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Condensed tannin and integrated parasite management for livestock

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Abstract
Animal husbandry is root base of rural economy. It plays an important role in upliftment of the economic status of rural and urban people. Livestock production depends on health of the livestock and any compromise on health ground will shatter the hope of livestock sector. Gastrointestinal (GI) parasitic worm infections have been found widely in tropics, and may cause serious clinical disease, welfare problems and loss in production in farm animals. Management and medication have an important influence on parasite concentration and productivity in small ruminants. Traditionally, chemoprophylaxis has been used as the main strategy to control GI parasitism in ruminants. However, frequent use of anthemintic drugs has led to widespread development of resistant strains. Use of phyto- chemicals is becoming preferable and may offer better control than anthelmintic to treat parasites. Consumption of condensed tannin containing plants may affect GI nematode numbers and animal performance in a number of ways. CT also may react directly by interfering with parasite egg hatching and development to infective stage larvae. Indirect effects on resistance and resilience could be mediated by changes in the supply of digested protein.

Keywords: gastrointestinal endoparasite, condensed tannin, drug resistance

Introduction
Livestock production depends on health of the livestock and any compromise on health ground will shatter the hope of livestock sector. The disease occurrence plays major role in reducing the livestock production. Gastrointestinal (GI) parasites or nematodes have been found widely in the tropics, and result in poor performance of ruminants. Parasitic worm infections can cause serious clinical diseases, welfare problems and loss in production from farm animals. As animal production has become more intensive, the threat of parasitic disease has increased. Infestation with internal parasites causes significant production losses, ranging from 13 to 33% in grazing ruminants, which typically have reduced immunity to nematode parasites (Stuedemann *et al*., 2005) [1]. In this respect, avoidance of re-infestation is more cost effective and biologically sustainable than use of antihelmintics. Drug resistance has become an important issue in small ruminant husbandry, when anthelmintic are applied at high levels and increasing frequency and inappropriate doses (Pandey *et al*., 2001) [2]. Over the last few years, the move towards organic farming systems has increased the stress for alternatives to chemoprophylaxis. Improving host resilience and/ or resistance to infection through management practices, which involve manipulation of nutrition, can be one of the components of integrated approach.

Metabolic consequences of parasitism
In parasitised ruminant's protein and other nutrients are diverted from productive processes such as skeletal growth and muscle deposition into responses essential for maintenance of homoeostasis such as plasma and blood protein synthesis, mucus production, Repair of GI tract mucosal integrity and maintenance of host defences. The result of this partitioning of nutrients, particularly protein, is a reduction in soft tissue deposition, skeletal growth, and milk and wool production. As per an estimate, the magnitude of this response would involve synthesis of an additional 50 g protein per day in a parasitised sheep (Coop and Kyriazakis, 1999) [3].

Nutrition and parasitism
The question now arises as to whether one can manipulate nutrition to the advantage of the host by increasing the supply of protein to assist the repair of the GI tract and provide an effective immune response. As considered above, although the GI tract may be locally damaged there appears to be little effect on protein digestion and absorption per se and therefore it may be beneficial to provide additional protein at the duodenum.

This could be achieved by increasing overall feed intake or by increasing the proportion of rumen undegradable protein in the diet. However, the mechanisms of appetite depression are not known, manipulation of feed intake is currently not possible.

Effect of nutrition on host resilience

Improved nutrition would always lead to an increase in host resilience, provided that the host continues to be offered access to a scarce food resource. The effect of improved nutrition will be more dramatic in infections of young, naive hosts, which result in substantial pathophysiological changes and damage or loss of host tissue (Holmes, 1993) [4]. Many studies have, in fact, shown that increased protein intake results in a reduction in the extent of pathophysiological consequences in terms of blood loss and hypoalbuminaemia. The resilience of the lambs to infection was maintained by the protein but not by the energy supplementation. The above suggestions are in good agreement with improvements reported in the literature on live weight gain and performance of parasitised hosts on improved planes of nutrition mainly in the form of increase in protein intake. Further, the responses to supplementation are particularly effective with bypass protein. The fact that parasitised sheep and goats, when given the choice, also select a diet of higher nutrient content than non-parasitised sheep, which also allows them to improve their resilience (Aumont *et al.*, 1984) [5].

Sustainable management of endoparasites

Traditionally, chemoprophylaxis has been used as the main strategy to control GI parasitism in ruminants. However, frequent use of anthemintic drugs has led to widespread development of resistant strains. This coupled with the increase public concern over drug residues in meat and milk products, and the move towards organic farming systems over the last few years, have increased the demands for alternatives to chemoprophylaxis. The potential alternative methods include use of tanniferous plants with anthelmintic properties, strategic supplementation of nutrient (Athanasiadou *et al.*, 2000) [6] and grazing management, as a strategy to reduce pasture parasite density.

