INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2002/04–3–438–440
http://www.ijab.org

Review
Anthelmintic Effects of Condensed Tannins

ZAFAR IQBAL, KAMRAN AFTAB MUFTI AND MUHAMMAD NISAR KHAN†
Department of Veterinary Parasitology, University of Agriculture, Faisalabad–38040, Pakistan

ABSTRACT

Helminthosis is one of the major problems of livestock production throughout the world, particularly in tropical and sub-tropical areas. Chemical control of helminthes is in practice in most of the parts of the world. In some regions, however, traditional treatment/control is achieved by using ethno-veterinary medicine. A number of chemicals had been effectively controlling/eliminating the worms, but increasing prevalence of anthelmintic resistance in nematodes in domestic ruminants (Waller, 1994), combined with rising consumer concerns about chemical use on farms, has encouraged research into alternative strategies for the control of internal parasites in New Zealand (Niezen *et al.,* 1993). Therefore, researchers are focusing researches on the alternatives to the chemical control of helminthes. Tannins containing plants have been reported to reduce worm burden and increase animal performance. This paper reviews some studies on the anthelmintic effects of tannins.

Key Words: Anti parasitic; Antimicrobial; Tannins

Feeding forage legumes containing condensed tannins, such as sulla (*Hedysarum coronarium*) and lotus major (*Lotus pedunculatus*) significantly increased growth of parasitized lambs (Niezen *et al.,* 1995, 1998; Robertson *et al.,* 1995), deer (Hoskin, 1998) relative to feeding legumes containing only trace levels of condensed tannins, such as Lucerne. Fresh sulla (Condensed tannins 55 g/kg DM) decreases the degradation of forage protein and 'S' amino acids to inorganic sulphide in the rumen and increase absorption of Methionine and Cystine in sheep (McNabb *et al.,* 1993).Grazing sulla also reduced gastrointestinal worm numbers in sheep relative to sheep grazing Lucerne (Neizen *et al.,* 1998). Hoskin (1998) found a linear negative relationship between the concentration of condensed tannins in forage legumes fed to deer and the apparent establishment of abomasal nematodes. In the same study, lower counts of faecal lungworm L_1 larvae were reported in the deer fed sulla, containing 3-5% tannins, than in deer fed Lucerne, with only 0.1% tannins.

Feeding diets containing rumen by-pass protein to parasite-infected sheep and goats reduced production losses attributed to parasitism (Blackburn *et al.,* 1991, Donaldson *et al.,* 1997), and enhanced immunity (Coop *et al.,* 1995; Van Houtert *et al.,* 1995). Bown *et al.* (1991a) showed that an infusion of protein into abomasums of lambs trickle – infected with *Trichostrongylus colubriformis* resulted in reduced worm numbers and improved lamb performance. It has been suggested that the increased by-pass protein supply caused by the action of condensed tannins present in the forage legumes helps counteract the protein losses caused by GI nematode infections (Poppi *et al.,* 1986, 1990; MacRae 1993; Sykes, 1994). However, no grazing or indoor feeding studies with by-pass protein supplements or forages containing condensed tannins have been carried out with parasitized deer.

In vitro research has demonstrated that condensed tannins extracted from forage legumes has direct inhibitory activity against L_1 and L_3-stage deer-origin lungworm larva and L_3 deer- and sheep-origin gastrointestinal nematode larvae, as measured using a larval migration inhibition assay (Molan *et al.,* 2000a,b). However, despite potential direct effects of condensed tannins on sheep and deer parasites and indirect nutritional benefits of condensed tannins for parasitized ruminants, no research has been conducted into the effects of feeding forages containing condensed tannins on any aspect of internal parasitism in deer.

The negative relationships between dietary condensed tannins concentration and abomasal nematode numbers suggest that the concentration of condensed tannins may be responsible, but the possibility remains that the structure (or plant origin) of condensed tannins may also exert an effect (Foo *et al.,* 1996).

Condensed tannins affect abomasal nematode numbers. Condensed tannins react and form complexes with protein in a pH-dependent manner (Jones & Mangan, 1977) and binding can be highly specific for different tannins as well as different proteins (Asquith & Butler, 1986). Condensed tannins found in forage legumes fed to deer could, therefore, interact with protein secretions excreted by nematodes in the gut (McKellar *et al.,* 1985), or excreted by gut microorganisms in response to the presence of parasites (Lawton, 1995).

