Effects of tannin-containing diets on small ruminant meat quality

Q. Priolo & V. Vasta

To cite this article: Q. Priolo & V. Vasta (2007) Effects of tannin-containing diets on small ruminant meat quality, Italian Journal of Animal Science, 6:sup1, 527-530

To link to this article: https://doi.org/10.4081/ijas.2007.1s.527
Effects of tannin-containing diets on small ruminant meat quality

A. Priolo, V. Vasta

Dipartimento di Scienze Agronomiche, Agrochimiche e delle Produzioni Animali.
Università di Catania, Italy

Corresponding author: Alessandro Priolo. Dipartimento di Scienze Agronomiche, Agrochimiche e delle Produzioni Animali. Facoltà di Agraria, Università di Catania. Via Valdisavoia 5, 95123 Catania, Italy - Tel. +39 095 234497 - Fax: +39 095 234345 - Email: a.priolo@unict.it

ABSTRACT: Tannins are phenolic compounds present in several forages, tree leaves and by-products used for small ruminant feeding in the Mediterranean area. Although the effects of dietary tannins on small ruminant growth performances have been largely studied, only in the last ten years researchers have started to study the effects of tannins on meat quality. Meat from small ruminants given tanniniferous diets is lighter in colour compared to meat from animals given the same diets but in which the effects of tannins have been eliminated by the supplementation of polyethylene glycol. This result has been obtained with tannins from different feeds (carob pulp, acacia leaves or sulla fresh herbage). Recent in vitro studies seem to indicate that a possible effect of tannins on meat colour could be due to a reduced microbial biosynthesis of vitamin B12 which is a precursor for the synthesis of haeme pigments. Meat from lambs given carob contains less conjugated linoleic acid compared to meat from animals fed the same diet but supplemented with polyethylene glycol. A possible explanation of this result has been proposed recently after an in vitro experiment on linoleic acid isomerase; it has been shown that when cattle ruminal fluid is incubated with tannins extracted from acacia, carob or quebracho, the conjugated linoleic acid formed from linoleic acid was lower compared to the amount of conjugated linoleic acid produced in tannin-free rumen fluid. Also, the ruminal biosynthesis of odour-active compounds seems to be affected by tanniniferous diets. This is the case of skatole (3-methylindole) and indole which confer unpleasant flavour connotations to lamb meat.

INTRODUCTION – Feeding costs are one of the major problems in the economic balance of small ruminant farmers. In several Mediterranean areas animal feed production is difficult and farmers purchase expensive concentrates. Many shrubs and by-products have been studied in these years by researchers from the three Mediterranean continents with the aim to replace expensive conventional feeds (Silanikove et al., 1994; Ben Salem et al., 1996; Priolo et al., 1998). In many cases a problem with the use of alternative feeds is the presence of anti-nutritional factors such as tannins, phenolic compounds found in many forage plants, particularly in a variety of legume forages (Sarkar et al., 1976; Terrill et al., 1992) and tree leaves (Kumar and Vaithiyanathan, 1990; Silanikove et al., 1994). Tannins are widespread in tropical trees, shrubs and herbaceous plants (Kumar and Vaithiyanathan, 1990; Rittner and Reed, 1992; Jackson et al., 1996) and tannin-containing feeds have been largely used as replacement or in association to conventional feeds. Negative effects exerted by dietary tannins include reduced absorption of some minerals (Wagborn et al., 1994a), reduction of protein digestibility and amino acid (AA) absorption (Wagborn et al., 1994b), reduction of rumen protein utilisation (Jones and Mangan, 1977; Barry and Duncan, 1984), and of voluntary intake (Reed, 1995), reduction of microbial activity in the rumen (Nuñez-Hernandez et al., 1991) and toxic effects reflected by damage of kidney and liver (Kumar and Singh, 1984). In the rumen, tannins bind with plant proteins, reducing their availability for microbial growth. As a consequence of that, the rate and extent of fibre digestion is also reduced with consequent reduction of voluntary intake, metabolizable energy availability and AA absorption. Tannins react preferentially with polyethylene glycol (PEG) and the supplementation of PEG has been largely used to eliminate and to evaluate the effects of tannins (Decandia et al., 2000). Only in the last few years, a number of studies have been focused on the effects of dietary tannins on small ruminants meat quality. These studies are here reviewed.