1. Parasite management through strategic supplementation

Nutritional management can play an important role in reducing the dependency on anthelmintics. In fact, the signs of parasitism are often used as a symptom of poor nutrition. Adult ruminants express acquired immunity to *Gl* parasites due to continuous exposure to these parasites under normal grazing conditions. This immunity is usually highly effective; majority of the incoming larvae are either rapidly rejected or their development is retarded. Acquired immunity usually breaks down around parturition, resulting in an increased nematode worm burden in the dam and hence enhanced egg deposition on pasture, leading ultimately to infect the grazing young ones. Overcoming this periparturient breakdown of immunity through nutritional management may reduce the intake of infected larvae by the young ones and potentially increase their growth performance. Studies have demonstrated that increased supply of metabolizable protein during late pregnancy was effective in reducing the faecal egg count (Houdijk *et al.*, 2000) [7]. Strategic supplementation of fishmeal during the feeding management of reproducing ewes also proved to prevent the breakdown of immunity (Donaldson *et al.*, 1997) [8]. Alternatively, feeding of high quality diets offered *ad libitum* may also overcome the nutrient scarcity through an increased food intake.

2. Use of tanniferous tree leaves for the management of endoparasites

The potential alternative methods include use of tanniferous plants with anthelmintic properties in the diet of ruminants. Tropical tree leaves are very good source of condensed tannins (CT) (Dey *et al*. 2006) [9]. CT can improve animal health by overcoming effects of gastrointestinal parasites (Aerts *et al.*, 1999) [10]. Condensed tannins (CT) protect the protein from microbial hydrolysis and deamination in the rumen and increase the proportion of dietary amino acids available for post-ruminal absorption. Anthelmintic properties of CT in ruminants are associated with improved nutrient supply to the lower gastrointestinal (GI) tract. Protein-CT complex formation also reduces rumen gas formation and prevents production of a stable foam in the rumen, alleviating bloat in ruminants consuming protein-rich diet.

a) Direct effect of CT on GI parasites

CT can reduce GI parasites directly by reducing nematode female fecundity and egg hatchability (Nguyen *et al*., 2005[11]; Pathak.,2010) [12] and killing of adult worms due to the ability of CT to interact with proteins of the cuticle, oral cavity, esophagus, cloaca and vulva of nematodes, changing their chemical and physical properties (Thompson and Geary, 1995)[13]. The CT could form a complex with nutrients and inhibit nutrients availability for larval growth or decrease GI parasites metabolism directly through inhibition of oxidative phosphorylation (Scalbert, 1991) [14], causing larval death (Athanasiadou et al. 2001) [15].

Molan *et al*. (2002) [16] have observed that CT extracts from several forages can disrupt the life cycle of nematodes by preventing their eggs from hatching and by preventing larval development to the infective stage. Pathak *et al*. (2009) [17] observed that aqueous defatted crude extracts of CT (freeze dried) from *Psidium guajava, Ficus glomerata, Eugenia jambolana, Artocarpus heterophyllus* and *Ficus infectoria* leaves possess the anthelmintic property and were found to be very effective ($P<0.01$) against *Haemonchus contortus*. It was observed that after 2 hrs of incubation *H. contortus* became very sluggish in all the CT extracts except control, however, mortality of parasites was started after 4 hrs of incubation. Dutta *et al.* (2012) [18] reported significantly lower faecal egg counts in kids fed diets containing CT at 1-2 % of diet from a mixture of tropical tree leaves. Sunil Kumar (2012) [19] reported significant decrease in fecal nematode egg counts in lambs fed CT @ 1.5 % of total mixed ration (TMR), compared to control; however, parasitic load was comparable to dewormed group (dewormed by fenbendazole @ 10mg/kg b.wt.).

