Small Ruminant Research 89 (2010) 164–173

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Tannins in tropical tree fodders fed to small ruminants: A friendly foe?☆

M.A. Alonso-Díaz[a,b,*], J.F.J. Torres-Acosta[a], C.A. Sandoval-Castro[a], H. Hoste[c,d]

[a] Facultad de Medicina Veterinaria y Zootecnia, UADY. Km. 15.5 Carretera Mérida-Xmatkuil, Mérida, Yucatán, Mexico
[b] Centro de Enseñanza Investigación y Extensión en Ganadería Tropical, Facultad de Medicina Veterinaria y Zootecnia, UNAM. Km. 5.5 Carretera Federal Tlapacoyan-Martínez de la Torre, C.P. 93600, Veracruz, Mexico
[c] INRA, UMR 1225 DGER, F31076 Toulouse, France
[d] Université de Toulouse, ENVT, 23 Chemin des Capelles, F31076 Toulouse, France

ARTICLE INFO

Article history:
Available online 20 January 2010

Keywords:
Goats
Sheep
Tannins
Preference
Saliva
Nematodes
Adaptive mechanisms

ABSTRACT

Livestock production systems worldwide rely largely on conventional feedstuffs. The current world food crisis highlights the need to improve the use of local resources for animal nutrition, such as fodder trees and shrubs. The detrimental effects of tropical tannin-rich plants (TRP) on animal production have been frequently described. In contrast, their potential benefits have long been neglected. This paper presents the potential positive effects of tropical TRP on small ruminants either as source of feed or as nutraceuticals with anthelmintic (AH) properties. It also analyses the host behavioral and physiological adaptations associated with exploitation of those tannin-rich resources. Both sheep and goats preferred a mixture of plants even when tannin-free forage was available. Moreover, the preference for TRP by goats and hair sheep were mainly associated with the digestible fraction of fiber and to a less extent with tannin content, which implies that they do not necessarily select against TRP. The addition of polyethylene glycol did not modify the preference or intake of TRP by goats and sheep. Evidence of physiological adaptation to TRP is presented and discussed. Both, experienced hair sheep and goats had saliva with tannin binding capacity, enabling both species to eat higher quantities of TRP which could lead to a higher availability of tannins in the gastrointestinal tract. Tannins in the gastrointestinal tract could be an AH against gastrointestinal nematodes (GIN). Indeed, *in vitro* and *in vivo* studies have shown AH effects of tannins from TRP, suggesting their possible use as natural anthelmintics against GIN. This paper supports the change in the current view of tannins in TRP as anti-nutritional compounds. If adequately managed, TRP can be a valuable component of sustainable small ruminant production systems.

1. Introduction

Although goat and sheep industries make marginal contributions to the world meat and milk markets, their products are important commodities for resource-poor human populations. To feed the increasing human population will require a substantial increase in animal products by 2030 (FAO, 2008). Historically, to achieve their potential contributions, grains and improved forages have been used as feed supplements for small ruminants at different levels.

☆ This paper is part of the special issue entitled: Plenary papers of the 9th International Conference on Goats, Guest Edited by Jorge R. Kawas.

* Corresponding author at: Centro de Enseñanza, Investigación y Extensión en Ganadería Tropical, Facultad de Medicina Veterinaria y Zootecnia, UNAM. Km. 5.5 Carretera Federal Tlapacoyan-Martínez de la Torre, C.P. 93600, Veracruz, México. Fax: +52 232 3243943.
E-mail address: alonsodm@servidor.unam.mx (M.A. Alonso-Díaz).

0921-4488/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.smallrumres.2009.12.040

However, the present world food crisis is causing people to re-consider the use of alternative feeds for animal production. While fodder trees and shrubs have not been an important source of human food, they can be a significant source of nutrients for ruminants in both harsh (Makkar, 2003) and biodiverse environments.

Tropical trees and shrubs are important sources of proteins for small ruminants. However, their high levels of plant secondary metabolites (PSM), including tannins, and/or their high fiber contents are often considered important factors limiting their use (Ben Salem et al., 2005; Sandoval-Castro et al., 2005). The concept of tannins being anti-nutritional, harmful and/or toxic to ruminants is common (Mueller-Harvey, 2006). However, tannins might also have beneficial effects on ruminant physiology, production and health (Ramírez-Restrepo et al., 2005; Hoste et al., 2006). Differences between the beneficial and detrimental effects amongst the diverse ecological niches depend on: (i) the type of vegetation (Iason and Villalba, 2006), (ii) the nutritional background/experience of the animals to use a specific vegetation (Villalba et al., 2002; Baraza et al., 2005; Sorensen et al., 2005; Provenza, 2006), and (iii) the existence of adaptation mechanisms (Shimada, 2006; Costa et al., 2008). Also most data illustrating the benefits from CT intake in small ruminants have been acquired on tannin-rich temperate legumes (Ramírez-Restrepo et al., 2005; Hoste et al., 2006; Waghorn, 2008). In contrast, the intake of tropical TRP has been frequently pointed out as detrimental for ruminants.

