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Role of the Tannins –Rich Feeds for Ruminants

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ABSTRACT

Tannins are one of antinutritional factors that are divided into hydrolysable and condensed tannins. The condensed tannins (CT) are the most wide spread and typical of the plant sources. Some of trees and shrub foliage and agro industrial –by products are considered as tannins- rich feeds. In the plant sources, CT present in a free form, once the cattle ingest these plants, tannins combine with the dietary nutrients, particularly, protein forming a tannin-protein complex. This complex couldn't be degraded in the rumen, it is not absorbed into the blood stream, but it is excreted in the faeces without any benefit for the animal. Also, tannins-rich feeds inhibit the cellulytic bacteria in the rumen via the dysfunction of the bacterial cell wall and decreasing the activity of the extracellular enzymes. Actually, both milk fat and milk protein contents would be decreased. The detanninification for tannins-rich feeds fed to dairy cattle must be carried out. Their treating by polyethylene glycol is the best method. Some of tannins benefits are reducing methane emission, increase the utilization of ruminal high degradable protein, modulate the milk fatty acids, reduce bloat, and control the gastrointestinal parasites. Because tannins have some benefits for ruminants, it is no longer appropriate to refer to them as anti nutritional factors.
KEY WORDS: condensed tannins, tannins effects, tannins inactivation, ruminants.

INTRODUCTION

What are tannins?

Tannins are a large and diverse group of plant phenolics that range from simple C_7- C_9 phenolic acids such as gallic and coumaric acids, through the C_{15} flavanoids to the highly- polymerized inert lignin. Tannins are divided into the hydrolysable and the condensed tannins. The hydrolysable tannins contain a carbohydrate moiety and are easily hydrolyzed either chemically or by enzymes. Tannic acid is a well known example that contains 8-10 mole gallic acid / mole glucose. The condensed tannins are the most wide spread and typical of the plant tannins, they do not have a carbohydrate core, and consist of oligomers of the flavan-3-ols. Procyanidins is an example of the condensed tannins. The phenolic hydroxyl groups can form the stable complexes primarily with proteins and to a lesser extent with other polymers such as cellulose, hemicellulose and pectine. The different proteins similarly have different affinities for tannins and react most effectively at pH values close to their isoelectric points. In traditional tanning the collagen chains of hides are crosslinked by tannins to give a durable leather resistant to microbial attack. [1,2]

Tannins-rich plants

Condensed tannins are widely distributed throughout the plant kingdom, especially among trees shrub and herbaceous leguminous plants. There are some genera known as tannins-rich plants such as Leguminaceae (*Lotus*, *Medicago*, *Trifolium*), Poaceae (*Lolium*, *Sorghum*, *Triticum*), Fabaceae (*Acacia salinga*, *Acacia nilotica*), and Tamaricaceae (*Tamarix aphylla*). Tannins can be found in the cell walls and vacuoles of stem, bark, leaf, flower and seed cells of many dicotyledonous plants. Generally tannins are found in the plant part that is more likely to be eaten by herbivores. The concentration of the plant phenolic compounds, including tannins, is high under conditions of low soil fertility, drought, and high temperature. So, the plants grown in the tropical or arid areas are rich in these phenolic compounds. The distribution of the different forms of condensed tannins (free, protein-bound CT, fiber-bound CT) can be varied by the total content of CT, the plant age, and the environmental condition. The comparison among the CT contents of the tannins –rich plants is difficult. That is because; the methods or standards used for CT quantification among laboratories are different [3,4]

Feeding trials on ruminants with Lotus species have recommended that diets containing CT at less than 5% (on DM basis) are beneficial. This recommendation may not be applicable to other tannins-containing feeds. As an

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explanation, one plant (carob) with 2.5% CT is harmful for lamp but other plant (sainfoin) with 8% CT is beneficial for sheep [3]

Are ruminants adapted to tannins-rich feeds?
In the desert or in the forest (wild life), ruminants are adapted to rich feeds by secreting certain substances (such as proline –rich proteins (PRPs)) from the salivary glands as a defense strategy against condensed tannins (CT). These substances have a high affinity for tannins forming soluble tannin- protein complexes degraded by the ruminal microorganisms. But, in livestock, ruminants do not produce the salivary PRPs and their ruminal microorganisms could not degrade the CT as they degrade the hydrolysable tannins (if there) through methylation of phenolic hydroxyl groups. Their rumen microbes might tolerate the CT via the secreting the polysaccharides that have affinity for binding to CT. As general, goats are more tolerance to CT than sheep and cows [5]

