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Feeding behaviour patterns and water intake in sheep and goats fed alfalfa hay treated with quebracho

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SUMMARY – Eight Merino sheep (49.4 ± 4.23 kg live weight, LW) and eight Alpine goats (53.2 ± 2.51 kg LW) were used in two experiments to study the changes in the feeding behaviour of the animals in response to the addition of quebracho to alfalfa hay. All the animals were fed 20 g dry matter (DM)/kg LW alfalfa hay for 15 days. After this period, four sheep and four goats were given alfalfa hay treated with 50 g quebracho/kg DM (Q) for 60 days, whereas the other animals were given untreated alfalfa hay (A) and used as the control group. Feeds were distributed once daily. Feeding behaviour was recorded on two consecutive days by videotaping the head of the animals. To follow medium-term changes, feeding behaviour was studied in three experimental periods, one (P1), 30 (P2) and 60 (P3) days after starting the administration of alfalfa hay treated with quebracho. Time spent eating (ET) and ruminating (RT) were similar with both diets. Mean values of the ET for the A and Q diets were 176 vs 224 min/d [standard error of mean (SEM) 18.7] for sheep, and 244 vs 260 min/d (SEM 20.1) for goats; and those for RT were 389 vs 421 min/d (SEM 45.2) for sheep, and 474 vs 486 min/d (SEM 27.4) for goats, respectively. The number of eating bouts (EB) was not significantly affected by the diet with mean values of 12.3 vs 10.9 (SEM 1.04) for sheep, and 11.7 vs 14.6 (SEM 2.18) for goats, for A and Q respectively. There were no significant differences in ET and RT between the three periods studied and there was a significant decrease in EB from P1 to P2 and P3 that was similar in both diets. Water intake (l/kg DM) was higher ($P < 0.05$) when sheep were fed Q diet (4.55 vs 3.28 SEM 0.444). On the contrary, water intake was not affected by the diet in goats.

Key words: Quebracho, tannins, feeding behaviour, water intake, sheep, goats.

RESUME – *"Comportement alimentaire et consommation d'eau chez des moutons et des chèvres recevant du foin de luzerne traité avec du quebracho". Huit moutons de race Mérinos (49,4 ± 4,23 kg poids vif, PV) et huit chèvres Alpines (53,2 ± 2,51 kg PV) ont été utilisés dans deux expériences pour étudier les changements du comportement alimentaire des animaux en réponse à l'addition du quebracho au foin de luzerne. Tous les animaux ont reçu 20 g matière sèche (MS)/kg PV de foin de luzerne pendant 15 jours. Après cette période, quatre moutons et quatre chèvres ont reçu le foin de luzerne traité avec 50 g quebracho/kg MS (Q) pendant 60 jours, tandis que les autres animaux ont reçu le foin de luzerne non traité (A ; groupe témoin). L'aliment a été distribué une fois par jour. Le comportement alimentaire a été enregistré pendant deux jours consécutifs en enregistrant en vidéo la tête des animaux. Pour suivre les changements à moyen terme, le comportement alimentaire était étudié en trois périodes expérimentales, commençant à 1 (P1), 30 (P2) et 60 jours (P3) après l'administration du foin de luzerne traité avec le quebracho. La durée d'ingestion (ET) et de rumination (RT) ont été similaires pour les deux rations. Les valeurs moyennes de ET pour les rations A et Q ont été de 176 vs 224 min/j (SEM 18,7) pour les moutons, et de 244 vs 260 min/j (SEM 20,1) pour les chèvres ; et celles de RT ont été de 389 vs 421 min/j (SEM 45,2) pour les moutons, et de 474 vs 486 min/j (SEM 27,4) pour les chèvres, respectivement. Le nombre de repas (EB) n'a pas été sensiblement affecté par la ration, avec des valeurs moyennes de 12,3 vs 10,9 (SEM 1,04) pour les moutons, et 11,7 vs 14,6 (SEM 2,18) pour les chèvres, pour A et Q respectivement. Il n'y a eu aucune différence significative de ET et RT entre les trois périodes étudiées et il y a eu une diminution significative de EB de P1 vers P2 et P3 qui a été similaire dans les deux rations. La prise d'eau (l/kg PV) a été plus élevée ($P < 0,05$) quand les moutons ont reçu la ration Q (4,55 vs 3,28 SEM 0,444). Au contraire, la prise d'eau n'a pas été affectée par la ration chez les chèvres.*

Mots-clés : *Quebracho, tannins, comportement alimentaire, consommation d'eau, ovins, caprins.*

Introduction

Tannins are compounds widely distributed in the plant kingdom, and often present in the diet of herbivores. Plant tannins are classified in two major groups: hydrolysable and condensed tannins (CT). Tannins reduce intake and digestibility of feeds by ruminants (Butter *et al.*, 1999; Salem *et al.*, 2001b). This effect has been associated with their capacity to bind proteins and carbohydrates (Mehansho *et al.*, 1987; Makkar and Becker, 1998), decreasing the palatability of feed (Wong, 1973;

McLeod, 1974; Hagerman and Butler, 1991; Jackson *et al*., 1996) and the activity of rumen microbial and intestinal enzymes (Dawson *et al*., 1999; McSweeney *et al.*, 2001). To study the nutritional effects of tannins, spray-dried meal from the south American tree *Aspidosperma quebracho* (quebracho) has been extensively used as a source of CT in *in vivo* (Dawson *et al*., 1999; Landau *et al*., 2000; Ramos *et al*., 2001; Salem *et al*., 2001b) and *in vitro* experiments (Makkar *et al*., 1995; Yu *et al*., 1995; Salawu *et al*., 1997).

