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Short term consumption of *Havardia albicans* tannin rich fodder by sheep: Effects on feed intake, diet digestibility and excretion of *Haemonchus contortus* eggs☆

Francisco Alejandro Méndez-Ortíz[a,b], Carlos Alfredo Sandoval-Castro[b,*], Juan Felipe de Jesús Torres-Acosta[b,*]

[a] *Escuela Superior de Ciencias Agropecuarias, Universidad Autónoma de Campeche, C. 53 s/n, Col. Unidad, Esfuerzo y Trabajo # 2, C.P. 24350, Escárcega, Campeche, Mexico*

[b] *Campus de Ciencias Biológicas y Agropecuarias, FMVZ, Universidad Autónoma de Yucatán, Km 15.5 Carretera Mérida-Xmatkuil, Mérida, Yucatán, Mexico*

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ABSTRACT

This experiment determined the short term effect of feeding *Havardia albicans* (HA) tannin rich fodder on voluntary feed intake (VFI), dry matter digestibility (DMD), digestible DM intake (DDMI) and fecal excretion of *Haemonchus contortus* eggs by hair sheep. Polyethylene glycol (PEG) was used to identify possible roles of tannins on the results. Hair sheep lambs (12.6 ± 3.33 kg body weight (BW)) without browsing experience and raised free of gastrointestinal nematode infections were maintained in metabolic cages. There were 5 experimental groups with 3 of them infected with *H. contortus* (350 L_3/kg BW): Group IC: infected and fed a tannin free diet ($n = 8$), Group IHA: infected and fed fresh HA fodder alone ($n = 5$) and Group IHA + PEG: similar to IHA plus PEG ($n = 5$). Two groups remained free of infection and were fed fresh HA fodder either alone (NIHA) ($n = 5$) or with PEG (NIHA + PEG) ($n = 5$). Sheep were assigned to the experimental groups when the *H. contortus* infection was patent (*i.e.*, day 25 post-infection). The HA fodder was fed daily at 14 g DM/kg BW) for 7 d as part of the diet after a 5 d of adaptation. A concentrate feed containing 150 g/kg crude protein (CP) and 10.1 MJ/kg DM of metabolizable energy, and sugar cane molasses, were used to meet requirements for a BW gain of 100 g/d. Infected sheep (IHA) had higher HA consumption than non-infected (NIHA) ($P<0.05$). Such differences in HA fodder consumption due to infection did not occur between PEG supplemented groups. As a result, VFI of the NIHA group was lower than the other groups ($P<0.05$). Sheep fed HA had a lower DMD and DDMI compared to controls and use of PEG did not have an impact. Short term consumption of HA fodder reduced fecal egg excretion by 58.8% in the IHA *versus* the IC group ($P<0.01$). Such a reduction in egg excretion did not occur in the IHA + PEG group. Results show that sheep infected with *H. contortus* may increase consumption of tannin rich foliage in spite of negative effects on digestibility of the foliage. Such an increase in foliage consumption reduced fecal excretion of nematode eggs and these effects were blocked by PEG.

Abbreviations: ADF, acid detergent fiber; AH, anthelmintic; BW, body weight; CT, condensed tannins; DDMI, digestible DM intake; DMD, dry matter digestibility; EPG, egg counts/g feces; GIN, gastro intestinal nematodes; HA, *Havardia albicans*; NDF, neutral detergent fiber; PEG, polyethylene glycol; PI, post-infection; TFEC, total fecal egg count/d; TP, total polyphenol; TRP, tannin rich plants; TT, total tannins; VFI, voluntary feed intake.

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* Corresponding authors at: Facultad de Medicina Veterinaria y Zootécnia, UADY, Km 15.5 Carretera Mérida-Xmatkuil, Mérida, Mexico. Tel.: +52 999 942 3200; fax: +52 999 942 3205.

E-mail addresses: ccastro@uady.mx (C.A. Sandoval-Castro), tacosta@uady.mx (J.F.d.J. Torres-Acosta).