Molan *et al.* (2000b) used an *in vitro* assay to show that condensed tannins extracted from sulla and birdsfoot trefoil inactivated deer L_1 lungworm larvae by 42 and 35%, respectively. Condensed tannins extracted from sulla were also found to be more effective than condensed tannins from birdsfoot trefoil at paralyzing sheep *Trichostrongylus colubriformis* larvae (Molan *et al.,* 2000a). Neizen *et al.* (1998) reported a reduction in GI nematodes, particularly intestinal *Trichostrongylus* spp., in lambs grazing sulla, compared with no reduction for lambs grazing other condensed tannins-containing forage legumes also suggesting that the structure of condensed tannins affect efficacy. Faecal egg count and worm burden were reduced in sheep infected with L_3 of *H. contortus, T. colubriformis* and *N. battus* given Quebracho (CT) at 3.5% w/w of food intake x 3 (Athanasiadou *et al.,* 2000). Condensed tannin (Quebracho) in the culture decreases the viability of L_3 in *H. contortus, Ostertagia and Trichostrongylus (*Athanasiadou *et al.,* 2001)

Hoskin (1998) observed that significantly fewer *Ostertagia*-type and *Trichostrongylus axei* nematodes became established in red deer fed sulla than in deer fed *L. corniculatus. L. corniculatus* (CT 27 g/kg DM) reduce rumen protein degradation and increases utilization of plasma cystine (Wang *et al.,* 1994).

Condensed tannins have been shown to inhibit endogenous enzyme activities (Oh and Hoff 1986, Horigome *et al.,* 1988) and condensed tannins isolated from 18 plant species including *L. pedunculatus* and *L. corniculatus* were potent inhibitors of the cyclic AMP-dependent protein kinase in rat liver (Wang *et al.,* 1996). *L. pedunculatus* feeding in animals can increase post ruminal flow of 'N' and 'EAA' (Barry & Manley, 1984).

Because of their reactivity with plant proteins as they are being chewed by ruminant animals, condensed tannins partially protect animals against rumen degradation, and so increase the flow of amino acids to the small intestine and increase their absorption from the small intestine of sheep (Waghorn *et al.,* 1987, 1987a, 1994).This increase may help to counteract the losses of protein attributed to gastrointestinal nematode infection (Poppi *et al.,* 1990; MacRae, 1993; Sykes 1994).Feeding forages containing condensed tannins, such as sulla and *L. pedunculatus,* significantly increased the growth rate of parasitized lambs (Niezen *et al.,* 1995; Robertson *et al.,* 1995) compared with that of lambs fed legumes not containing tannins, and the rate of establishment of the parasites was lower in lambs grazing sulla (Robertson *et al.,* 1995)

The condensed tannins extracted from the four forages differed greatly in their activity against the larvae of lungworm and gastrointestinal nematodes of deer, with the order from highest to lowest consistently being sainfoin, *L. pedunculatus,* sulla and *L. crniculatus.* The differences in activity may be attributed to differences in the molecular weight and structure of the different tannins (Jones *et al.,* 1976; Asquith & Butler, 1986; Foo *et al.,* 1996, 1997).The average molecular weight of the tannins from *L. pedunculatus* is 2200, slightly higher than that of the tannins from *L. corniculatus*, that has molecular weight 1990 (Foo *et al.,* 1996, 1997). Furthermore, the tannins from *L. pedunculatus* contain a predominance of prodelphinidin-type subunits (Foo *et al.,* 1997); whereas, the tannins from *L. corniculatus* have predominantly procyanidin-type subunits (Foo *et al.,* 1996). Condensed tannins with a high molecular weight interact more strongly with enzyme and other proteins than those with a low molecular weight (Beart *et al.,* 1985; Horigome *et al.,* 1998; Kawamoto *et al.,* 1996), and their reactivity increases with increasing prodelphinidin content (Jones *et al.,* 1976).

CONCLUSIONS

Based on review, it is concluded that condensed tannins may be tries as potential candidate for the control of helminthes in livestock. Therefore, controlled studies to evaluate the anthelmintic activity of tannins be carried out.

