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Effects of dietary condensed tannins on small ruminant productions

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SUMMARY – This mini-review has the aim to collate and discuss information available in the scientific literature on the effects of condensed tannins on small ruminant milk and meat quality and wool production. Polyethylene glycol (PEG) has been used in most experiments to deactivate condensed tannins (CT). The effects of dietary CT on wool and milk production have been studied principally in New Zealand with tannins from temperate legume pastures. At low concentrations, CT appear to increase wool growth because of a reduced protein degradation in the rumen and better amino acids supply to, and absorption from, the small intestine. CT from *Lotus corniculatus* increased milk yield, protein and lactose percentages, and reducing fat percentage. Regarding carcass characteristics, CT from temperate plants, at low concentrations, have increased carcass leanness and reduced carcass fatness. This can be due to improved protein nutrition due to an increased flow of protein and essential amino acids to the intestine. Condensed tannins from *Acacia cyanophylla* had no significant effects on lamb tissue repartition. Meat quality has been evaluated after lambs received diets containing CT from this shrub species or *Ceratonia siliqua* pulp with or without PEG. In both cases, lean colour appeared to be greatly affected by dietary CT, being darker in the animals that receive PEG supplementation ($P < 0.01$). The effect of CT on meat colour could be linked with a reduced myoglobin synthesis although iron absorption seems not to be affected by CT in sheep.

Key words: Tannins, milk, meat, wool, small ruminants.

RESUME – *"Effets des tanins condensés sur les productions des petits ruminants". Cette courte synthèse rapporte et discute les données disponibles dans la littérature sur l'effet des tanins condensés (TC) sur la qualité du lait et de la viande ainsi que sur la production de laine chez les petits ruminants. Le polyéthylène glycol (PEG) a été utilisé dans la majorité des expériences pour désactiver les TC. Les effets des TC sur les productions de lait et de laine ont été étudiés essentiellement en Nouvelle-Zélande en utilisant des fourrages tempérés. A de faibles concentrations, les TC semblent accroître la production de laine par suite d'une réduction de la dégradation des protéines dans le rumen et d'une amélioration de l'absorption des acides aminés au niveau de l'intestin grêle. Les TC du lotier (*Lotus corniculatus*) ont fait augmenter la production de lait, et le pourcentage de protéines et de lactose et diminuer le pourcentage de matières grasses. Concernant la qualité de la carcasse, les TC présents en faible quantité dans les plantes tempérées ont augmenté la clarté de la carcasse et ont réduit le niveau de gras dans la carcasse. Ce phénomène pourrait s'expliquer par une amélioration de la valeur azotée des régimes alimentaires, conséquence d'un accroissement des flux de protéines et d'acides aminés essentiels au niveau de l'intestin. Les TC du feuillage d'*Acacia cyanophylla *Lindl. n'ont aucun effet sur la répartition des tissus des agneaux. La qualité de la viande a été évaluée après distribution à des moutons d'arbustes riches en TC,* Acacia cyanophylla *et la pulpe des gousses de* Ceratonia siliqua *additionnée ou non de PEG. Dans les deux cas, la couleur de la viande a été plus dense chez les animaux recevant du PEG ($P < 0,001$), en d'autres termes les TC ont tendance à rendre la viande plus claire. Cet effet des TC sur la couleur de la viande pourrait être dû à une réduction de la synthèse de myoglobine bien que l'absorption du fer ne semble pas être affectée chez les ovins recevant des régimes enrichis en TC.*

Mots-clés : *Tanins, lait, viande, laine, petits ruminants.*

Introduction

Feeding costs are one of the major problems in the economic balance of the sheep farmers. In most of the semi-arid Mediterranean regions, animal feed production is difficult and farmers purchase expensive concentrates. Many shrubs and by-products have been studied by researchers from the Mediterranean continents with the aim to substitute expensive conventional feeds (Silanikove *et al*., 1994; Ben Salem *et al*., 1996; Priolo *et al*., 1998a). In many cases a problem in utilization of these alternative feeds is the presence of anti-nutritional factors such as condensed tannins (CT) and phenolic compounds found in many forage plants (Kumar and Vaithiyanathan, 1990; Terrill *et al*., 1992). CT in some plant species have been associated with a number of adverse conditions. Examples include *Lespedeza cuneata* (Terrill *et al*., 1989), *Acacia aneura* (Pritchard *et al*., 1988), *Lotus pedunculatus* grown under wet cold conditions (Barry and Duncan, 1984), *Calliandra calothyrsus* (Salawu *et al*., 1997) and *Ceratonia siliqua* (Priolo *et al*., 2000). Negative effects include reduced absorption of some minerals (Waghorn *et al*., 1994a), reduced rumen protein utilisation (Jones and Mangan, 1977; Barry and Duncan, 1984), voluntary intake (Reed, 1995), and 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, CT bind with plant proteins, reducing their availability for rumen microflora and the host animal. Consequently, the rate and extent of fibre digestion is also reduced with consequent reductions of voluntary intake, metabolizable energy availability and amino acid (AA) absorption. CT react preferentially with polyethylene glycol (PEG) and the supplementation of PEG has been largely used to eliminate and to measure the effects of CT (see, e.g. Waghorn *et al*., 1999).

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The effects of CT upon small ruminant physiology have been studied although several processes are still unclear. The studies on the effects of CT on product quality (meat, milk, wool) have been poorly studied and further research is necessary. It is clear that if a small amount of CT in the diet could enhance small ruminant production in general, a large amount of CT could be deleterious. However, research by Foo *et al.* (1996, 1997) underlined the difference in reactivity between tannins of different species.

