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The effects of supplementation with green tea waste on *in vivo* and *in vitro* rumen fermentation in cattle

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ABSTRACT

Ensiled green tea waste (GTW) was offered to growing cattle as a protein supplement compared to lucerne hay cube. Rumen fermentation was evaluated by *in vivo* rumen pH, volatile fatty acids (VFA) and NH_3-N as well as *in vitro* gas production from hay, maize, and soyabean meal. GTW contained about 340 g/kg crude protein (CP), 90 g/kg total extractable tannins and 14 g/kg condensed tannins, and was offered as protein supplement to growing cattle. GTW silage made up 56 g/kg DM and 130 g/kg CP of the diet in this performance trial. Gas production from maize incubated with rumen fluid of cattle fed GTW was reduced compared with cattle fed lucerne hay cube during 2 months. However, VFA and NH_3-N concentrations of *in vivo* rumen were not affected and growth performance of cattle was similar to lucerne hay cube treatment. It is concluded that GTW silage could be used as protein supplement in a low proportion (about 50 g/kg DM and 130 g/kg CP of diet) in the ration for growing cattle.

KEY WORDS: green tea waste, protein supplement, tannin, rumen fermentation, *in vitro* gas production, cattle

INTRODUCTION

Tea is one of the world's most popular beverages, and more than 3 million tons of tea leaf were produced in 2002. In Japan, beverage companies manufacturing various tea drinks produce about 100 thousand tons of tea leaf waste annually. Green tea waste (GTW) contained 280 g/kg DM of crude protein (CP) and 90 g/kg DM of tannins (Kondo et al., 2004). Kondo et al. (2004) found that GTW has a potential of protein supplement for low-quality forages. However, it is still necessary to evaluate GTW as a feedstuff from the point of rumen fermentation.

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In this study, the activity of rumen fermentation in cattle fed GTW was assessed with parameters such as in vivo pH, NH_3-N, volatile fatty acids (VFA) concentration and also in vitro gas production using rumen fluid obtained from the animals fed GTW. Simultaneously, growth performance in cattle fed GTW silage substituted with lucerne hay cube was investigated to evaluate the value of GTW as a protein supplement.

MATERIAL AND METHODS

Animals and dietary treatments

Ten Japanese Black beef cattle (6 female and 4 castrates) were divided into two groups (each group had 3 females and 2 castrates) and housed in two groups. At the start of the preliminary period, the mean body weight of the animals was 263.5 kg. The diets were as follows:

a. Commercial concentrate plus timothy hay plus lucerne hay cube (LHC);

b. Commercial concentrate plus timothy hay plus GTW silage (GTWs).

Both treatments had the same amount of commercial concentrate and timothy hay. Lucerne hay cube or GTW silage was added as a protein supplement. The diets designed to satisfy the nutrient requirements of growing cattle were offered in fixed quantities. Rumen fluid was collected 4 h after the morning feed at month 0, 0.5, 1 and 2 for pH, VFA and NH_3-N analysis as well as *in vitro* gas production.

In vitro gas production experiment

The degradation characteristics of timothy hay, maize and soyabean meal were measured by *in vitro* gas production technique (Menke et al., 1979). Two hundred mg sample ground to 1 mm screen was incubated in 100 ml glass syringes with 30 ml buffered rumen fluid from the cattle fed experimental diets. The glass syringes containing samples and rumen fluid-buffer mixtures were incubated in a water bath at 39°C, and subsequently gas production (ml/200 mg DM) was measured before incubation (0 h) and at 2, 4, 6, 8, 10, 12, 24, 48 and 72 h and fitted to the model described as $G = a + b(1 - e^{-ct})$ (Ørskov and McDonald, 1979).

Table 1. Chemical compositions of feedstuffs

Feed	DM	CP	NDF	TEPH	TET	CT
	g/kg			g/kg DM		
Timothy hay	894	103	652	12.6	3.1	0.9
Commercial concentrates	885	184	299	4.4	0.9	0.1
Lucerne hay cube	884	176	426	7.2	1.3	N.D.
GTW silage	199	337	321	109.8	89.7	13.5

TEPH- total extractable phenolics, TET- total extractable tannins, CT- condensed tannins, N.D.- not detected

RESULTS

The chemical composition of the feedstuffs fed to growing cattle in experiment 2 is presented in Table 1. CP content in GTW was higher than in timothy hay, formulated commercial concentrates and lucerne hay cube. In this experiment, the amount of CP from lucerne hay cube or GTW silage covered 130 g/kg CP of the whole diets given to cattle. TET and CT contents in GTW silage were higher than in the other feedstuffs (Table 1). GTW silage was added at a rate of 56 g/kg DM of total feed in GTWs treatment. TET and CT concentrations of the whole diets given to cattle were 3.2 and 8.2 g/kg DM, 0.4 and 1.2 g/kg DM in LHC and GTWs treatments, respectively.

Table 2. *In vitro* gas production characteristics of timothy hay, maize and soyabean meal in beef cattle fed the diets with lucerne hay cube (LHC) or GTW silage (GTWs) on months 0, 0.5, 1 and 2

Month	Diet	a + b (ml)					
		Timothy hay		Maize		Soyabean meal	
0	LHC	56.6		90.9		51.3	
	GTWs	60.2		97.9	+	49.2	
0.5	LHC	70.6		108.0		62.8	
	GTWs	59.6		89.1	+	60.5	
1	LHC	60.5		102.9		69.5	
	GTWs	60.3		91.4	*	64.0	
2	LHC	69.9		106.4		67.7	
	GTWs	57.0	+	94.4	+	53.6	+

+,* means of GTWs with these marks are significantly different from that of LHC, +: $P<0.10$, * - $P<0.05$

Rumen pH, VFA and NH_3-N concentrations on months 0, 0.5, 1 and 2, were not significantly different among the treatments on each month. Potential gas production (a + b) from maize incubated with rumen fluid of GTWs treatment tended to be lower ($P<0.10$) on months 0.5 and 2, and significantly lower on month 1 ($P<0.01$) (Table 2). With incubated timothy hay and soyabean meal, no treatment differences were observed in months 0.5 and 1, but in month 2 the gas production tended to be lower ($P<0.10$) on the GTWs treatment. The fractional rate of gas production from any substrate incubated with rumen fluid from both treatments was not significantly different. Although the experiment lasted three months, the body weight gain did not differ significantly between treatments.

DISCUSSION

Although the *in vitro* gas production from the incubated feedstuffs, particularly maize, was decreased on the GTWs treatment, rumen parameters (pH, VFA and NH_3-N) were not affected by GTW silage ingestion. One of the differences between LHC and GTWs treatment was the intake of tannins. Hervas et al. (2003) reported that rumen VFA and NH3-N concentration was not affected, but *in vitro* gas production and *in sacco* degradation of hay was decreased by tannin intake. The GTWs treatment resulted in higher amounts of tannins than the LHC treatment, but the amount was relatively lower than reported earlier (e.g., Hervas et al., 2003). We assume that the structure of tannins in GTW might be important for anti-nutritive effects. Another possibility is that in this study, the *in vitro* gas production might overestimate the effect occurring *in vivo*.

GTW silage contributed about 130 g/kg of the total N intake. Growth performance in beef cattle supplemented with GTW silage was similar to that obtained with lucerne hay cube. These data suggest that GTW could be a useful protein supplement similar to lucerne hay cube. The suppression of *in vitro* gas production from several feedstuffs on the GTW treatment seems to have no relation to rumen VFA, NH_3-N concentration and body weight gain.

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