

Effects of Flavomycin on Ruminal Fermentation, *In Situ* Degradability and *In Vivo* Digestibility in Bovine Fed Sugarcane Diets

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Abstract: Problem statement: The aim of the present study was to characterize and differentiate the effects of addition of flavomycin or monensin on ruminal fermentation and degradability as well as on total digestibility in bovine. **Approach:** Twelve non-pregnant and non-lactating cows (736 kg of BW) were randomly assigned to three treatments: control, flavomycin (20 mg animal⁻¹ day⁻¹) and monensin (300 mg animal⁻¹ day⁻¹). The trial lasted 21 days. The last 10 days were used for external marker administration (15 g of chromic oxide animal⁻¹ day⁻¹). The last 5 days of the trial were used for feces collection and evaluation of corn grain, soybean meal or sugarcane ruminal degradability and the 21st day was used for ruminal fluid sampling. **Results:** Monensin increased 27.2%, on average, propionate molar proportion at 0, 4, 6, 8, 10 and 12 h after feeding, compared to control and flavomycin groups. When compared to control, flavomycin reduced the degradation rate of soybean meal CP in 31.0%, decreasing the effective degradability when passage rates of 5 and 8% h⁻¹ were used. Dry matter intake, pH, total Short Chain Fatty Acids (tSCFA) or ammoniacal Nitrogen (NH₃-N) concentration were not influenced by the addition of either antibiotics. Effective degradability of sugarcane NDF was not influenced by the use of either antibiotic; neither were the TDN nor the digestibility of DM, CP, EE, NFE, ADF, NDF, GE or starch of the diet. **Conclusion/Recommendations:** In the present study, it was possible to show the beneficial effects of monensin but not of flavomycin, on rumen fermentation.

Key words: Intake, ionophore, non-ionophore antibiotic, ruminant, short chain fatty acids

INTRODUCTION

It is widely accepted that the controlled administration of certain antibiotics can be useful for ruminants, swine and poultry (Parker and Armstrong, 1987). Since antibiotics started to be used in animal nutrition, it has been suggested that the observed improvement in performance is due to antimicrobial action on gastrointestinal microbiota (Parker and Armstrong, 1987).

In ruminants, several types of chemical agents and antibiotics have been developed in order to manipulate the fermentative digestion and flux of nutrients from rumen (Rodrigues *et al.*, 2001). Nowadays, most of the

products used for ruminants are ionophores and in less scale, non-ionophores antibiotics. There is little information available on the effects of non-ionophores antibiotics applied in animal nutrition. These antibiotics represent a diversified group with differences in their chemical composition, antimicrobial spectrum, mode of action, molecular weight and capacity of absorption by small intestine. Avoparcin, flavomycin, tilosin and virginamicin could enhance animal growth by the modification of ruminal fermentation products (Nagaraja *et al.*, 1997).

Flavomycin has been exclusively used as a growth promoter and its mode of action on ruminal bacterial

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population seems to differ from well-characterized ionophores (Febel *et al.*, 1988). Flavomycin is a phosphoglycolipid antibiotic that acts inhibiting bacterial growth by competitive inhibition of the enzyme that catalyzes transglycosylation reaction during the synthesis of peptideoglycan layer (Van Heijenoort, 2001). This inhibition occurs mainly in Gram-positive bacteria, which has larger peptideoglycan layer. Flavomycin mainly inhibits two groups of bacterias, ones from the group High Activity of Ammonia Production (HAAP) and also Gram-negative fusobacteria, where both groups have high specific activity of desamination (Edwards *et al.*, 2005).

Chen and Russell (1991); Dennis *et al.* (1981); Duffield *et al.* (1998); Funk *et al.* (1986); McGuffey *et al.* (2001); McKain *et al.* (2000); Phipps *et al.* (2000); Ovchinnikov (1979) and Schelling (1984) are trying to characterize the antimicrobial mode of action and clarify how these agents act in digestive efficiency improvement and, consequently, animal productivity.

With the recent search of new ruminal fermentation modifiers around the world, the aim of the present study was to test the effects of flavomycin and sodium monensin administration on ruminal fermentation and degradability, as well as on total digestion of nutrients in cattle fed diets with sugarcane as forage source.

MATERIALS AND METHODS

Animals and design: All animal care and personnel were trained and animals were cared for, according to the guidelines established by University of Sao Paulo State (Brazil) Ethical Committee for Animal Research (ECAR).

