Plant Tannins- Their Role in Forage Legume Quality

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ABSTRACT

Forage legumes, especially browse plants, are important in the maintenance and survival of ruminant animals. However many browse species contain high levels of polyphenolic compounds including tannins. The effects of tannins on the quality of forages are reviewed. These include reduction in palatability and intake of feeds, growth rate, digestion of fibre fractions and nitrogen utilization by animals.

INTRODUCTION

In the tropics and subtropics, forage consists mainly of grain and forage residue which is generally high in fibre and low in protein content. This results in reduced animal performance, particularly in the dry season. A great number of forage legumes, particularly the fodder trees, are available as supplement and are characterised by relatively high protein content digestibility as compared to grasses. Besides their favourable nutrient composition, these multipurpose trees have further positive properties; they increase the nutrient content of the soil, protect soil against erosion and are used as fuel, medicine and building materials. However, many fodder trees have high content (up to 50% in DM, (Reed et al, 1985)) of secondary ingredients particularly tannins which may bind the protein, thus rendering it unavailable to the animal and thereby having a negative effect on nutritional value and acceptance. This paper therefore looks at the effect of tannins on the quality of forages.

TANNINS

Tannins are complex polyphenolics found widely in the plant kingdom (Hagerman and Butler, 1978). They are found in leaves, twigs, flowers, fruits and tree bark. Tannins are usually subdivided into two major groups, the hydrolysable and condensed tannins (Fig 1).

The hydrolysable tannins: Hydrolysable tannins split into sugars and phenolic carboxylic acids in acid and alkaline conditions (White, 1957) and are further classified according to the products of hydrolysis into gallo tannins (gallic acid and glucose) and ellagic tannins (ellagic acid and glucose) (Mcleod, 1974). Two other categories, tara-gallo tannins (gallic and quinic acid plus glucose) and caffe - tannin (caffeic acid and quinic acid plus glucose) have also been suggested (Haslam, 1966). Hydrolysable tannins can be broken down to their hydrolysis upon heating with weak acids or enzymatically.

The condensed tannins: Condensed tannis are often referred to as proanthocyanidins because they produce red anthocyanidins when heated in acids (Haslam, 1982). Proanthocyanidins are phenylpropanoid polyphenols and are categorised by the type of monomer they contain: either Flavan - 3-ols or Flavan - 3-4 diols into catechin or lecoanthocyanidin (Horvath, 1981). Generally the high molecular weight condensed tannins (i.e >10 flavonol units) have limited solubility and extractability and hence may have little nutritional significance (Mehansho et al., 1987). Condensed tannins polymerise on heating in acids to the amorphous phlobaphenes. Besides hydrolysable and condensed tannins, a group called the beta tannins can be added (Swain, 1979; Horvath, 1981). Beta - tannins are protein precipitating compounds which are insoluble in water. They form very stable bonds with protein and they can have lower molecular weight than other tannins and still be effective.

Tannins bring about their antinutritional influences largely by precipitating or binding dietary proteins and digestive enzymes to form complexes which are not readily digestible. The precipitation can be the result of hydrogen bonding (Loomis and Battaile, 1966), covalent bonding (Swain, 1979), ionic bonding (Gustavson, 1956) or hydrophilic bonding (Oh et al., 1980). The interaction between tannins and protein is very specific (Hagermand and Butter, 1981). The ability of tannins to precipitate proteins depends on their molecular weight, water solubility, conformation and compatibility of binding sites. It also depends on the properties of the solvent especially its pH. Reed et al. (1985) showed that condensed tannins seem to be more important in forming complexes in feed than hydrolysable tannins.

FORAGE QUALITY

The quality of forages has some behavioural and physiological effects on ruminants. The effects of tannins on the quality of forages is manifested in the palatability of feeds, the growth rate, the digestion of fibre fractions and the utilization of nitrogen.

