectins.

2.6. Statistical analyses

Statistical procedures were carried out using the GLM procedure of SAS 9.2 Program (SAS Institute Inc., Cary, NC, USA) with the following model:

$$Y_{ijk} = \mu + l_k + c_l + a_i + b_j + (ab)_{ij} + e_{ijk}$$

where Y_{ijk} = response variable; μ = overall mean; l_k = effect of period k; c_l = effect of animal l; a_i = effect of level i of a; b_j = effect of level j of b; $(ab)_{ij}$ = interaction of factors a and b; e_{ijk} = random variation. The data were subjected to analysis of variance followed by Tukey's test to determine the difference between treatment means. Unless otherwise noted, probabilities were considered significant at $P \leq 0.05$.

3. Results

3.1. Composition and histochemical analyses of the legume

The $A + B1$ fractions (541 g/kg DM) were greater in the legume than in the grass (211 g/kg DM). The CHO fraction $B2$ in Tifton 85 and flemingia were 518 and 226 g/kg DM, respectively. The average C fractions were 189 g/kg DM in the legume and 89 g/kg DM in Tifton 85.

The results achieved with histochemical tests of flemingia leaves closely parallel those of the carbohydrate fractions. The phloem vascular bundles in the midrib, petiole and petiolule presented non-lignified wall and revealed a large amount of rapidly degradable polysaccharides (Fig. 1A–C). Lignin deposition was anatomically revealed by the phloroglucin test. Lignin appeared mainly in the pericyclic fibers and xylem fibers. These cells appeared to have thick walls and were heavily lignified (Fig. 1D and E).

Flemingia, harvested in the dry season, had 191 g CP/kg DM (Table 1). The profile of nitrogenous compounds revealed a greater percentage of the fractions $B3$ and C and lesser percentages of fractions A and $(B1 + B2)$.

Flemingia had 105 g CT/kg DM. Extractable and fiber-bound CT concentrations were greater than protein-bound