This raises the possibility that feeding locally available plant material containing CT may be an alternative method for controlling parasite infections, especially in areas such as the tropics and subtropics.

b) Indirect effect of CT on parasites by improving bioavailability of protein in rumen

Anthelmintic properties of CT in ruminants are also associated with improved nutrient supply to the lower GI tract. CT can improve immune response against GI parasites by protecting the dietary proteins from rumen degradation thus increasing protein flow to, and amino acid absorption by, the small intestine (Shaik *et al*., 2006; Dutta *et al*., 2012). [20, 18] Protein in ruminant's diet is often poorly utilized because of extensive break-down in the rumen. CT can be used as an organic protectant of proteins, which facilitate the by-pass of protein that might otherwise be lost through microbial deamination in the rumen. CT are claimed to have the potential to modify rumen fermentation, however, higher levels of CT are reported to negatively affect rumen fermentation. An optimum concentration has been suggested to be 15 to 40 g/ kg dry-matter (Min *et al*., 2001; Dey *et al*., 2008) [21, 22]. When CT-containing herbage is masticated, CT-protein complexes are formed; these are stable over the pH range of 3.5-7.0 but dissociate in the abomasum and anterior duodenum. This protects the protein from microbial hydrolysis and deamination in the rumen and increases the proportion of dietary amino acids available for post-ruminal absorption (Makkar, 2003) [23], since the tannin-protein complex is assumed to dissociate at low pH of abomasum (Barry and McNabb, 1999) [24]. Sunil Kumar (2012) [19] reported significantly lower serum urea nitrogen level in lambs fed on CT based diet. Significantly lower level of serum urea N in CT group may be attributed to the reduced rumen protein breakdown and increased EAA absorption (Waghorn., 1990) [25]. Similarly, lower serum urea level was reported in lambs given diets containing CT supplied through Ficus infectoria or mixture of tree leaves at 1.0-2.0% of diet (Dey et al., 2008, Pathak., 2010) [22, 12] The high-quality protein (by-pass effect) has the potential to enhance the immune response and increase resistance to GI nematodes (Min *et al*., 2004; Dutta *et al*., 2012) [18, 26]. By-passing amino acids like arginine, glutamine and cysteine can enhance immune responses as these amino acids regulate activation of T and B lymphocytes, natural killer cells and macrophages, gene expression and lymphocyte proliferation, and the production of antibodies, cytokines and other cytotoxic substances (Li *et al*., 2007) [27]

Sunil Kumar (2012) [19] reported significantly ($P<0.01$) higher N-retention in CT based TMR (1.5% CT) fed lambs followed by their counterparts dewormed (DW) and control (CON) group, respectively (Table 1). This observation is further substantiated by the fact that lambs given CT treated diets excreted significantly lower N in urine as % intake relative to dewormed and control animals. Studies indicated that the rumen protective effect of CT was much higher for essential amino acids than non-essential amino acids, which is likely to account for at least part of higher growth rates and N retention in sheep given diets containing condensed tannins (Min *et al*., 2001, Dey *et al*., 2008) [22, 28]. The presence of CT have a potentially beneficial effect to protein nutrition to the host animal by altering partitioning of nutrients towards higher microbial yield rather than short chain fatty acids (Baba *et al*., 2002) [29].

Improved protein utilization would always lead to an increase in host resilience, provided that the host continues to be offered access to a scarce food resource. The effect of improved protein utilization will be more dramatic in infections of young, naive hosts, which result in substantial pathophysiological changes and damage or loss of host tissue (Holmes, 1993) [4].

Pathak (2010) [12] observed that supplementation of CT from tropical tree leaves mixture at 1.5% of diet in *H. contortus* infected sheep improved humoral and cell mediated immune response and inhibited the different development stages of *H. contortus.* Who further reported significantly lower adult worm count and no histopathological changes in CT fed animals as compared to control. Similarly, Sunil Kumar (2012) [19] found that feeding of CT based total mixed ration (1.5% CT) to natural GI infected lambs, reduced ($P<0.01$) the feacal egg counts by 64% and improved cell mediated and humoral immune response as compared to control.

3. Grazing management, as a strategy to reduce pasture parasite density

Management of animals and pastures is key to reducing the amount of internal parasite problems in livestock. An understanding of the life cycles of the different parasites within the whole soil-plant-animal system will help show the interrelationships between these three components. The major part of the parasite life cycle is outside of the animal. Pasture contamination by infective larvae is the primary factor to deal with. By using controlled grazing methods that allow pastures to rest and soil life to function well, contamination can be reduced. This reduction occurs because soil organisms, including earthworms, dung beetles, and nematophagous fungi will destroy or keep a lot of the parasite eggs and larvae from developing.

Feeding of tanniferous plants to animals also helps to reduce parasite density since CT is not absorbed in the digestive tract, they become concentrated in the faeces and may be chemically active in the faeces. The CT may react directly with parasite larvae in the faecal pellet by binding to the cuticle of the larvae, which is high in glycoprotein (Thompson and Geary, 1995) [13], inhibiting larval development.