Wool

Condensed tannins seem to have different effect on wool growth depending on the concentration. Wool growth has a direct correlation with protein utilization. At low concentrations, CT seem to increase wool growth (Terrill *et al*., 1992; Douglas *et al*., 1995). The reduced protein degradation in the rumen and the better AA absorption from the small intestine noted by Barry *et al*. (1986b) and Waghorn *et al*. (1987) could be, responsible for the increased wool growth when *Hedysarum coronarium* (Terrill *et al*., 1992) and *Lotus corniculatus* (Douglas *et al*., 1995; Wang *et al*., 1996a,b) were fed to sheep. However, Barry (1985) found that oral PEG administration in sheep fed *L. pedunculatus* tended ($P < 0.07$) to increase wool growth. This was due to higher level and activity of tannins of *L. pedunculatus*. On addition of PEG, the adverse effects of these tannins were alleviated, leading to the increased voluntary feed intake and to a possible increase of growth hormone (GH) titre.

Milk

In ewes rearing twin lambs, Wang *et al*. (1996a) found that CT from *L. corniculatus* increased milk yield, protein and lactose percentage, reducing fat percentage. The higher protein percentage could be due, as reported by the authors, to an increase of AA and especially essential AA flows from the small intestine. Decandia *et al*. (2000) found that goats browsing a shrubland comprising lentisk (*Pistacia lentiscus*) and *Quercus* spp., increased milk yield and milk urea with no difference in milk fat and protein percentage, when supplemented with PEG. Similar results were reported by Pintus (2000). These results indicate that CT from different plant species have different effects, depending on different levels and activity.

Carcass and meat characteristics

The effect of CT on lamb growth depends on the degree of tannin activity. Terrill *et al*. (1992) found that PEG tended to increase live weight gain and reduce carcass dressing percentage in sheep grazing sulla. Also, Wang *et al*. (1996b) found that PEG given to lambs grazing *L. corniculatus* tended to reduce live weight gain ($P = 0.07$) with no effect on carcass weight. Addition of PEG to a carob-rich diet (Priolo *et al*., 2000) increased lamb daily gain threefold ($P < 0.01$). The presence of CT has been associated with reduced carcass fat content in lambs grazing *L. pedunculatus* (Purchas and Keogh, 1984) and *H. coronarium* (Terrill *et al*., 1992). However, in lambs grazing *L. corniculatus*, Wang *et al*. (1996b) found no difference in carcass fatness. A possible explanation for this reduction of fatness has been suggested by Barry *et al*. (1986a) who found a lower level of GH in lambs when diet (*L. pedunculatus* containing 95 g CT/kg dry matter) were sprayed with PEG. GH increases N retention and reduces carcass fat deposition, with an increase in fat turnover. The reason for the higher level in plasma GH has been explained with a possible inactivation of gut-wall proteins by CT. However Waghorn *et al*. (1994b) have not found difference in the GH titre in lambs fed *L. pedunculatus* with or without PEG.

McLeod (1974) reported that tannins added to the diet of fowls has produced deterioration of taste and odour of the meat. In the field of small ruminant there are only few studies with specific regard to CT and meat quality. In a trial conducted to compare two sorghum strains with different content in CT, lambs fed with the strain containing the higher level of CT showed a meat lighter in colour (Verna *et al*., 1989). Priolo *et al.* (1998a) found that feeding carob pulp in partial replacement of dietary barley to Comisana male lambs between weaning (50 d) and slaughter (100 d) significantly increased *longissimus* muscle (1 h blooming at 4°C) lightness (L*). Animal growth rate, carcass weight, carcass fatness and muscle ultimate-pH were comparable between groups in this experiment. Previous literature had shown that some tannins can reduce blood haemoglobin concentration in cattle fed oak (*Quercus incana*) leaves (Garg *et al*., 1992). The authors (Priolo *et al*., 1998a) hypothesised that tannins were responsible for the differences found in meat colour. A successive experiment designed to evaluate the specific effect of carob pulp CT on lamb growth and meat quality (Priolo *et al*., 1998b, 2000 for more detail), showed that when the effects of CT 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 tannins high astringency. Our previous experiments (Ben Salem *et al*., 2002; Priolo *et al*., 2002) evaluated the effects of CT from *Acacia cyanophylla* foliage on meat quality of Barbarine male lamb. The animals were slaughtered at 230 d of age after being allowed to acacia foliage with or without PEG for 80 days. The *longissimus* muscle (2 h blooming at 4°C) of animal that did not receive the PEG was significantly lighter. This result, together with that of Priolo *et al.* (2000) indicate that tannins from different plant species have similar effect on lamb meat colour. Zembayashy *et al.* (1999) reported that feeding tea leaves to Japanese heifers (476 kg body weight; 174-day of feeding trial) reduced muscle iron content. A strongly negative correlation between muscle iron and meat lightness was also found, and it is concluded that feeding tea leaves would be effective in increasing the luminosity 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 *L. pedunculatus* supplemented with or without PEG. Garg *et al*. (1992) found that although the blood hemoglobin was affected by a strong tannin poisoning in cattle, 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 as suggested by Garg *et al*. (1992).

It is concluded that, in contrast to nutrient utilisation and metabolism, the effects of tannins on product quality are poorly investigated. Available data suggested that low concentrations of CT increased wool growth as a consequence of an increase of rumen escape proteins and higher absorption of amino-acids. Milk yield and proteins may be increased in such conditions. The reverse situation may be observed when CT level in the diet is high. Lighter colour of meat has been obtained with lambs given CT-rich diets.

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