EFFECTS OF TANNINS ON MEAT COLOUR – In a trial aimed to compare two sorghum varieties with different content of tannins, lambs fed the strain containing the higher level of tannins showed a meat lighter in colour (Verna et al., 1989). Later, Priolo et al. (1998) found that feeding tannins from carob pulp in partial replacement of barley to
Comisana lambs, increased longissimus muscle (1 hr blooming at 4°C) lightness (L*). Animal growth rate, carcass weight, carcass fatness and muscle ultimate-pH were comparable between groups in this experiment. The authors hypothesised that tannins were responsible for the differences found in meat colour. A second experiment designed to evaluate the specific effect of carob tannins on lamb growth and meat quality (Priolo et al., 2000), showed that when the effects of tannins from carob pulp are eliminated by PEG supply, Comisana lamb longissimus muscle was significantly darker (lower L*). However in this experiment the growth rate between animals was very different due to the high astringency of tannins. Another experiment (Priolo et al., 2002) evaluated the effect of tannins from Acacia cyanophylla foliage on meat quality of Barbarine male lambs. The longissimus muscle (2 hr blooming at 4°C) of animals that did not receive PEG was significantly lighter compared to that of the supplemented animals. Also, in a third experiment in which Comisana lambs were fed sulla (Hedysarum coronarium) with or without PEG, the meat of the animals not receiving PEG was lighter in colour compared to the supplemented lambs (Priolo et al., 2005). This result, together with those of Priolo et al. (2000 and 2002) indicates that tannins from different plant species have similar effects on lamb meat colour. The effect of tannins from acacia and carob on lamb meat colour is showed in Figure 1.

Zembayashy et al. (1999) reported that feeding tea leaves to Japanese heifers reduced muscle iron content. It was found also a strongly negative correlation between muscle iron and meat lightness, and it is concluded that feeding tea leaves would be effective in increasing the lightness of the meat. Tea leaves are rich in catechins as reported by the authors and the two findings appear to be correlated. The mechanism of action of tannins (or catechins) on meat colour is not clear. Tannins seem not to influence iron absorption in ruminant: Waghorn et al. (1994a) found no difference in Fe absorption in 12 months old Romney wethers grazing on Lotus pedunculatus with or without PEG. In an experiment with cattle fed tannins from oak (Quercus incana) leaves, Garg et al. (1992) found that although the blood haemoglobin was affected by tannin poisoning, no differences in blood iron were present. Similar results have been obtained by Priolo et al. (2000) with tannins from carob pulp. It is therefore likely that the tannins do not affect ruminant Fe absorption but hamper the successive utilisation of the iron for synthesis of haemoglobin as suggested by Garg et al. (1992). In a recent in vitro study on cattle ruminal fluid, it was found that tannins extracted from carob pulp, from acacia leaves or from quebracho reduced the microbial biosynthesis of vitamin B12 (Vasta V., Makkar H.P.S., Priolo A., unpublished data), which is a precursor for the synthesis of haemoglobin. According to these findings, it is likely that a reduced biosynthesis of haemoglobin caused by dietary tannins could result in a lighter colour in meat.

**EFFECTS OF TANNINS ON RUMINAL BIOHYDROGENATION AND INTRAMUSCULAR FATTY ACID COMPOSITION** – Only few studies have investigated on the effects of feeding tanniferous feed on lamb meat fatty acid composition with a particular focus on cis-9 trans-11 conjugated linoleic acid (CLA), a fatty acid which has favorable effects on human health. It is well known that CLA is partially synthesised by ruminal microorganism during the biohydrogenation of dietary polyunsaturated fatty acids (PUFA). Priolo et al.
The effect of different concentrations of tannins (0, 0.6 or 1.0 mg/mL of incubation medium) extracted from acacia, carob or quebracho on the in vitro production of CLA by linoleic acid isomerase from cattle ruminal fluid (Vasta V., Makkar H.P.S., Mele M. and Priolo A., unpublished results).

