Timely Topics December 2024

All about condensed tannins

American Consortium for Small Ruminant Parasite Control

Introduction

The American Consortium for Small Ruminant Parasite Control, drawing on various research findings, has recommended sericea lespedeza (AU Grazer; *Lespedeza cuneata*) as an alternative method for managing gastrointestinal nematodes (worms) in small ruminants. But what makes sericea lespedeza a good option in an integrated parasite control program? The answer is condensed tannins (CT).

When experts talk about lespedeza's potential to reduce parasite infections in small ruminants, some producers say "I have lespedeza in my pastures", expecting the positive effects on parasite control. Yes, they have lespedeza, but not all lespedezas are created in the same way. Different varieties of lespedeza vary in CT concentration, which will have an impact on intake and parasite control. The lespedeza they have in their pasture may not have the CT concentration and profile of AU Grazer, the main variety of sericea lespedeza that has been tested. However, it has been shown that other CT-rich plants can have antiparasitic effects too. Additionally, some agro-industrial byproducts used as feedstuffs can be a source of CT.

Plants synthesize a vast range of organic compounds classified as primary and secondary metabolites. Primary metabolites are compounds that have essential roles associated with photosynthesis, respiration, growth. and development. These include phytosterols, acyl lipids, nucleotides, amino acids and organic acids. Secondary metabolites, a structurally diverse group of phytochemicals, play a key role in protecting plants from herbivores and microbial infection, attracting pollinators and seed-dispersing animals, acting as allelopathic agents, providing ultraviolet protection, and serving as signaling molecules for the formation of nitrogen-fixing root nodules in legumes. Secondary metabolites have been objects of interest because of their use as dyes, fibers, glues, oils, waxes, flavoring agents, drugs, and perfumes. They are viewed as having a potential role in the development of new natural drugs, antibiotics, insecticides, and herbicides.

Sericea lespedeza

Tannins are the most abundant secondary metabolites synthesized by plants.

The goal of this article is to enhance the understanding of the role of CT in small ruminant diets. It provides a summary of their chemistry, their function in plants, dietary sources, nutritional impacts, and their effects on worms.

Chemistry and role for the plants

Tannins are the most abundant secondary metabolites synthesized by plants. They are phenolic compounds of high molecular weight . Hydrolysable tannins (HT) and condensed tannins (CT) are the two major classes of tannins that form an important defense against herbivores. Very few studies have focused on the effects of HT on animal nutrition and health. Normally, HT is associated with toxicity in animals. Comparatively, there are numerous studies on CT isolation and chemical structure determination, the interaction with proteins, and effects on health, productivity, and the environment.

Condensed tannins exist in nature as diverse mixtures of oligomeric and polymeric substances constructed from a common set of building blocks called flavan-3-ols. They are characterized based on hydroxylation pattern, stereochemistry, functional groups, and interflavan-3-ol linkages. Most of the CT occurring in forage plants are primarily composed of the four flavan-3-ol subunits: catechin and epicatechin (procyanidin tannins) and gallocatechin and epigallocatechin, which possess an additional hydroxyl group at C5 of the B-ring (prodelphinidin tannins). However, taking into account the different possible flavan-3-ol subunits and the different possible types of interflavan-3-ol linkages, CT have an extremely diverse set of structures.

CT analysis is not included in a routine feed analysis. Cleary, improvements and standardization of analytical techniques are necessary. It is common in trials testing CT-rich forages to not have CT analysis. Besides, CT content data are not sufficient for accurately correlating biological activity.

Sources of condensed tannins in small ruminant diets

Forage legumes are a major source of CT in small ruminant diets. Birdsfoot trefoil (*Lotus corniculatus*), big trefoil (*L. pedunculatus*), sainfoin (*Onobrychis vicifolia*) and sulla (*Hedysarum coronarium*) are temperate plants associated with parasite reduction. Studies with tropical forage legumes rich in CT such as sericea lespedeza have intensified in recent years.

Besides these various legume (*Fabaceae*) species, many other plants containing CT from a wide range of botanical families have also been examined for their potential antiparasitic properties. For instance, chicory (*Cichorium intybus*) from the *Asteracea* family has also been tested for antiparasitic properties. A small amount of data has been acquired on woody plants from a range of botanical families, which are better exploited when goats, and lesser extent sheep, are browsing in tropical and temperate environments.

Other possible sources of CT in small ruminant diets are numerous industrial byproducts (availability varies by region). For instance, there is evidence of antiparasitic effects of carob pods, bark from trees, and spent coffee ground. The presence of CT in both hazelnuts and chestnut peels helps to explain the biological activity and the potential antiparasitic properties of nut peels. Peanut skins supplementation of up to 30 percent of the diet can improve average daily gain and rumen fermentation while reducing gastrointestinal parasite infection in meat goats.