The height of the pasture sward can affect parasites. The majority of worm larvae crawl only one inch from the ground onto plants, so not allowing animals to graze below that point will cut down on a lot of infestation. This is one reason sheep tend to have more problems with internal parasites; they eat much lower to the ground than cattle do, thereby picking up higher numbers of larvae. Larvae migrate from the manure no more than 12 inches from the manure pile. If livestock are not forced to eat close to their own manure, they will eat fewer larvae. Keeping the grass in a more vegetative stage, and tall enough to provide the animal with adequate forage, will provide better nutrition to keep the animal healthier, strengthening the immune system to prevent the adult worms from producing eggs.

Table 1: Comparative efficacy of deworming and CT supplementation on N balace

Attributes	**Treatments***			**SEM**	**P Values**
	CON	**DW**	**CT**		
N balance (gd^{-1})					
Intake	16.88^{a}	19.03^{ab}	23.48^{b}	1.05	0.020
Faeces loss	4.16	4.31	5.22	0.28	0.252
Urine loss	6.45	6.25	5.82	0.23	0.551
Balance	6.25^{a}	8.47^{a}	12.42^{b}	0.92	0.012
N excretion (% intake)					
Faecal	24.94	22.65	22.20	0.93	0.464
Urinary	40.56^{c}	33.1^{b}	25.10^{a}	2.08	0.018
N retention (%)					
% of intake	34.49^{a}	44.23^{b}	52.69^{c}	2.17	0.017
% of absorbed	45.72^{a}	57.09^{b}	67.59^{c}	3.03	0.017

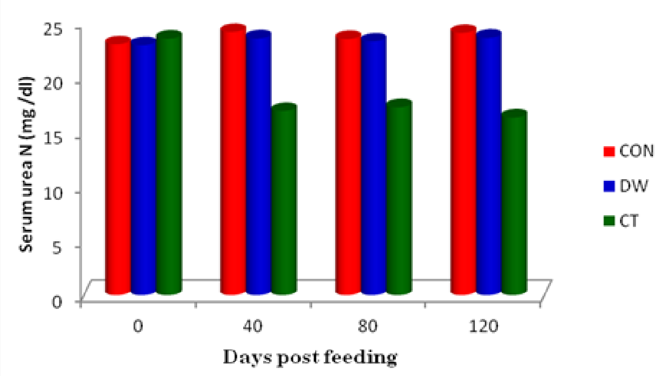

Fig 1: Comparative efficacy of deworming and CT supplementation on serum urea-N in lambs

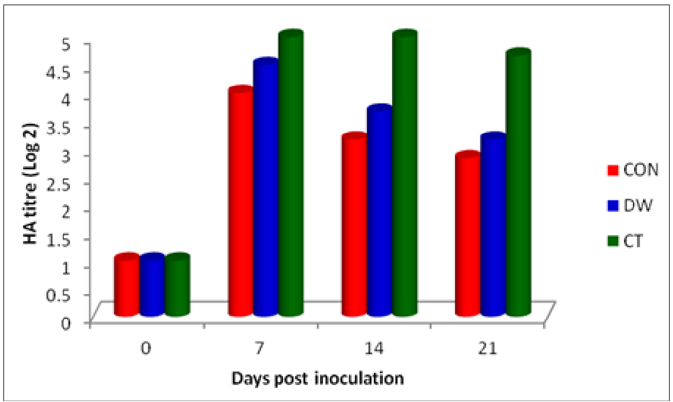

Fig 2: Comparative efficacy of deworming and CT supplementation on humoral antibody response (antibody titre log 2) in lambs measured through HA test against chicken RBC

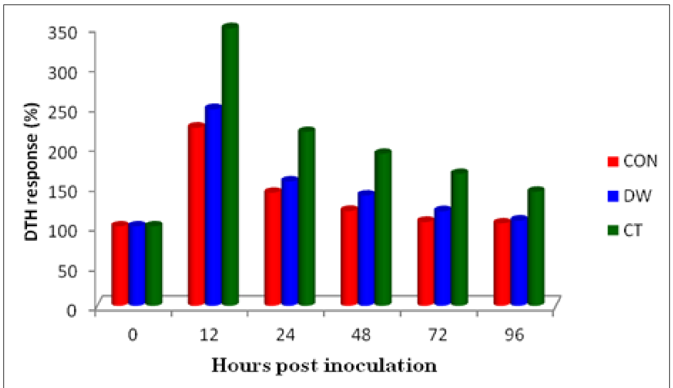

Fig 3: Comparative efficacy of deworming and CT supplementation on DTH response (%) of lambs to PHA-p

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