Condensed tannin assimilation
First of the all, unpleasant astringency is due to possible reaction of salivary proteins with plant tannins ingested by the ruminant animal. If the leaf tissue contains a large amount of soluble proteins that react rapidly with the tannins in the mouth, unpleasant astringency due to possible reaction of salivary proteins with the tannins probably does not occur [1]
The plant protein-tannins complexes escape the rumen fermentation (pH5-7) to be degraded into the two fractions; the condensed tannins (CT) and the proteins. The protein portion is digested by the gastric enzymes in the abomasums (pH 2-5) and is absorbed by pancreatic secretion in the small intestine (pH 8-9). But the CT is not degraded or even absorbed but only it is excreted in the faeces[1]

Effects of tannins-rich feeds on ruminants
It is of interest to report that the improved or impaired effects of the condensed tannins on the ruminants' performance depend on many factors such as: the CT structure and its level in the plant, the diet composition, the dietary protein degradability and its content, and the physiological stage of the ruminant.
It is notable to report that protein –tannins complex acts as a detrimental factor on the protein degradability in the rumen, only if, the dietary protein type is insoluble and its content is low. This complex protects the dietary protein from the microbial degradation. Thus the synthesis of the microbial protein decreases in the rumen. Also, tannins inhibit the activity of the cellulytic bacteria resulting in decreasing the digestibility of the fiber and the organic matter in the rumen. So, not only the parameters of the runinal fluid are affected by the tannins-rich feeds, but also the parameters of the whole digestive tract are affected.
Condensed tannins usually reduce ruminal digestion of plant protein, reduce rumen ammonia concentration, reduce protein solubility, and increase the proportion of plant protein reaching the intestine. Also, CT inhibit some rumen bacteria, reduce nitrogen digestibility; increase faecal nitrogen concentration, reduce urinary nitrogen output, and slow or reduce the rate of amino absorption from the intestine. Moreover, reduce dietary DM able to be digested, and lower the proportion of dietary energy loss to methane [6]
Some workers[7] have evaluated the effects of tannins-rich ground pine bark (PB) as a partial feed replacement on feed intake, dietary apparent digestibility, nitrogen balance, and mineral retention in meat goat. Their results suggest that tannin-containing PB has negative impact on fiber, lignin, and protein digestibility, but positively impacted on N-balance in Kiko cross goat
Some parameters of rumen fluid of the control diet, and the control diet supplemented with *Vaccinium vitis idaea* (VVI) extract (a source of condensed tannins) incubated in RUSITEC systems have been reported[8] as follows in Table 1.

Table 1 Some parameters of rumen fluid of the control diet, and the control diet with *Vaccinium vitis idaea* (VVI*) extract.

Item	Control diet	Control with 4.5 g of VVI/ kg DM
pH	6.84	6.83
NH3, mM	11.3	11,1
Methane , mM	3.14	2.98
Total VFA, mM	63.7	62.3
Total bacteria, x108 /ml	6.30a	5.18^b
Total protozoa, x 103 ml	2.36	2.10
In vitro CP digestibility, g/kg	696	698

Each kg dry matter of VVI contained 37 g of tannins.

Also, it was found that using supplements of a mixture of *Vaccinium vitis idaea* (VVI) extract and fish-soybean oils blend modulated the unsaturated fatty acid proportion in blood, without affecting the dairy cows' blood parameters that were all within the normal ranges [9] .

It is of importance to point out the study of Grainger, et al., (2009)[10] who have dosed sixty lactating cows twice daily with 0, 163, 328 g of CT extract d^{-1} for 5wk. The cows were grazed grass pasture and were supplemented with grains. The CT was extracted from *Acacia mearnsii* . The daily dry matter intake (DMI) was 18 kg /day, and at this intake, the levels of CT represented to 0, 0.9, 1.8 % of DMI, respectively. The cows were dosed with CT extract, rather than adding it to the grain supplement, to ensure that they received the correct amount. The authors have noticed that these treatments resulted in a beneficial effect on methane emission but resulted in a detrimental effect on the milk production. It was found that low and high levels of the CT extract reduced ($p\leq$ o.o5) methane emissions by 14, and 29%, respectively. However, milk production was reduced by the CT ($p\leq0.05$), especially at the high dose level. Milk yield was 33.0, 31.8, 29.8 kg/ h/day for the cows dosed by 0, 163, 328 g of CT extract, respectively. Only, the high level of CT extract declined both milk fat and protein yields by 19, and7%, respectively. Neither lactose content nor protein content was affected by CT.