Some animal species have developed adaptive mechanisms to counteract the antinutritional effects of tannins. Changes in the feeding behaviour of the animals are one of these mechanisms but available data are sparse (Silanikove *et al*., 1997; Landau *et al*., 2000). The purpose of the work presented herein was to investigate the effect of feeding alfalfa hay treated with quebracho tannins on the feeding behaviour patterns and water intake (WI) in sheep and goats.

Materials and methods

Animals and diets

Sixteen adult, non-pregnant and non-lactating animals [eight Merino sheep (49.4 ± 4.23 kg live weight, LW) and eight Alpine goats (53.2 ± 2.51 kg LW)] were used in two experiments with identical design. In both trials the animals were housed in individual pens and fed 20 g dry matter (DM)/kg LW of chopped (3-4 cm) alfalfa hay [168 g crude protein (CP) and 503 g neutral detergent fibre (NDF) per kg DM] for 15 days. After this period of adaptation to the basal diet, level of intake and experimental conditions, four sheep (experiment 1) and four goats (experiment 2) were given alfalfa hay treated with 50 g quebracho/kg DM of hay (Q) for 60 days, whereas the other animals were given untreated alfalfa hay (A) and used as the control group. The quebracho (Roy Wilson Dickson Ltd., United Kingdom) was daily dissolved in tap water (250 g quebracho/l water), sprayed on hay and thoroughly mixed by hand just before feeding the animals. The same volume of tap water was also sprayed on the A diet. Feeds were distributed once daily in the morning (09:00 a.m.), and animals had free access to clean water and to trace-mineralized salt blocks.

Feeding behaviour

Feeding behaviour was observed continuously during 48 hours by videotaping the head of the animals in each of three experimental periods, at one (P1), 30 (P2), and 60 (P3) days after starting of the administration of the Q diet. The feeding behaviour parameters analysed were: time spent eating (ET), and ruminating (RT) (both in min/d), the intake rate (IR, g DM/min of eating) and the number of eating bouts (EB, bouts/day).

Water intake

WI [l/kg of dry matter intake (DMI)] was recorded by measuring the amount of water added daily to restore the initial level of water in the drinker.

Statistical analysis

Data were analysed by ANOVA, using a split-plot in time design in which the diet (A, Q) was the main plot and the experimental period (time after start feeding quebracho treated hay) the subplot (Steel and Torrie, 1980).

Results

Quebracho treated hay was not rejected by the animals, although the feed intake of diet Q throughout the experiment was not as regular as that with diet A. The effects of the inclusion of treating alfalfa hay with quebracho tannins on feeding behaviour and WI at different experimental periods in sheep and goats are shown in Table 1.

Table 1. Average time spent eating (ET, min/day) and ruminating (RT, min/day), intake rate (IR, g DM/min of eating), number of eating bouts (EB, bouts/day) and water intake (WI, l/kg DMI) in sheep and goats fed alfalfa hay (A) or alfalfa hay treated with 50 g quebracho/kg DM (Q), in each of three experiment periods [after one (P1), 30 (P2), and 60 (P3) days from beginning of the administration of quebracho treated hay]

	Diet	Period			(SEM)† and LS††		
		P1	P2	P3	Diet	Period	D × P
Sheep							
ET	A	203	176[b]	148 †	(18.7)	(13.4)	(18.9)
	Q	240	231[a]	201 †	NS	NS	NS
RT	A	417	347	403	(45.2)	(34.6)	(48.9)
	Q	432	422	409	NS	NS	NS
IR	A	4.29	4.89	5.95 †	(0.58)	(0.29)	(0.41)
	Q	3.46	4.16	4.28 †	NS	NS	NS
EB	A	16.1	11.2	9.6	(1.04)	(0.77)	(1.08)
	Q	13.7	9.2	9.6	NS	***	NS
WI	A	3.59	3.57	2.67[b]	(0.44)	(0.55)	(0.81)
	Q	4.89	5.64	6.13[a]	*	NS	NS
Goats							
ET	A	250	269	213	(20.1)	(13.2)	(18.7)
	Q	281	254	245	NS	NS	NS
RT	A	414	523	484	(27.4)	(37.6)	(53.1)
	Q	506	478	475	NS	NS	NS
IR	A	3.46	3.17	3.90	(0.42)	(0.20)	(0.29)
	Q	2.78	3.60	4.02	NS	**	NS
EB	A	13.5[b]	11.0 †	10.7 †	(2.18)	(0.74)	(1.04)
	Q	16.9[a]	13.0 †	13.8 †	NS	**	NS
WI	A	3.56	3.65	2.99 †	(0.43)	(0.28)	(0.39)
	Q	3.91	3.77	3.81 †	NS	NS	NS

†SEM: standard error of the mean.