1. **Palatability and intake of feeds:** It has been found that tannins reduce the palatability and intake of feeds. The poor palatability generally associated with high tannin diets can be ascribed to its astringent property (Bate-Smith, 1973) or dry feeling in the mouth (Goldstein and Swain, 1963) which is a consequence of its ability to bind with the proteins of saliva and the mucosal membrane of the mouth during the mastication of food (Mehansho et al., 1987; Aletor, 1993). Tannins also negatively affect digestion by strongly inhibiting digestive enzymes and binding proline - rich protein in the saliva. Reed et al. (in press) in a study compared the intake of animals fed three browses high in polyphenolics (leaves of *Acacia cyanophylla, Acacia seyal* and fruits of *Acacia sieberiana*) with *Sesbania sesban* (low in polyphenolics) and three standard protein supplements (*Vicia dasycarps* and noug or urea) all of which were fed in combination with teff straw (*Eragrostis abyssinica*). They found that tannins reduce total feed intake which was attributed to the high content of insoluble pro-anthocyanidins (Tanner, 1988) (Table 1).

2. **Growth rate:** Diets high in tannin content have been found to reduce the growth rate of animals. This is due to reduction in feed intake caused by fibre and phenolic contents. It may also be due to the unavailability of nutrients, especially nitrogen, in the diet (Woodward and Reed, 1989).

3. **Digestion of fibre fractions:** Tannins have a negative effect on the digestion of fibre fraction in feeds. They reduce the cell wall digestibility by binding bacterial enzymes and forming indigestible complexes with cellwall carbohydrates (Barry and Manley, 1984; Barry et al., 1986; Reed, 1986). The formation of tannin protein complexes formed in the digestive tract and recovered as faecal lignin can lead to apparent negative digestibility of lignin as recorded by Reed (1988).

4. **Nitrogen utilization:** Tannins form complexes with protein and this leads to reduced digestibility of nitrogen. The consequences are reduced availability of crude protein to animals, increased faecal nitrogen excretion and lower rumen fermentation rate for the animals. Faecal nitrogen is composed of indigestible feed nitrogen, microbial nitrogen from the rumen and lower - tract and endogenous (metabolic) nitrogen secreted into the digestive tract but not incorporated into microbial nitrogen (Van Soest, 1982). Nitrogen in neutral-detergent fibre (NDF-N) may also include indigestible tannin - protein complexes (Reed, 1986). Higher total faecal nitrogen (caused by higher faecal NDF-N and which can be attributed to indigestible tannin-protein complexes) was observed for diets containing tanniferous feeds (Woodward, 1988; Woodward and Reed, 1989). The higher levels of faecal nitrogen may result from a higher production of rumen microbes as a consequence of greater recycling of urea from blood to rumen.

With high amounts of forage nitrogen bound, animals will not be able to achieve positive nitrogen balance and would eventually starve, whereas when the phenolic content of feed is low, fermentation will be so rapid that excess ammonia is excreted as urea in urine, thus representing a loss of nitrogen as well as of energy which is required for detoxification (Woodward and Reed, 1989). In cases where animals eat feed with moderate levels of proanthocyanidins, the higher faecal nitrogen loss was offset by lower urinary loss. The lower fermentation rate of nitrogen also helps improve the utilisation of fibrous crop residues which also ferment slowly. Paradoxically, there is ample evidence that subject to a certain dietary level, tannins may not always be antinutritional in ruminants. For example studies by Barry and Manley (1984); Barry et al. (1986) have shown that at regulated dietary levels (20-40g/kg diet dry matter) condensed tannins may have some beneficial effect in rumen protein metabolism, largely by protecting some proteins against microbial degradation in the rumen. However higher levels (e.g 76-90g/kg diet) are considered detrimental.

CONCLUSION

This study clearly indicates that browses with moderate levels of phenolic compounds are promising protein supplements for ruminant animals. The principal problem is the presence of tannins which could greatly reduce nitrogen availability and also reduce intake and palatability. The negative effect could be partially offset by lower urinary loss of nitrogen thereby allowing adequate animal performance. It also shows that ruminant animals could generally have a greater capacity for dietary tannins than the monogastrics.

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Table 1

Browse and roughage intakes aand growth rate recorded in three experiments with sheep

	Intake g/d			
Browse	Browse	Roughage*	Total	Growth
Acacia cyanophylla	170	318	488 -11	
Acacia sieberiana	195	269	464	20
Sesbania sesban	157	473	630	48
Acacia seyal	193	285	478	21

*Roughages used include maize stover, grass hay and teff straw.

Source Reed et al (in press)

Figure 1

Chemical parent substances and possible structure of hydrolyzable and condensed tannins