Conclusions – Dietary tannins affect meat quality in several aspects. Meat from animals fed tanniniferous diets appear to be lighter in colour compared to meat from animals fed the same diets but supplemented with polyethylene glycol. A possible explanation of this result is the reduced production of B12 vitamin by ruminal microorganisms, as found in vitro resulting in a reduced production of haemoglobin. In vitro studies have also demonstrated that tannins reduce ruminal biohydrogenation, affecting the biosynthesis of conjugated linoleic acid and of its precursor, trans-vaccenic acid. However, in vivo studies have reported converse results about the effect of feeding tannins and the accumulation of CLA in lamb meat and further researches are needed to deepen the knowledge on this topic. Dietary tannins can also reduce the production by ruminal microorganisms of some volatile compounds such as skatole and indole and this can have important implication for ameliorating meat flavour.
REFERENCES: Barry T.N., and Duncan S.J.. 1984. The role of condensed tannins in the nutritive value of *Lotus pedunculatus* for sheep. 1. Voluntary intake. Br. J. Nutr.51:485-491. Bauman, D.E., Baugmard, L.H., Corl, B.A., and Grinari, J.M.. 1999. Biosynthesis of conjugated linoleic acid in ruminants. Proc. Am. Soc. Anim. Sci. available at: http://www.asas.org/jas/symposia/proceedings/0937.pdf. Ben Salem, H., Nezfaoui, A., Abdouli, H., and Ørskov, E.R.. 1996. Effect of increasing level of spinaceous cactus (*Opuntia ficus-indica* var. inermis) on intake and digestion by sheep given straw-based diets. Anim. Sci.62:293-299. Decandia, M., Sitzia, M., Cabiddu, A., Kababya, D., and Malle, G.. 2000. The use of polyethylene glycol to reduce the anti nutritional effects of tannins in goats fed woody species. Small Rum. Res.38:157-164. Garg S.K., Makkar H.P.S., Nagal K.B., Sharma S.K., Wadhwa D.R., and Singh B.. 1992. Oak (*Quercus incana*) leaf poisoning in cattle. Vet. Hum. Toxicol.34:161-164. Khiaosa-Ard, R., Bryner, S.F., Scheeder, M.R.L., Wettstein, H.-R., Kreuzer, M., and Soliva, C.R.. 2007. Ruminal biohydrogenation of ω3-linolenic acid as affected by plant secondary metabolites *in vitro*. Tagung der Gesellschaft für Ernährungsphysiologie, Göttingen, 2007, Germany, Kumar R., and Vaithiyanathan S.. 1990. Occurrence, nutritional significance and effect on animal productivity of tannins in tree leaves. Anim. Feed Sci. Tech.30:21-38. Kumar R., and Singh M.. 1984. Tannins, their adverse role in ruminant nutrition. J. Agric. Food. Chem.32:447-453. Jackson E.S., Barry T.N., Lascano C., and Palmer B.. 1996. The extractable and bound condensed tannins content of leaves from tropical tree, shrub and forage legumes. J. Sci. Food Agric.71:103-110. Jones W.T., and Mangan J.L.. 1977. Complexes of the condensed tannins of sainfoin (*Onobrychis vicifolia* Scop.) with fraction 1 leaf protein and with submaxillary mucoprotein, an their reversal by polyethylene glycol and pH. J. Sci. Food Agric.28:126-156. Nuñez-Hernandez G., Wallace J.D., Holecch J.K., Galypeon M.L. and Cardenas M.. 1991. Condensed tannins and nutrient utilization by lambs and goats fed low-quality diets. J. Anim. Sci.69:1167-1177. Priolo, A., Lanza, M., Biondi, L., Pappalardo, D., and Young, O.A.. 1998. Effect of partially replacing dietary barley with 20% carob pulp on post-weaning growth, and carcass and meat characteristics of Comisana lambs. Meat Sci.50.355-363. Priolo A., Waghorn, G., Lanza, M., Biondi, L., and Pennisi, P.. 2000. Polyethylene glycol as a means for reducing