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Effect of foliage-tannins on feeding activity in goats

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SUMMARY - The concept that tannins in foliage reduce the voluntary intake of foliage by goats by evoking negative post-ingestive responses was examined. Meals and breaks between meals of goats fed high-tannin foliage were cyclic; the first meal within each cycle was the longest. Once-daily supplementation of polyethylene glycol (PEG) with a molecular weight of 4000, a tannin-binding agent, increased the duration of feeding activity and decreased the duration of breaks between meals. The cyclic feeding behaviour could be associated with development of food aversion due to interaction of tannins with the rumen epithelium.

Key words: Foliage-tannins, feeding activity, pistacia, goats.

RESUME - "Effet des tannins des feuillages sur l'activité alimentaire des caprins". On a examiné le concept selon lequel les tannins des feuillages réduisent l'ingestion volontaire de ces feuillages par les caprins en évoquant des réponses négatives post-ingestives. Les repas et les pauses entre repas de caprins recevant des feuillages riches en tannins ont été cycliques ; le premier repas de chaque cycle était le plus long. En donnant une fois par jour une supplémentation en polyéthylène-glycol (PEG) de poids moléculaire 4 000, un agent qui lie les tannins, on a augmenté la durée de l'activité alimentaire et diminué la durée des pauses entre repas. Le comportement alimentaire cyclique pourrait être associé au développement d'une aversion vis-à-vis de l'aliment due à l'interaction des tannins avec l'épithélium du rumen.

Mots-clés : Feuillage-tannins, activité alimentaire, pistache, caprins.

Introduction

Tannins are antinutritional phenolic components which are found in the cell sap of approximately 80% of woody and 15% of herbaceous dicotyledonous species (Bryant *et al.*, 1991). Ingestion of tannin-containing food by mammalian herbivores may reduce digestibility, particularly that of protein, and voluntary food intake (Robbins *et al.*, 1987). The effect is accentuated as the level of tannins increases (Silanikove *et al.*, 1996a,b). Once-daily provision of a tannin-binding chemical polyethylene glycol (PEG, molecular weight 4000), improved feed intake and digestibility due to the neutralization of the effects of tannins (Silanikove *et al.*, 1994, 1996a). It was concluded that in goats the effects of tannin on food intake are not associated with those on digestibility (Silanikove *et al.*, 1996a). According to recent concepts, voluntary food intake of ruminants is best understood as an outcome of the interaction between taste and post-ingestive feedback (Forbes, 1995; Provenza, 1995). When animals ingest antinutritional factors, such as tannins, the development of physical discomfort evokes an aversion toward the food that causes malaise (Provenza, 1995).

The concept that tannins reduce voluntary intake of goats by evoking negative post-ingestive responses was examined by studying the effect on goat's feeding activity.

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Materials and methods

Animals. The experiments were carried out with four non-lactating and non-pregnant Mamber goats (a breed indigenous to the Mediterranean woodland) weighing 35 (SD \pm 5) kg. The animals were stall-fed individually in a yard protected from rain and wind and equipped with troughs which enabled quantitative measurement of feed intake.

Foliage. *Pistacia lentiscus* (pistacia) leaves attached to small edible branches (2-3 mm wide) were harvested once a week early in the morning and stored at -20°C. The composition of pistacia leaves has been described in detail elsewhere (Silanikove *et al.*, 1996a).

Feeding behaviour. Feeding activity was measured during 3 consecutive days for 8 hours each day starting from 08:00. The duration of feeding and non-feeding activities of each goat was recorded by an observer. The goats were adapted to pistacia and supplemented with 10 g/day PEG. To record the feeding behaviour of goats given non-supplemented pistacia, PEG supplementation was omitted 4 days before the start of the observation.

Statistical analysis. Statistical analysis was conducted using the general linear model procedures of SAS (1989). The model for food preference was a one-way analysis of variance with separate blocks for each type of foliage, and included the effects of goat and of repetition. The model for eating activity was a two-way analysis of variance with blocks, and included the effects of goat, treatment and repetition. Differences between treatments were determined by Duncan's multiple range test.

Results

Meals and breaks between meals of goats fed a high-tannin pistacia leaf diet were cyclic. The first meal within each cycle was the longest, lasting an average of 32 min in goats supplemented with PEG and 23 min in non-supplemented ones ($P < 0.05$). The subsequent four meals within each cycle lasted only 5 to 1 min and, conversely, the duration of the breaks between meals increased gradually from 5 to 40 min (without PEG), or from 5 to 50 min (with PEG), followed by the next cycle. During the total 8 h of observation, four cycles in which total eating activity lasted 132 min in goats supplemented with PEG, and 91 min in non-supplemented ones, were recorded ($P < 0.05$). Conversely, the non-feeding activity was shorter in goats supplemented with PEG (348 vs 389 min).

Discussion

The longest feeding activity is recorded in ruminants at maintenance when fresh food is provided, followed by several smaller meals after a long break (Forbes, 1995). It was shown that sheep at maintenance can be adapted to consume their entire daily food requirement within 2 h (Ternouth and Beattie, 1971). In goats offered a roughage meal once daily in the morning, Silanikove *et al.* (1993) found a large postprandial drop in the rumen fluid pH, and an increase in the concentration of volatile fatty acids. These goats consumed most of their daily intake during several hours following food presentation. On the other hand, no diurnal variations in pH or in concentration of volatile fatty acids were recorded in goats fed a tannin-rich diet (Silanikove *et al.*, 1996a). These findings are consistent with the cyclic pattern of feeding activity in the present study. It seems that the short cycles of eating provided a nearly steady state environment in the rumen. Thus, it may be concluded that the feeding behaviour of goats fed tannin-rich foliage differs considerably from that of goats fed high-fibre tannin-free diets. Although PEG supplemented once daily neutralized many of the effects of tannins, it did not abolish their specific effect on feeding behaviour.

It was argued by Provenza *et al.* (1990) that condensed tannins from current season growth of blackbrush cause malaise in goats because some of them were reactive (i.e., they were not bound to food protein or cell-wall constituents). The substantial negative protein balance found in goats fed pistacia (Silanikove *et al.*, 1996a) supports the possibility raised by Provenza *et al.* (1990) that it can result only from the interaction of tannins with endogenous proteins of salivary, mucosal or enzyme origin. The cyclic feeding behaviour could be associated with the development of food aversion. This probably developed from an interaction of tannins with the rumen epithelium, because: (i) the possibility that tannins affected other parts of the digestive tract was slight, since the response was

too rapid to allow significant outflow of newly ingested food to the abomasum and the intestine; (ii) the pH was close to neutral and the concentrations of volatile fatty acids in rumen fluid were very low (Silanikove *et al.*, 1996a), both these parameters being far from threshold values that may induce negative feedback signals leading to satiation (Forbes, 1995) and (iii) a subclinical or clinical toxic effect of tannins was ruled out by Silanikove *et al.* (1996b), who showed that there was no effect on biochemical parameters in serum which reflect damage to the liver and kidneys. It is known that tannins, particularly hydrolysable tannins, cause necrosis and ulceration of the epithelium in various parts of the gastro-intestinal tract (McLeod, 1974). Thus, the interaction of tannins with the rumen epithelium may explain the rapid development of malaise through vagal activation of the emetic system in the brain, as suggested by Provenza *et al.* (1990). The increase in voluntary feed intake in goats supplemented with PEG can be related to a reduction in the amount of reactive tannins in rumen fluid (Silanikove *et al.*, unpublished results), which allow an increase in the duration of feeding. The increase in the mass of rumen content may reflect the increase in the mass of tannin-rich foliage required to halt feeding.

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