REFERENCES

Asquith, T.N. and L.G. Butler, 1986. Interactions of condensed tannins with selected proteins. *Phytochemistry,* 25: 1591–3

Athanasiadou, S., I. Kyriazakis, F. Jackson and R.L. Coop, 2000. Consequences of long term feeding with condensed tannins on sheep parasitized with *Trichostrongylus colubriformes*. *J. Parasitol.,* 30: 1025–33.

Athanasiadou, S., I. Kyriazakis, F. Jackson and R.L. Coop, 2001. Direct anthelmintic effects of condensed tannins towards different gastrointestinal species: *in vitro* and i*n vivo* studies. *Vet. Parasitol.,* 99: 205–19.

Barry, T.N. and T.R. Manley, 1984. The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep 2. Quantitative digestion of carbohydrates and protein. *British J. Nutr.,* 51: 493

Beart, J.E., T.H. Lilley and E. Haslam, 1985. Plant polyphenols-secondary metabolism and chemical defence: some observations. *Phytochemistry,* 24: 33–8

Blackburn, H.D., J.L. Rocha, E.P. Igueiredo, M.E. Berne, L.S. Vieira, A.R. Cavalcante, and J.S. Rosa, 1991. Interaction of parasitism and nutrition and their effects on production and clinical parameters in goats. *Veterinary Parasitol.,* 40: 99–112

Bown, M.D., D.P. Poppi and A.R. Sykes, 1991a. The effect of post–ruminal infusion of protein of energy on the pathophysiology of *Trichostrongylus colubriformis* infection and body composition in lambs. *Australian J. Agri. Res.,* 42, 253–267

Coop, R.L., J.F. Huntley and W.D. Smith, 1995. Effect of dietary protein supplementation on the development of immunity to *Ostertagia circumcincta* in growing lambs. *Res. Vet. Sci.,* 59: 24–9

Donaldson, J., M.F.J. Van Houtert and A.R. Sykes, 1997. The effect of protein supply on the periparturient parasite status of the mature ewe. *Proc. New Zealand Soc. Anim. Prod.,* 57: 186–9

Foo, L.Y., W.C. McNabb, G.C. Waghorn and M.J. Ulyatt, 1997. Proanthocyanidins from *Lotus pedunculatus*. *Phytochemistry,* 45: 1689–96

Foo, L.Y., R. Newman, G.C. Waghorn, W.C. McNabb and M.J. Ulyatt, 1996. Proanthocyanidins from *Lotus corniculatus*. *Phytochemistry,* 41: 617–24

Horigome, T., R.O. Kumar and K. Kamoto, 1998. Effects of condensed tannins prepared from leaves of fodder plants on digestive enzymes *in vitro* and in the intestine of rats. *British J. Nutr.,* 60: 275–285

Hoskin, S.O., 1998. Internal parasitism and growth of farmed deer fed different forage species. *PhD Thesis,* Massey University, Palmerston North, New Zealand

Jones, W.T., R.B. Broadhurst and J. Lyttleton, 1976. The condensed tannins of pasture legume species. *Phytochemistry,* 15: 1407–9

Jones, W.T. and J.L. Mangan, 1977. Complexes of the condensed tannins of sainfoin , *Onobrychis viciifolia* scop.. with fraction 1 leaf protein and with submaxillary mucoprotein, and their reversal with polyethylene glycol and pH. *J. Sci. Food and Agri.,* 28: 126–36

Kawamoto, H., F. Nakatsubo and K. Murakami, 1996. Stoichiometric studies of tannin coprecipitation. *Phytochemistry,* 41: 1427–31

Lawton, D.E.B., 1995. Abomasal secretion in parasitized sheep. *PhD Thesis*, Massey University, Palmerston North, New Zealand

McKellar, Q.A., J.L. Duncan, J. Armour, F.E.F. Lindsay and McWilliam, 1985. Further studies on the response to transplanted adult *Ostertagia ostertagi* in calves. *Res. Vet. Sci.*, 42: 29–34

McNabb, W.C., G.C. Waghorn, T.N. Barry and I.D. Shelton, 1993. The effects of condensed tannin in *Lotus pedunculatus* upon the digestion and metabolism of methionine, cystine and inorganic sulphur in sheep. *British J. Nutr.*, 70: 647–61

MacRae, J.C., 1993. Metabolic consequences of intestinal parasitism. *Proc. Nutr. Soc.*, 52: 121–30

Molan, A.L., G.C. Waghorn, B.R. Min and W.C. McNab, 2000a. The effect of condensed tannins from seven herbages on *Trichostrongylus colubriformis* larval migration *in vitro*. *Folia Parasitologica*, 47: 39–44

Molan, A.L., S.O. Hoskin, T.N. Barry W.C. McNab, 2000b. The effect of condensed tannins extracted from four forages on deer lungworm and gastrointestinal nematode viability. *Vet. Rec.*, 147: 44–8.