Sainfoin **Birdsfoot trefoil** **Sulla**

CT Impacts on Nutrition

In small ruminant nutrition, condensed tannins:

- Reduce ruminal digestion of plant protein
- Reduce rumen ammonia concentrations
- Reduce protein solubility
- Increase the proportion of plant protein reaching the intestine
- Inhibit some rumen bacteria
- Reduce nitrogen digestibility
- Increase fecal nitrogen concentration
- Reduce urinary nitrogen output
- Slow or reduce the rate of amino absorption from the intestine
- Reduce dietary dry matter able to be digested
- Lower the proportion of dietary energy loss to methane.

In the past, CT were seen as detrimental to ruminant nutrition, notably impacting dry matter intake. But, in more recent years, the focus has switched to potential positive effects, such as:

- Improved feed efficiency
- Increased live weight gain
- Increased reproductive efficiency
- Increased wool production
- Reduced impacts of parasitism
- Reduced nitrogen pollution
- Less methane emissions from rumen fermentation

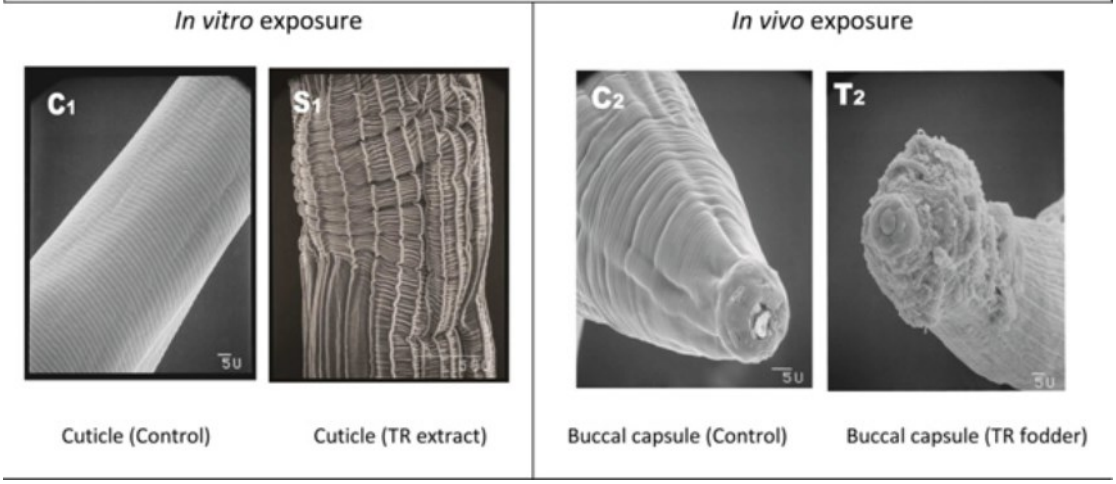
Dietary CT concentration and animal species are important factors to determine potential benefits or detrimental effects. Goats can tolerate higher dietary CT concentrations (~8 percent) than sheep (4 to 5 percent) without negative effects on intake. One explanation is that goats have salivary tannin-binding proteins, which minimizes the deleterious effects. However, due to the chemical diversity of CT, future studies should consider the source of CT due to variation in astringency (bitterness, pungency, and sourness that causes reduced palatability), protein precipitation, and antiparasitic effect varies.

Effects on parasites

In goats, fecal egg counts (FEC) were reduced by 50 percent with CT containing forages (4.5 to 5.5 percent CT) relative to non-CT-containing forages. When CT concentration increased above 5.5 percent CT, the responses became variable and when CT concentration decreased below 4.5 percent CT, the FEC response was inconsistent.

The CT disrupt the life cycle of worms by reducing egg viability and larval development. The CT forages have direct effects on worms such as reducing egg output and development of egg to larvae, inhibiting first and second larval stages, inhibiting third-stage larvae migration and larval exsheathment, and inhibiting the adult motility. The CT might also affect indirectly the nematode biology by improving the host's immune response .

SEM of *Haemonchus contortus* showing structural changes induced by tannin rich (TR) materials



Martínez-Ortíz-de-Montellano et al. (2013)

In vitro assays and in vivo studies, the scanning electron microscopy (SEM) observations revealed structural alterations in the worms after contact with CT-rich plants when compared to the control worms (i.e., longitudinal and transversal folds and thicker cuticular ridges, mate-

rial aggregates around the buccal capsule and/or vulva or anus). The main changes concerned the cuticle and the buccal area. The structural changes found in the worms exposed to CT-rich plants might affect their motility and nutrition with possible consequences on their reproduction.

Furthermore, CT could compete with nutrients and directly inhibit nutrient supply for larval growth of worms or indirectly decrease their metabolism through inhibition of oxidative phosphorylation, ultimately causing larval death.

Conclusion

The impact of condensed tannins on small ruminant performance depends on the concentration in the diet, bitterness of the feed, animals' species, animals' nutrient requirements, and other dietary components. There are potential benefits of incorporating condensed tannins into small ruminant diets, such as improved animal health, reduced need for deworming , and more sustainable farming practices.

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Sheep grazing sericea lespedeza Image by Joan Burke

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Condensed tannins disrupt the life cycle of worms by reducing egg viability and larval development.

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