The trial was conducted at the College of Veterinary Medicine and Animal Science at University of Sao Paulo (USP), Brazil. Twelve Holstein × Zebu non-pregnant dry cows, fitted with ruminal cannulas, averaging 736 kg of initial body weight were used. Cows were housed in a tie-stall barn equipped with individual feed bunks, rubbermatted floors and automatic water buckets common to each 2 animals. There were fans on the ceiling in order to relieve the high temperatures during the day. The experimental design was completely randomized with three treatments: (1) Negative control (absence of antibiotics), (2) Treated (flavomycin) and (3) Positive control (sodium monensin). Flavomycin was used at the dose 20 mg animal⁻¹ day⁻¹ (250 mg of commercial product animal⁻¹ day⁻¹), following suggestion of the product maker. For monensin treatment the commercial product Rumensin® (Elanco) was used at the dose 300 mg of sodium monensin animal⁻¹ day⁻¹

Table 2: Chemical composition of feeds (percentage of DM)

(3.0 g of commercial product animal⁻¹ day⁻¹). Each product was weighted separately in analytical scale and packed in envelopes prepared in absorbent tissue paper. They were administered through ruminal cannulae, twice a day, at the moment of the meals and mixed in ruminal content through manual agitation. Animals were fed at 0800 and 1600, except on 21 day, when the second meal was offered only after ruminal fluid collection at 2000. Diets were fed as Total Mixed Ratios (TMR), for *ad libitum* consumption (minimum of 10% feed refusal), with a ratio of concentrate to forage of 60:40 (DM basis) (Table 1).

Sampling, measurements and analyses: Experimental period consisted of 21 days; the first 11 days were designated to adaptation of animals to diets. Between the 12 and 21 day the digestibility trial was performed, between the 17 and 21 day, dry matter feed intake evaluation and *in situ* degradability and the 21st day was used for ruminal fluid sampling.

The *in situ* degradability of NDF from sugarcane, starch from corn grain and CP from soybean meal was measured by nylon bag technique (Mehrez and Orskov, 1977). Nylon bags with a porosity of 50 µm (10.0 X 20.0 cm) were filled with approximately 6 g of feed previously dried at 55°C for 72 h and grinded in sieve of 5 mm. Bags were weighed, tied and stored in a refrigerator (5°C) before use. Nylon bags were attached to the rumen cannulae by a nylon thread with a minimum of 50 cm length and incubated during 0; 6; 12; 24; 48; 72 and 96 h for fiber source, 0; 3; 6; 12; 24; 48 and 72 h for energy source and 0; 1.5; 3; 6; 12; 24 and 48 h for protein source.

Table 1: Ingredients and chemical composition of diets (DM basis)

Ingredients	Proportion (%)
Sugarcane	40.00
Grounded corn grain	39.80
Soybean meal	18.40
Limestone	0.30
White salt	0.50
Mineral mixture ¹	1.00
	100.00
	Composition
DM (%)	44.31
CP (%)	14.76
RDP (% of CP) ²	64.50
RUP (% of CP) ²	35.50
ADF (%)	22.16
NDF (%)	29.67
EE (%)	2.24
NEL (Mcal kg ⁻¹) ²	1.55
Ca (%)	0.44
P (%)	0.26

¹: Composition per kg of mineral mixture: 180 g Ca; 90 g P; 20 g Mg; 20 g S; 100 g Na; 3,000 mg Zn; 1,000 mg Cu; 1,250 mg Mn; 2,000 mg Fe; 200 mg Co; 90 mg I; 36 mg Se; 900 mg F (maximum); ²: Estimated by NRC (2001); RDP: Rumen Degradable Protein; RUP: Rumen Undegradable Protein; NEL: Net Energy for Lactation

Feed	DM (%)	CP	EE	Ash	NDF	ADF	Starch	Ca ¹	P ²
Sugarcane	25.30	1.51	0.87	1.03	55.63	36.99	0.19	0.17	0.04
Corn grain	87.90	9.61	4.09	1.29	13.90	8.30	61.44	0.03	0.22
Soybean meal	89.10	50.05	1.71	6.24	11.77	6.57	0.47	0.32	0.61

¹Ca: Calcium, ²P: Phosphorus

After incubation period, all bags were washed thoroughly by hand and dried at 55°C for 72 h for later weighing and chemical analyses as described later on the text. Results of chemical analysis of each feed are described at Table 2.