Niezen, J., T.S. Waghorn, G.C. Waghorn and W.A.G. Charleston, 1993. Internal parasites and lamb production–a role for plant containing condensed tannins? Proc. New Zealand Soc. Anim. Prod., 53: 235–8

Niezen, J.H., T.S. Waghorn, W.A.G. Charleston and G.C. Waghorn, 1995. Growth and gastrointestinal nematode parasitism in lambs grazing either Lucerne , *Medicago sativa*. or sulla , *Hedysarium coronarum*. which contains condensed tannins. *J. Agri. Sci.*, Cambridge, 125: 281–9

Niezen, J.H., H.A. Robertson, G.C. Waghorn and W.A.G. Charleston, 1998. Production, Faecal egg counts and worm burdens of ewe lambs which grazed six contrasting forages. *Vet. Parasitol.*, 80: 15–27

Oh, H.I. and J.E. Hoff, 1986. Effect of condensed grape tannins on the *in vitro* activity of digestive proteases and activation of their zymogens. *J. Food Sci.*, 51: 577–80

Poppi, D.P., J.C. MacRae, A. Brewer and R.L. Coop, 1986. Nitrogen Transactions in the digestive tract of lambs exposed to the intestinal parasite *Trichostrongylus colubriformis*. *British J. Nutr.*, 55: 593–602

Poppi, D.P., A.R. Sykes and R.A. Dynes, 1990. The effect of endoparasitism on host nutrition – the implications for nutrient manipulation. *Proc. New Zealand Soc. Anim. Prod.*, 50: 237–43

Robertson, H.A., J.H. Niezen, G.C. Waghorn, W.A.G. Charleston and M. Jinlong, 1995. The effect of six herbages on live weight gain, wool growth and faecal egg count of parasitized ewe lambs. *Proc. New Zealand Soc. Anim. Prod.*, 55: 99–201

Sykes, A.R., 1994. Parasitism and production in farm animals. *Anim. Prod.*, 59: 155–72

Van Houtert, M.F.J., I.A. Barger, J.W. Steel, R.G. Windon and D.L. Emery, 1995. Effect of dietary protein on responses of young sheep to infection with *Trichostrongylus colubriformis*. Vet. Parasitol., 59: 163–80

Waghorn, G.C., A. John, W.T. Jones and I.D. Shelton, 1987. Nutritive value of *Lotus corniculatus* L containing low and medium concentrations of condensed tannins for sheep. *Proc. New Zealand Soc. Anim. Prod.*, 47: 25–30

Waghorn, G.C., M.J. Ulyatt, A. John and M.T. Fisher, 1987a. The effect of condensed tannins on the site of digestion of amino acids and other nutrients in sheep fed on *Lotus corniculatus*. *British J. Nutr.*, 57: 115–26

Waghorn, G.C., I.D. Shelton, W.C. McNabb and S.N. McCutcheon, 1994. Effect of condensed tannins in *Lotus pedunculatus* on its nutritive value for sheep.2. Nitrogen aspects. *J. Agri. Sci.*, Cambridge, 123: 109–19

Waller, P.J., 1994. The development of anthelmintic resistance in ruminant livestock. *Acta Tropica*, 56: 233–43

Wang, Y., G.C. Waghorn, G.B. Douglas, T.N. Barry and G.F. Wilson, 1994. The effects of condensed tannin in *Lotus corniculatus* upon nutrient metabolism and upon body and wool growth in sheep. *Proc. New Zealand Soc. Anim. Prod.*, 54: 219–22

Wang, B.H., L.Y. Foo and G.M. Polya, 1996. Differential inhibition of eukaryote protein kinases by condensed tannins. *Phytochemistry*, 43: 359–65

(Received 06 May 2002; Accepted 10 June 2002)