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Review

An overview of tannins rich plants as alternative supplementation on ruminant animals: A Review

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Sheep, cattle and goats are domestic ruminants of significant economic interest in the Southern Africa region. Their nutrition depended on grasses and browse plant species, some of these plants are reported to possess secondary compounds known as tannins. Also, these compounds are known to have properties that are both beneficial and disadvantageous towards animal production. Rural farmers tend to experience severe feed shortage during winter. Therefore, proper use of trees and shrubs (containing tannins) as supplementary feed by rural farmers will be beneficial. Rural farmers cannot afford to purchase commercial supplementary feeds. Hence, there is a need for alternative supplementary feeding. Moreover, use of tannin rich plants by rural farmers will reduce gastrointestinal, and in turn, it will enhance ruminant animal production on the rural areas. This review aims to find out how beneficial tannins rich plants to ruminant animal production.

Keywords: Tannins; ruminant; animal production; rural farmers.

INTRODUCTION

Environmental changes demonstrated by a progressive growth in woody plant invasion and/or bush encroachment, are the common causes of herbaceous vegetation loss in many rangelands and are accountable for a decline in range condition (Angassa, 2005). This results on the low forage availability and cause a steady decline in livestock productivity on rural farmers. Therefore, livestock production systems globally rely mostly 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 (FAO, 2008). Therefore, browse plants are essential in animal feed programs because they are better supplementary feed than most pasture vegetation and maintain their nutrients into dry season when feed resources are exhausted (FAO, 2008). Browse and shrubs may supply important protein source to support ruminant production. These browse plants and shrubs are usually rich in plant secondary compounds commonly known as tannins (Makkar, 2003; Lee et al., 2010; Norton, 2000). Tannins are naturally occurring plant secondary compounds that are present in many species commonly consumed by ruminants (Makkar, 2003). Certain plant species such as *Acacia spp*, *Sericea lespedeza* as well as pasture species such as *Lotus spp* are reported to contain tannins (Ahmed and Ignatius, 2010). Predominantly, *Acacia karroo* is one of the most common and abundant indigenous tree legume species that have presence of tannins in Southern Africa (Mapiye et al., 2011).Tannins are tentatively classified into two groups such as hydrolysable and condensed tannins. They are considered to have both adverse and beneficial effects depending on their concentration and nature besides other factors such as animal species, physiological state of the animal and composition of the diet (Amlan and Jyotisna, 2010 a).

Anti-nutritional effect and toxicity of tannins in the rumen digestion became major obstacle for rural farmers to certainly utilize their resources such as available trees and shrubs efficiently. Nevertheless, the apparent digestion of soluble carbohydrates appears to be unaffected by tannins and in concise, the effects of tannins on ruminal bacteria are reported to be dependent upon the species of microorganism and type or source of tannin (Wallace, 2004). Moreover, potential benefits of tannins have been neglected for long time (Alonso-Diaza et al., 2010).

According to Garry (2008), the benefits of forages containing condensed tannins for productivity of livestock carrying an intestinal parasite burden is that the gastro-internal parasite will be reduced. Thus, condensed tannins always increase plant protein flow to the intestine in such way that it increases absorption of essential amino acid by 60%, and reduce net absorption of ammonia from the rumen (Waghorn, 1996). According to Mapiye et al. (2011), steers fed *Acacia Karoo* leaves had a good performance in terms of body condition score, average daily gain, slaughter weight, cold and warm carcass weights than those were not consuming *Acacia Karoo*. In addition, manipulation of the protein and energy content of the diet (Dawson et al., 2011) and control gastrointestinal parasite via condensed tannins will display a desirable effects of tannins in the ruminant performance (Krueger et al., 2010). However, this review aims to find out how beneficial tannins rich plants to ruminant animal production.

Supplementation of ruminant animals in rural communal farms

Inadequate feed supply is a major constraint of ruminant animal production in Africa. This results on rural famers to differ from their supplementary approach to such extent supplementation with crop and crop residues became common phenomena among rural areas in Eastern Cape, South Africa (Beyene et al., 2013). Gxasheka (2013) also reported maize stock as most commonly feed supplement used during time of feed shortage (winter). Like in many rural areas of South Africa, the available grazing is not generally sufficient to meet the feed requirements of ruminant animals during dry periods (Matlebyane *et al.,* 2010).