††LS: level of significance, NS: not significant, *P < 0.05, **P < 0.01, ***P < 0.001.

[a,b]Within each column and parameter, means with different superscripts represent significant differences (P < 0.05) between A and Q. The symbol † represents a tendency (P < 0.10) for significant differences.

In both sheep and goats time spent eating was about 30 min longer when fed the diet Q than with the control diet (A) during P1 (immediately after the starting of feeding the animals with the diet Q), but the differences were not significant (P > 0.05). After 30 days (P2) on the diet, the sheep fed diet Q spent almost one hour more time eating than the sheep fed diet A (P < 0.05), whereas no significant (P > 0.05) effect of treating hay with quebracho on ET in goats was observed. In P3 (after two months), the sheep and goats fed diet Q spent more time eating than those receiving diet A, but differences were not significant (P > 0.05), although for sheep there was tendency (P < 0.10) towards longer ET.

Rumination time was more variable than eating time, and the differences between diets were not statistically significant (P > 0.05) in any experimental period.

On average the consumption of the diet Q was associated with longer ET (176 vs 224 min/d in sheep and 244 vs 260 min/d in goats, for diets A and Q, respectively) and RT (389 vs 421 min/d in sheep and 474 vs 486 min/d in goats, for diets A and Q, respectively). However, the differences did not reach the level of statistical significance (P > 0.05) in any species. Furthermore, there were no significant differences (P > 0.05) among the three experimental periods in ET and RT.

In sheep, IR was lower in Q that A diet, and the differences between diets were larger in P2 and P3 than in P1. However, the differences between diets were not statistically significant (P > 0.05) at

any experimental period, although tended to be significant ($P < 0.10$) after 60 days of starting the administration of diet Q. No significant differences ($P > 0.05$) in IR between diets were observed in goats at any experimental period.

The addition of quebracho to the hay resulted in different responses in sheep and goats in the number of EB. In sheep, the number of EB was smaller with diet Q than with diet A, although differences were not significant. In goats, the number of EB was larger with diet Q, with significant differences between diet in P1, and differences that tended ($P < 0.10$) to be significant in P2 and P3.

On average, in both species IR and EB were not affected by the diet. Whereas there was a significant ($P < 0.05$) decrease in EB from P1 to P2 and P3, no change in IR in sheep and a significant increase ($P < 0.01$) between P1 and P3 in goats were observed.

WI was always higher when the animals were fed the Q diet, but the differences only reached or tended to reach the level of significance at P3 ($P < 0.05$ for sheep and $P < 0.10$ for goats). On average the effect of the diet on WI was significant ($P < 0.05$) only for sheep and was unaffected by the experimental period.

Discussion

The longer ET and the lower IR found in P1 – i.e. during the first day of feeding quebracho treated hay – for the animals fed the diet Q may indicate a lower palatability induced by the addition of quebracho that could be due to the binding of CT with salivary proteins in the mouth (Wong, 1973), to a direct effect on gustative receptors (McLeod, 1974) and/or to the astringent bitterness taste felt in the mouth (Jackson *et al*., 1996). The mechanisms chosen to minimize the negative effects of CT on the palatability seemed to be different in sheep than in goats. Sheep reduced the number of meals (EB), each of longer duration as tended to spend more time eating during the day. On the other hand, goats increased the number of EB without affecting the total time spent eating during the day.

Sheep maintained this behaviour (longer ET, lower IR and smaller EB when fed the diet Q) after 30 (P2) and 60 (P3) days being fed the diet Q. However, in goats there were some medium-term changes in the feeding behaviour patterns, as the differences in ET and EB between the animals fed the diet Q and those receiving the diet A were reduced from P1 to P3. On the other hand, IR in goats fed diet Q tended to increase from P1 to P3. These results would suggest that goats may be more tolerant to tannins than sheep, by developing some adaptive mechanisms in response to the presence of tannins in the diet (Provenza and Malechek, 1984; Silanikove *et al*., 1996; Kababya *et al*., 1998).

The increase in WI (l/kg DMI) when the animals were fed the diet Q may suggest a means to rinse out or dilute the soluble tannin-protein complexes and remove the bitterness taste felt in the mouth (Landau *et al*., 2000). The fact that the differences in WI were higher in sheep than in goats could be due to a different response between sheep and goats in the secretion of saliva (Salem *et al*., 2000, 2001a) that again may reflect a better ability in goats than in sheep to neutralize the adverse effects of tannins.

Conclusion

The short- and medium-term responses in feeding behaviour to the inclusion of CT from quebracho in the diet tends to be different in sheep and goats, and could suggest that goats are more tolerant than sheep to the consumption of tannins.

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