Degradability at time zero was measured by washing bags in water (39°C) for 15 min (Cummings *et al.*, 1983). For degradation parameters estimative, the model proposed by Orskov and McDonald (1979): $p = a + b(1 - e^{-ct})$ were used, where p is the degradation at each time, “ a ” is the soluble fraction; “ b ”, the potentially degradable fraction of the insoluble fraction that would be degraded at a rate “ c ”; “ c ”, the rate of degradation of fraction “ b ” and “ t ”, the incubation period in hours. Potential degradability (Pd) was calculated as: $a + b$. The effective ruminal degradability (Ed) was calculated according to the mathematic model proposed by Orskov and McDonald (1979): $Ed = a + [(b \times c)/(c + k)]$, where “ k ” is the passage rate of solids by the rumen, defined as 0.02, 0.05 and 0.08% h^{-1} .

Digestibility trial consisted of 10 days from the 11th to 21st day of each experimental period. The first five days (11-16 day) were used for marker adaptation and the last five days (17-21 day) for sample collection. Chromic oxide was used as an external marker to estimate apparent nutrient digestibility, according to Bateman (1970). For each animal, Dry Matter Intake (DMI) was measured at the last five days of each period and grab samples of feces (approximately 200 g) were collected directly from the rectum at the last five days of the period. Cows received the chromic oxide, through ruminal cannulae, at 15 g $animal^{-1} day^{-1}$, twice a day (7.5 g of the marker/dose), at the moment of the meals, through absorbent paper envelopes. The chromic oxide concentration was determined by colorimetry through its reaction with σ -difenilcarbazine, according to Williams *et al.* (1962).

After drying at 55°C for 72 h, feed and fecal samples were ground to pass a 1-mm screen. Composite samples per cow were used to determine DM (AOAC, 1990); OM determined by ash (AOAC, 1990); CP obtained by total N determination using the micro-Kjeldahl technique (AOAC, 1990); Ether Extract (EE) determined gravimetrically after extraction using petroleum ether in a Soxhlet instrument (AOAC, 1990); NDF (with heat-stable α -amylase) and ADF according to Van Soest *et al.* (1991). Starch analysis was done

according to Pereira and Rossi (1995), with previous extraction of soluble carbohydrates, as proposed by Hendrix (1994).

Ruminal fluid samples were collected at 21 day of each period, through ruminal cannulae with a vacuum pump at 0, 2, 4, 6, 8, 10 e 12 h after the morning meal. Approximately 500 mL of rumen fluid were collected, in each time, from three different parts of the rumen. It was returned to the pre-ventricle after the collection of the samples. Immediately after collection, 100 mL of rumen fluid was used for pH determination with a portable digital pH meter (HANNA instruments HI8424) calibrated with solutions of pH 4.0 and 7.0. Then, samples were prepared and stored for further analyses of Short-Chain Fatty Acids (SCFA) and ammoniacal Nitrogen (NH₃-N) concentration.

For SCFA analyses, a fraction of approximately 100 mL of rumen fluid was centrifuged at 2000×g for 20 min; 2 mL of the supernatant was added to 0.4 mL of formic acid and frozen at -20°C for further analyses, according to Erwin *et al.* (1961). For this evaluation, a gas chromatography was used (model: 9001; Finnigan) equipped with a glass column of 4 feet of length and ¼ inch of diameter packed up with 80/120 Carbowax B-DA/4%. For NH₃-N concentration determination, 2 mL of the supernatant were added to 1 mL of 1 N sulphuric acid solution and the centrifuge tubes immediately frozen until the analyses by colorimetric, according method described by Kulasek (1972).

Statistical analysis: Results were analyzed by Statistical Analysis System software (SAS Institute Inc. 2001). Data of dry matter feed intake, *in situ* degradability and *in vivo* digestibility were submitted to analysis of variance (PROC GLM from SAS), which separated the treatment effect as the only cause of variation. Data of pH, SCFA and NH₃-N in ruminal fluid were analyzed as described previously, but also added the factor repeated measures in time (command REPEATED from GLM from SAS), regarding several times of sampling collection. In presence of interaction between time and treatment, analysis of variance was done inside each time through command SLICE (GLM from SAS). The effects of treatments were separated by Duncan test. Effects were declared significant at $p \leq 0.05$.

RESULTS

Values of dry matter intake are presented at Table 3. Neither of tested antibiotics altered ($p > 0.05$) dry matter feed intake, even if data were expressed in $\text{kg animal}^{-1} \text{ day}^{-1}$, in percentage of body weight or in g kg^{-1} of metabolic weight day^{-1} .