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1. Introduction

Effects of tannin rich plants (TRP) have been evaluated on ruminant intake (Goel et al., 2005; Alonso-Díaz et al., 2008a; Hernández-Orduño et al., 2012), feed digestibility (Barry and Manley, 1984; McSweeney et al., 2001) and *in vitro* and *in vivo* anthelmintic (AH) properties against gastrointestinal nematodes (GIN) (Kabasa et al., 2000; Alonso-Díaz et al., 2008b, 2009; Martínez-Ortiz-de-Montellano et al., 2010; Marie-Magdeleine et al., 2010). Several studies used polyethylene glycol (PEG) to assess effects of tannins on intake, digestibility or the AH effect *in vitro* and *in vivo*. Results from a considerable number of studies, from temperate and tropical environments, support the hypothesis that the foliage of some TRP might be considered nutraceutical as well as having a pharmacological AH effect (Hoste et al., 2006; Alonso-Díaz et al., 2010). However, most studies evaluated either the nutritional effect or the antiparasitic effect in isolation. In order to confirm the true nutraceutical value of any plant material, we believed it to be necessary to confirm the nutritive value of a diet containing a TRP foliage and its *in vivo* AH effect simultaneously.

Thus, this study evaluated *Havardia albicans* foliage as a potential nutraceutical. For this purpose, the nutritional value (dry matter digestibility (DMD), DM intake and digestible DM intake (DDMI), as well as the AH effect of a diet containing *H. albicans* tannin rich foliage, were evaluated in hair sheep infected with *Haemonchus contortus*. The role of tannins in the nutritive value and the AH effect was assessed with PEG.

2. Materials and methods

2.1. Location

The study was completed at the Campus of Biological and Agricultural Sciences at the Autonomous University of Yucatan (FMVZ-UADY) in Merida, Mexico. The climate in the area is hot sub-humid with summer rains and an average annual temperature of 27 °C. The average annual rainfall is 940 mm with an annual average relative humidity of 72% (Flores and Espejel, 1994).

2.2. Experimental sheep and groups

Hair sheep lambs, 28, with an age of ~3 month and 12.6 ± 3.33 kg body weight (BW) were used. The lambs had no previous browsing or grazing experience and were raised free of GIN by keeping them under conditions which avoided contact with infective larvae in the feed and they were maintained in concrete floor pens. Lambs were kept in individual metabolic cages for the duration of the study and divided into 5 experimental groups. Three groups received a monospecific infection of *H. contortus* (350 L_3 larvae/kg BW *per os*) on Day 0 (D0) and two other groups were kept nematode-free. The experimental groups were: IC = infected control ($n = 8$); IHA = infected and supplemented with *H. albicans* foliage (IHA) ($n = 5$); IHA + PEG = infected and supplemented with *H. albicans* and PEG ($n = 5$); NIHA = non-infected and supplemented with *H. albicans* ($n = 5$) and, NIHA + PEG = non-infected and supplemented with *H. albicans* and PEG ($n = 5$).

2.3. Diets

During the first 24 d after the artificial infection, which included the pre-patent phase of infection and the first days of patent infection, all lambs consumed a commercial grain based balanced feed (M & M, Merida, Mexico; 150 g CP/kg DM) including sugar cane molasses supplied as to sustain an estimated daily BW gain of 100 g (AFRC, 1993) based upon feeding 30 g concentrate and 3 g sugarcane molasses/kg BW.

Once all the infected lambs were confirmed with a stable excretion of *H. contortus* eggs in the feces after day 25 post infection, the IHA, NIHA, IHA + PEG and NIHA + PEG groups were fed HA fodder at 14 g/kg of animal BW (DM basis). Foliage was available only from 12:00 to 16:00 h. An adaptation starting on day 25 post infection and ending when a stable intake of HA foliage occurred on two consecutive days in all lambs. This period lasted for 5 d until day 30 post infection.

H. albicans foliage was harvested daily in the morning from 10 *H. albicans* trees which provided all the foliage for the study. After pruning the foliage, leaves from the trees were homogenized to ensure that foliage of similar characteristics was fed every day. In addition to the HA foliage, the lambs fed the same commercial feed mixture with molasses as a supplement at 16:00 h in order to meet estimated requirements for 100 g BW gain/d. Lambs in the group IC (without HA) were fed the same basal diet during the pre-patent period (*i.e.*, before nematode eggs were present in faeces) at the same rate to achieve 100 g BW gain/d during the experiment. Lambs were weighed at the beginning and end of the study.

2.4. Dose of polyethylene glycol

Lambs in the IHA + PEG and NIHA + PEG groups received 25 g of PEG/d dissolved in 25 ml of water (Wt 3.350; Sigma St. Louis, MO, USA). The PEG was administered *per os* in two portions with half of the dose administered before HA fodder was fed and the second half of the dose after the HA fodder was removed (Silanikove et al., 2001).