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Beneficial and detrimental effects of dietary condensed tannins for sustainable sheep and goat production—Progress and challenges☆

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Abstract

Condensed tannins (CT) have improved liveweight gain, wool production and reproductive efficiency in sheep fed temperate forages and reduced the impact of gastro-intestinal parasitism. However, their value is also linked to environmental issues, such as reducing nitrogen pollution from animals grazing lush pastures with a high nitrogen content and lessening methane emissions from rumen fermentation. When forages are fed as a sole diet, the CT in birdsfoot trefoil (*Lotus corniculatus*) have been beneficial for ruminant production, but the CT in sainfoin, (*Onobrychis*), sulla (*Hedysarum coronarium*) and lotus major (*L. pedunculatus*) do not appear to benefit productivity other than by mitigating the impact of parasites. The sainfoin, sulla and lotus major have a high feeding value, but the CT *per se* offer no benefits for nutrition. In contrast to temperate farming, the CT in browse, typical of warm and hot climates, are nearly always detrimental to ruminants, except for reducing internal parasite numbers. Grasses fed in these regions contain less protein (and usually more fibre) than temperate forages and inclusion of CT from browse further reduces protein availability for absorption by limiting ruminal microbial growth and lowering the fractional absorption of amino acids from the intestine. Intakes of CT from browse, in combination with a medium–poor quality diet, are detrimental to performance. However recent studies have shown inclusion of polyethylene glycol (PEG) in diets for sheep and goats grazing scrub and woodland can markedly improve performance, with as little as 10 g/day. The success of research to improve the performance of animals consuming diets

Abbreviations: AA, amino acid; BW, body weight; CP, crude protein; CT, condensed tannin(s); DM, dry matter; FEC, faecal egg count; GHG, greenhouse gas(es); ME, metabolisable energy; MJ, mega joule; N, nitrogen; na, not applicable; PEG, polyethylene glycol; VFA, volatile fatty acids.

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containing CT in both temperate and hot climates will depend on communication between animal scientists and chemists. Researchers must measure the astringency and chemical characteristics of CT (and other secondary metabolites), to better understand the impact of tanniniferous feeds on nutritive value. These measurements will enable findings from unrelated trials to be evaluated and provide opportunities for optimising and mitigating the CT in contrasting ruminant production systems.

Keywords: Condensed tannin; Sheep and goat nutrition; Gastro-intestinal parasites

1. Introduction

The term "tannin" refers to "tanning" or preservation of skins to create leather, and tannins also contribute to the astringency of many popular drinks, for example tea and wine. Condensed tannins (CT), also known as proanthocyanidins, are secondary plant metabolites. Their role in plant metabolism is not known, although several hypotheses have been advanced, but effects on ruminant digestion are becoming increasingly clear. Condensed tannins bind to proteins in the rumen, reduce protein degradation and when dietary crude protein (CP) concentrations exceed animal requirements for CP, these effects can improve performance. However when dietary CP concentrations are low and fibre concentrations are high, CT are nearly always detrimental.

Condensed tannins are heterogeneous compounds (*e.g*. Mueller-Harvey, 1999) and both size and structure affects their reactivity and impact on digestion. Their structure and propensity for binding to protein and fibre makes accurate measurements of concentration difficult. Determination of CT concentration requires both unbound and bound CT to be measured, using purified CT from the same forage species as a standard. Alternative standards will lessen the accuracy of CT measurements. However astringency (protein binding capacity) is equally important, and the variation between tannins has frustrated attempts to relate concentration with animal performance. The structure of the CT affects their binding capacity, the impact upon digestion, nutritive value and anthelmintic properties.

Other secondary metabolites present in browse may have a greater impact than CT upon animal performance (Acamovic and Brooker, 2005; Reed et al., 2000). Examples include hydrolysable tannins, which are potentially toxic but also degradable in the rumen. The presence of other secondary metabolites must be recognised in evaluations of CT containing forages.

Condensed tannins are widespread in dicotyledonous species and occur infrequently in graminacae. In temperate species they are often restricted to seed coats (*e.g*. faber bean, *Vicia faber*; lucerne, *Medicago sativa*) or flowers (white clover, *Trifolium repens*) (Jansman, 1993; Burggraaf et al., 2003), but they must be expressed in foliage to have real benefits for ruminant nutrition. The condensed tannins in the foliage of birdsfoot trefoil (*Lotus corniculatus*), Lotus major (*L. pedunculatus*), sainfoin, (*Onobrychis viciifolia*) and sulla, (*Hedysarum coronarium*) have provided significant benefits for ruminant performance, health and environmental sustainability. These benefits have prompted an intensive research effort to define the chemical composition of CT, identify synthetic pathways and especially to understand the regulation of CT expression in foliage. The challenges in engineering plant expression of secondary metabolites have been illustrated by Dixon (2005), and some recent progress