Native vegetation from the tropical forest of the Yucatan Peninsula has more than 260 legume species (Flores et al., 2006), some of which contain high levels of crude protein, low to moderate neutral detergent fiber (NDF) and variable levels of PSMs, including tannins (Ayala-Burgos et al., 2006). Animals foraging such chemically diverse environments likely show different response to the intake of tannins due to the development of different behavioral and/or physiological strategies to harvest nutrients and/or medicinal compounds as well as to counteract PSM. This review aims at presenting recent data obtained with tropical TRP using the flora of Yucatan as a model to explore: preferences and intake of tannin-rich species in goats and sheep with and without polyethylene glycol (PEG); the possible existence of adaptive mechanisms related to the presence of tannin-binding proteins in the saliva of goats and sheep; and the potential properties of native TRP as anthelmintics against gastrointestinal nematodes.

2. Preferences and intake of native tannin-rich tree fodders by goats and sheep

Compared to temperate countries, livestock under tropical conditions face variable conditions in terms of feed quality. Trees and shrubs contain high levels of lignin and PSMs (i.e. tannins) (Sandoval-Castro et al., 2005). Indeed, some plants have low crude protein (CP) and/or energy content which, in combination with the presence of PSMs, might detrimentally affect animal performance (Waghorn, 2008; Ben Salem et al., 2003). However, the toxicity of PSMs (i.e. tannins) has often been reported without considering the nutrient profile of the feed. The latter is crucial information as excess nutrients, nutrient imbalances and toxins can all limit feed intake or give a satiation sensation to animals (Provenza, 2006). Under natural conditions, it is rare that grazing animals avoid specific forages (Iason, 2005). Usually, the PSM intake is regulated within limits that are tolerable by the herbivores (Provenza, 1995, 1996). They ingest many feeds containing PSMs and use both, behavioral strategies and/or physiological adaptations, to counteract their negative effects (Provenza, 2006). The way plants are provided (as a single feed or in cafeteria trials), the relationship between tannins and nutritive value (crude protein, energy, fiber), the nutritional status of animals and their experience of the diet developed during previous ingestions of TRP may result in better intake or tolerance of plant materials. Even more, these plants may be useful to small ruminants in certain circumstances.

Even though small ruminants can spend a high proportion of their time browsing TRP (Rios and Riley, 1985), little information is available on the effects of tannins on goats and sheep preference and intake of these plants, especially when offered simultaneously. Preference and selection studies represent a useful tool to evaluate tropical TRP. In such studies, it is important to distinguish whether the choice made by herbivores reflects the concentration of PSMs, the availability of nutrients, or both factors interacting in the plants (Iason and Villalba, 2006).

The ways TRP are fed (as a single feed or cafeteria) can influence preference and intake by small ruminants (Provenza et al., 2009). Rogosic et al. (2006) reported a higher biomass intake when goats were offered the choice of tree shrubs with high tannin content and diverse metabolite compounds than when offered a single plant. A meta-analysis from different preference studies performed in Yucatan, Mexico using tropical TRP with the same characteristics in their nutritive values for sheep and/or goats showed several similarities (Alonso-Díaz et al., 2008a, 2009a; Hernández-Orduño et al., 2008a; Revaud, 2007).

- *Animals do not seem to select against TRP and they favour diversity in food consumption*: When foliage from four plants (three tannin-rich plants and one with high nutritive value and low tannin content) was offered *ad libitum* to animals with browsing experience, 50–63% of the dry matter (DM) intake was comprised of TRP foliage (Revaud, 2007; Alonso-Díaz et al., 2008a, 2009a; Hernández-Orduño et al., 2008a). Duncan et al. (2003) suggested that toxin dilution could be an important reason why herbivores select a mixed diet. Indeed, the quality of toxins in foods and the availability of nutrients may all interact to modify intake (Mote et al., 2007). Animals eating a mixed diet might face different mixtures of PSMs, which are usually eliminated from the body via different metabolic pathways. If animals restrict their diet to a plant rich in a single PSM, a single pathway might become saturated. Consequently, the nutritive cost (protein and energy) to eliminate this specific PSM could be higher. In conclusion, intake of a mixed diet suggests the existence of a trade-off between ingesting nutritious feed and spreading the risk from PSM ingestion.