the impact of condensed tannins in carob pulp: effects on lamb growth, performance and meat quality. J. Anim. Sci.78:810-816. Priolo, A., Ben Salem, H., Atti, N., and Nezfaoui, A.. 2002. Polyethylene glycol in concentrate or feedblock to deactivate condensed tannins in *Acacia cyanophylla* Lindl. Foliage 2. Effects on meat quality of Barbarine lambs. Anim. Sci.75:137-140. Priolo, A., Bella, M., Lanza, M., Galofaro, V., Biondi, L., Barbagallo, D., Ben Salem, H., and Pennisi, P.. 2005. Carcass and meat quality of lambs fed fresh *sulla* (*Hedysarum coronarium* L.) with or without polyethylene glycol or concentrate. Small Rum. Res.59:281-288. Reed J.D.. 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. J. Anim. Sci.73:1516-1528. Rittner U., and Reed J.D.. 1992. Phenolics and *in vitro* degradability of protein and fibre in west African browse. J. Sci. Food Agric.58:21-28. Sarkar S.K., Howarth R.E., and Golpen B.P.. 1976. Condensed tannins in herbaceous legumes. Crop Sci.16:543-546. Silanikove, N., Nitsan, Z., and Perevolotsky, A.. 1994. Effect of a daily supplementation of polyethylene glycol on intake and digestion of tannin-containing leaves (*Ceratonia siliqua*) by sheep. J. Agric. Food. Chem.42:2844-2847. Schreurs, N.M., Tavendale, M.H., Lane, G.A., Barry, T.N., McNabb, W.C., Cummings, T., Fraser, K., and López-Villalobos, N.. 2005. Effect of supplementation of a white clover or perennial ryegrass diet with grape seed extract on indole and skatole metabolism and the sensory characteristics of lamb. J. Sci. Food Agric.In press. Tavendale, M.H., Lane, G.A., Schreurs, N.M., Fraser, K., and Meagher, L.P.. 2005. The effects of condensed tannins from *Dorycnium rectum* on skatole and indole ruminal biogenesis for grazing sheep. Austr. J. Agric. Res.56:1331-1337. Terrill T.H., Rowan A.M., Douglas G.B., and Barry T.N.. 1992. Determination of extractable and bound condensed tannins concentrations in forage plants, protein concentrate meals and cereal grains. J. Sci. Food Agric.58:321-329. Vasta, V., Nudda, A., Cannas, A., Lanza, M., and Priolo, A.. 2007a. Alternative feed resources and their effects on the quality of meat and milk from small ruminants - a review. Anim. Feed Sci. Technol.In press. Vasta, V., Pennisi, P., Lanza, M., Barbagallo, D., Bella, M., and Priolo, A.. 2007b. Intramuscular fatty acid composition of lambs given a tanniferous diet with or without polyethylene glycol supplementation. Meat Sci.In press. Vasta, V., and Priolo, A.. 2006. Ruminant fat volatiles as affected by diet. A review. Meat Sci.73:218-228. Verna, M., Pace, V., Settineri, D., Di Giacomo, A., and Nanni, A.. 1989. Impiego di Sorgo a diverso tenore di tannini nell'alimentazione degli agnelli. IF - Considerazioni sulla dissezione della coscia, sulla qualità delle carni e sui rilievi istologici ed istochimici degli organi. Ann. Ist. Sper. Zootec.22:1-14. Waghorn G.C., Shelton I.D., and McNabb W.C.. 1994a. Effects of condensed tannins in *Lotus pedunculatus* on its nutritive value for sheep. 1. Non-nitrogenous aspects. J. Agric. Sci. Camb.123:99-107. Waghorn G.C., Shelton I.D., McNabb W.C., and McCutcheon S.N.. 1994b. Effects of condensed tannins in *Lotus pedunculatus* on its nutritive value for sheep. 2. Nitrogenous aspects. J. Agric. Sci. Camb.123:109-119. Young, O.A., and Baumester, B.M.B.. 1999. The effect of diet on the flavour of beef and the odour compounds in beef fat. N. Z. J. Agric. Res.42:297-304. Zembyashi, M., Lunt, D.K., and Smith, S.B.. 1999. Dietary tea reduces the iron content of meat. Meat Sci.53:221-226.