However, Belachew et al. (2013) indicated trees and shrubs as cheap and affordable supplements for ruminant animals which used by rural farmers in several regions of the world. Therefore, use of various trees and shrubs seemed to be the potential way of increasing the quality and availability of livestock feeds. In Ethiopia, it has been indicated that smallholder farmers are more relying on various potential trees and shrubs that can provide a green feed throughout the year which may be particularly useful as feed supplements to the typical low-quality diets (Yisehak et al., 2012; Yisehak and Belay, 2011). Likewise, more studies has been done on acacia species (*Acacia karroo, Acacia nilotica, Acacia tortilis, Acacia galpinii, Acacia sieberiana, Acacia hebeclada and Acacia rhemniana*) as supplementary feed in ruminant animal production especially *Acacia karroo* in South Africa (Ngambu et al., 2012; Marume,2010; Mapiye et al., 2009; Mokoboki et al., 2005).

Chepape et al. (2011) further stated that all the acacia species had crude protein levels above 100 g/kg dry matter are adequate to support the requirements of cattle, sheep and goats at low to medium production levels. This is further support by study of Ngambu et al. (2013) who reported that *Acacia karroo* significantly improved growth performance of goats. Moreover, supplementation with dietary protein particularly from browse trees in the diet of ruminants produces carcasses of good quality (Arsenos et al*.,* 2009; Mapiye et al*.,* 2009). In general, most of palatable tree and shrubs are naturally growing plants and also easily accessed from rural areas where the ruminant animals are freely grazed. This is an important opportunity that need to be implemented with a good management approach in rural areas to efficiently utilize natural resources without deplete them. However, anti-nutritional factors, such as tannins, are known to be a significant component of many browse tree and shrubs species (Mlambo et al., 2008).

Tannin effects on ruminants

The concept of tannins being anti-nutritional, harmful and toxic to ruminants is common (Mueller-Harvey, 2006).The amount of tannins that plants contain varies broadly and mostly unpredictably, and their effects on animals range from beneficial to toxicity and death (Makkar, 2003). Ammara et al. (2011) indicated that when increase concentrations of tannins greater than 5% tannins adversely affect intake and can be toxic, then some adaptation to these compounds can be attained through a regular ingestion of tannins. Tannins can suppress intake by reducing digestibility or causing illness due to the fact that tannins may bind to cell walls and cell soluble (Reed, 1995). Detrimental effects of tannins are commonly associated with reduction in the concentration of ammonia and volatile fatty acids in the rumen fluids which can automatically leads to the deficiency of nitrogen and energy (Silanikove et al., 2001).

The toxic or anti-nutritional effects tend to occur in times of stress when a very large proportion of the diet is tanniniferous (Makkar, 2003). Furthermore, the anti-nutritive effects of tannins are also linked with their ability to combine with dietary protein, polymers such as

cellulose, hemicelluloses, pectin and minerals thus retarding their digestion and tannins can also impair the digestive process by compositing with secreted enzymes and endogenous protein (McSweeney et al., 2001). The direct effects of condensed tannin might be mediated through condensed tannin-nematode interactions affecting physiological functions of gastrointestinal parasites (Nguyen et al., 2005). Tannins might be associated with adverse effects as anti-nutritional factor, causing lower dry matter intake and reduced digestion of protein and fibre (James, 2011). The effects depend on tannin concentration in the plant as well as other factors such as type of tannin, animal species, physiological status and diet composition (De Oliveira et al., 2007). The effects of condensed tannin on feeding value can be regarded as the sum of the effects on voluntary feed intake, on the digestive process and on the metabolism of absorbed nutrients (Georg, 2008). Tannins tend to affect the nutritive value of ruminant feeds by reducing voluntary feed intake and digestibility (Barry and McNabb, 1999). Furthermore, high levels of tannins in leaves restrict the nutrient utilization and nutrient digestibility and N retention (Kamalak, 2006). In addition, condensed tannins may bind to digestive enzymes, thus reducing their activity, and also have an astringent taste (Christopher, 2011).