Feeding up to 2% of the dietary DM as quebracho tannin extract (The measured condensed tannin content of the extract was 91%) failed to reduce enteric methane emissions from growing cattle, although the protein-binding effect of the quebracho tannin extract was evident [11]. Bhatta, et al., (2009)[12] found that tannins suppress methanogenesis by directly reducing methanogenic populations in the rumen or indirectly by reducing the protozoal population (thereby reducing symbiotically associated methanogens). Methanogens are a distinct group of organisms that form a normal component of the rumen microbial ecosystem. Hydrogen (H_2) and carbon dioxide CO_2 are the principal substrates used by rumen methanogens to produce the methane (CH_4 .(The finding that CT can reduce ruminant CH_4 emissions has important environmental implications.

Moreover, CT may reduce bloat by inhibiting growth of microorganisms that produce a dextran slime that increases the viscosity of ruminal fluid causing frothy feedlot bloat. Or, CT may precipitate the stable forage protein foam. Bloat occurs in ruminants grazed leguminous forages containing high level of soluble proteins. The produced gases during fermentation cannot be released but are trapped in foam[7] .

CT-containing forages may have the ability to break the life cycle of sheep nematodes (such as: *Trichostrongelus colubriformis*) and reduce the contamination of pasture with infective larvae. This may reduce dependence on anthelmintic drugs as the main method of controlling internal parasites in grazing ruminants.

In our opinion, condensed tannins might be used as a supplement for diets of low fertility cows or for diets of cows exposed to heat stress. This suggestion may be explained on the basis of the findings reported by some workers[13,14] who have illustrated the beneficial effects of the high content of the ruminal un degradable protein (RUP) for cows. The former workers have found increasing in the conception rate of cows fed low level of protein with high level of the RUP. and the latter workers have found that reduced the ruminal degradable protein (RDP) and RUP increases the use of amino acids (AA) to maintain milk protein synthesis and limit AA catabolism in cows exposed to warm climates.

In general, the study of the nutritional effects of tannins is complicated because of their great structural diversity, and this difficulty has led to considerable confusion in the literature aimed at determining their beneficial or detrimental effects on ruminants [15].

Methods to inactivate or remove tannins

As it is mentioned previously, ruminants fed tannins-rich feeds are not adapted to high levels of the condensed tannins (CT). So, various studies have been conducted to inactivate or remove the CT. Makkar, 2003[5], has illustrated the methods by that CT were inactivated or removed as follows in Table 2:

Table 2 Methods to inactivate or to remove the condensed tannins (CT) from tannins- rich feeds.

Method		Mode of action
1-	Alkalies: unrefined materials(10% solution of pine or oak wood ash) or refined materials(Na OH (0.05 M), $NaCO_3$ (0.05M), $NaHCO_3$ (0.1M))	Oxidation of phenolics by air oxgen at higher pH resulting in tannins reduction
2-	Aqueous organic solvents (acetone 30%, methanol 50%, ethanol 40%)	extract the tannins that are recovered for the leather tanning
3-	Ferrous sulphate (0.015 M)	acts as a tannins- complex agent
4-	Mechanical methods (leaves are chopped and storage for about 5-days before feeding	chopping increase the phenol oxidases availability to tannins and storage helps to polymerize the CT to higher inert polymer
5-	Biodegradation of tannins: incubation of tannins-rich feeds with white rote fungi (WRF) for only 10 days, if more than this period, cell soluble compounds are degraded	not only the CT are degraded by the enzymes of WRF but also, lignin, another phenol compound is degraded
6-	Tannins-complex agent such as: polyvinlpyrrolidone (PVPs), and polyethyleneglycol (PEG)	their affinity for binding to tannins is higher than that of proteins, the affinity of PEG is higher than that of PVP

The PEG is suggested to be the best. It could be applied in both farm and industry. It could be sprayed on the foliage in the farm or incorporated in the pelted composed of tannins- rich by-products in the industry.

Conclusion

It could be concluded that condensed tannins in feedstuffs may act as a detrimental or as a beneficial factor for ruminants. Their role is affected by different factors that may be related to the plant and may be related to the animal. The detanninification approaches, particularly inactivation of CT from tannins-rich forest or agro- industrial by products, could overcome the problems of the feed shortage. Because tannins have some benefits for ruminants, it is no longer appropriate to refer to them as anti nutritional factor.

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