Tannins play a significant role in the nutrition of animals, causing either adverse or beneficial effects on nutrient utilization, health and production (Schofield et al., 2001). Soluble plant proteins released in the rumen stabilise foam that can entrap gas bubbles and cause bloat. Basically, it is involved in bloat prevention and another possible effect of tannins is related to the stimulation of salivary flow in animals (Nguyena et al., 2005). Tannins feeds can also produce beneficial effects in ruminants such as improved amino acid absorption and anthelmintic effects (Min et al., 2003). The major benefit of tannins in feed is protection of plant protein from digestion in the rumen, making it available for digestion and utilization in the abomasum and small intestine (Waghorn, 1990). Tannins bind with proteins at common rumen pH of 5.5 to 7.0 thereby slowing down microbial degradation of proteins (Makkar, 2003). The tannin protein complexes are dissociated in the acidic pH of pH 2.5 to 3.5 in the abomasum. Therefore, in the situation of the distal small intestine at the pH of 7.5 proteins is released for digestion and absorption (Alipour and Rouzbehan, 2010).

Tannins effects on microbial population

The effects of tannins on ruminal bacteria are reported to be dependent upon the species of microorganism and type or source of tannin. The antimicrobial activities of tannins are ascribed to the interactions of tannins with the extracellular enzymes secreted and the cell wall of bacteria causing morphological changes of the cell wall, tannin-induced membrane disruption, and direct action on microbial metabolism, deprivation of substrates for microbial growth and chelation of cations by tannins reducing its availability to microbes (Chung et al., 1998).

James (2011) indicated that there is a decrease in protein and fiber breakdown in the rumen, with lower production of ruminal ammonia but no change in bacterial protein outflow. Specific populations of proteolytic rumen bacteria changed with the addition of forage condensed tannins and the addition of condensed tannins to the rumen environment fosters a decrease in relative numbers of bacteria such as *Clostridium proteoclasticum* and *Butyrivibrio fibrisolven* (Min et al., 2002).

Microbes are inhibited by tannins which lead to reduced fiber digestion in ruminants and to decreased infection of plants by plants pathogens (Schofield et al., 2001). Amlan and Jyotisna (2010 b), mention that low molecular weight tannins could be a more effective inhibitor of microbes including methanogens compared with high molecular weight tannins because low molecular weight tannins could form strong binding with microbial enzymes. Addition of tannins results in significantly lowering of microbial respiration (Mutabaruka et al., 2007).

Adaptation of ruminants to tannins

Adaptation of the animal on the tannins is largely relying on the breed the way it respond to tannins rich- plants (Papanastasis et al.,2008). Ruminants exposed to tannins rich diets for a long time are able to develop diverse adaptation mechanisms to overcome deleterious effects of these secondary compounds. Therefore, several animal species such as rats, mice and deer are adapted to high tannin diets by producing unique salivary proline-rich proteins (Ben Salem et al., 2005). Cattle and sheep predominantly consume grass diets virtually free of tannins; they would not need to produce tannin-binding salivary proteins but in the case of cattle, it has not been observed an increase in the production of proline-rich proteins in response to tannin ingestion (Lamy et al., 2011).

Ruminal adaptation to condensed tannins is likely to be in the form of defence mechanisms, such as extracellular secretions that reduce the effect of tannins on microbes, rather than tannin degradation (Mlambo et al., 2007). Adaptation time had a clear effect on feed intake, especially in the first 6 days in other words the effect of the adaptation time on diet digestibility was noticeable between 6 and 24 days (Ben Salem et al.,

2005). One significant adaptation of ruminal metabolism to counter anti-nutritive effects of forage tannins may involve the microbial degradation of these compounds (McSweeney et al., 2001).

Anthelmintic effect of tannin rich plants

Helminthiosis is one of the chief constraints in small ruminant animal production. Thus, proanthocyanidin containing forages have been reported to minimize the detrimental effects including diarrhoea due to heavy load of internal parasites (Iqbal et al., 2007). Numerous tannin-rich plants can have direct anthelmintic effects against the main nematode of small stock and seem to affect the biological processes of nematodes depending on where and how the tannins bind with various nematode structures (Alonso-Diaz et al., 2011).

In South Eastern of U.S, Miller et al. (2011) pointed out that high tannin forage has been the centre of alternative suppression of gastro-internal nematode in small ruminants, even though high levels of tannins can reduce feed intake and disrupt digestion. Tolerance of goats toward the bitterness of secondary plant compounds can play an anthelmintic role and make goats more suitable for high-forage organic production systems than other ruminant species (Christopher, 2011). Tyasi and Tyasi (2015) also mentioned that tannin rich plants have a potential to remove gastrointestinal parasites on goats of rural famers in Eastern Cape, South Africa.

Tannins rich plants also have a potential to reduce a produced egg number, rate of larval development, and mobility of larvae of gastrointestinal nematodes in small ruminants (James, 2011; Krimpen van et al., 2010). In vivo studies also have shown that the anthelmintic effect related with the consumption of tannins rich plants vary depending on the parasitic species or the parasitic stages (Martinez-Ortiz-de-Montellano et al., 2010).

Effect of tannins in the intestinal absorption

A unique chemical property of tannins have their affinity to bind to feed proteins and thereby reduce excessive breakdown of protein in rumen and increase availability of high quality protein for absorption in the lower gut of ruminants (Iqbal et al., 2007; Getachewa et al., 2008). Tannins increase the flux of essential amino acids to small intestine. In the lactating animals, low concentrations of condensed tannins increases the apparent absorption of essential amino acids in the intestines and increase milk secretion without affecting intake, thus improving the efficiency of feed conversion (Barry and McNabb, 1999; Norton, 2000). However, efficiency of essential amino acids absorption significantly decreased at high condensed tannin concentrations (Norton, 2000). The modest concentrations of tannin increases protein digestion in the abomasums and small intestine, and lead to greater subsequent absorption of amino acids, without adversely affecting feed consumption or digestion (Min et al., 2003). Tannins do not reduce microbial protein flow to the small intestines; they may be advantageous by protecting dietary protein from digestion in the rumen and thus increasing total supply of protein for absorption (McSweeney et al ., 2001).

Effect of tannins on ruminant performance

Condensed tannins and hydrolysable tannins supplementation at low levels does not have detrimental effects on animal performance or other economically important traits (Krueger et al., 2010). Since, no detrimental effect was observed on animal performance, attention will need to be paid to inclusion ratios so as to avoid lowered dry matter intake and subsequent animal performance (Theodoridou et al., 2010).

Papanastasis et al. (2008) indicated that performance of small ruminants fed trees and shrubs depends on animal species and breed as well as plant species. Ngambu et al. (2013) also reported that supplementation of goats with tanniniferous browse plant species such as *A.karroo* influence the growth performance of the goats. Furthermore, even within breeds, the response of animals to tannins could be influenced by their experience or degree of adaptation to a particular ecological niche (Provenza et al., 2003). Animals browsing/grazing in a vegetation rich in tannins might develop diverse mechanisms to attenuate the adverse effects of these plants and increase their intake (Pablo et al., 2011).

Alonso-Diaza et al. (2010) mention that ecological theory on other side predicts that specialist mammalian herbivores consume greater quantities of tannins then loose less body mass, experience fewer signs of toxicity and maintain a more positive energy balance on their preferred plant. Benchaar et al. (2008) also noticed that addition of tannins to the diet resulted on lack of effects on dry matter intake and milk production. Therefore, action of condensed tannins increase lambing percentage through increasing with no effect on ewes ovulating and ewes mated (Min et al., 2003).

In addition, tannins have the potential to increase sustainable ruminant production from grazed forages due to beneficial effects of condensed tannins on protein digestion and animal health, thereby increasing the efficiency of animal production (Miller et al., 2011). Performance of sheep and goats decreased due to

consumption of diets rich in these anti-nutritional factors of tannins (Ben Salem et al., 2005).

CONCLUSION AND RECOMMENDATION

Tannins rich plants have a potential to improve absorption of essential amino acid and also controlling gastro-internal parasites. Moreover, these plants can also be used to mitigate feed shortage during winter since rural farmer tend to have less potential to buy supplementary feeds. Therefore, this will also improve use of local resources for animal nutrition such as fodder trees and shrubs. Supplementing with tannins rich plants can be practically implemented by rural famers and these plants are easily accessible. Nevertheless, these tannins rich plants also have some harmful effects such as tannin concentration greater than 5% adversely affects feed intake and can be toxic. Therefore, tannins rich plants should be utilized in moderate amounts in order to improve ruminant animal performance. In addition, it is imperative for local extension officers to advice rural farmers about the use of tannins rich plants include their benefits and side effect on ruminant animal production. Nevertheless, studies on tannin rich plant as supplements to meet nutritional requirements of ruminant animal production are required to address the growing for local supplementary feeds.

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