Ruminal fermentation data are presented at Table 4. There was an interaction between time and treatment for variables pH ($p = 0.0219$), total concentration of Short Chain Fatty Acids (tSCFA) ($p = 0.0425$), molar proportion of acetate ($p = 0.0246$), propionate ($p = 0.0155$) and acetate: Propionate ratio ($p = 0.0170$).

Although there was an interaction between time and treatment for variables pH ($p = 0.0219$) and tSCFA ($p = 0.0425$), there was no effect of treatment when the analyses were performed inside each time.

When the effects of treatment were evaluated inside each time, in presence of interaction, it was observed that only monensin decreased molar proportion of acetate and acetate: Propionate ratio at 0 h (data not shown). In relation to propionate, monensin increased ($p > 0.05$) its molar proportion at 0, 4, 6, 8, 10 and 12 h, in relation to control group (Fig. 1). In relation to molar proportion of butyrate, there was an absence of treatments effect.

In general, sodium monensin increased molar proportion of propionate in 27.2% (equivalent to 5.26% units) in relation to control group, considering all measurement times. Flavomycin did not alter this variable in relation to control group.

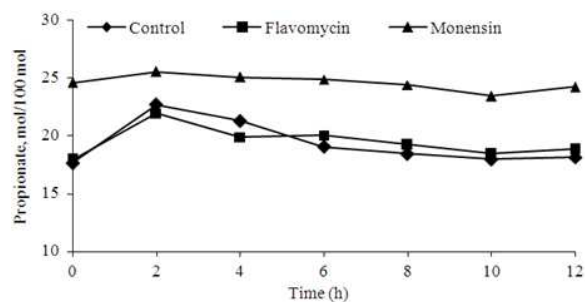


Fig. 1: Molar percentage of propionate in ruminal fluid

Table 3: Dry matter intake obtained with different treatments¹

	Treatments ²			Mean	SEM	Prob.
	Control	Flavomycin	Monensin			
DMI	10.56	8.93	11.33	10.27	0.57	NS
DMI/BW	1.37	1.25	1.50	1.37	0.06	NS
DMI/BW ^{0.75}	72.13	64.55	78.71	71.80	3.40	NS

¹DMI: Dry Matter Intake ($\text{kg animal}^{-1} \text{ day}^{-1}$), DMI/BW: Dry Matter Intake per Body Weight (%), DMI/BW^{0.75}: Dry Matter Intake per kg of metabolic Body Weight (g kg^{-1} of BW^{0.75}), SEM: Standard Error of Mean; Prob: Statistical Probability; NS: Non-Significant; ²: Rows with different letters differ by Duncan test (5%)

No tested treatment altered ruminal degradability parameters of sugarcane NDF (Table 5).

For corn grain starch (Table 5), monensin and flavomycin differed ($p < 0.05$) in effective degradability, although none of them differed from control group. Differences were 9.6%, 19.1% and 24.3% for passage rates of 2, 5 and 8% h^{-1} , taking as basis the increase caused by monensin in relation to the group treated with flavomycin.

Table 4: Ruminal fermentation pattern obtained with treatments¹

	Treatments ²			SEM	Probability	
	Control	Flavomycin	Monensin		Treat.	Treat*Time
pH	6.32	6.23	6.27	0.03	NS	0.0219
tSCFA	100.53	102.71	99.89	1.59	NS	0.0425
C ₂	69.05	69.59	64.36	0.53	NS	0.0246
C ₃	19.33 ^b	19.47 ^b	24.59 ^a	0.41	0.0390	0.0155
C ₄	11.62	10.93	11.05	0.27	NS	NS
C ₂ /C ₃	3.66	3.75	2.65	0.10	0.0850	0.0170
NH ₃ -N	13.88	13.16	14.37	0.43	NS	NS

¹tSCFA: Total Short Chain Fatty Acids concentration (mM); C₂: Acetate (mol/100 mol); C₃: Propionate (mol/100 mol); C₄: Butyrate (mol/100 mol); C₂/C₃: Acetate: Propionate ratio; NH₃-N: Ammoniacal Nitrogen (mg dL^{-1}); SEM: Standard Error of Mean; Treat: Probability for treatment effect; Treat*Time: Probability for treatment and time interaction effect; NS: non-significant; ²: Rows with different letters differ by Duncan test (5%)

Table 5: *In situ* degradability of sugarcane NDF, corn grain starch and soybean meal CP obtained with treatments¹

	Treatments ²				Prob.
	Control	Flavomycin	Monensin	SEM	
Sugarcane NDF					
a	7.5900	7.5600	8.5500	0.300	NS
b	47.0800	51.0500	42.2900	1.990	NS
c	0.0245	0.0143	0.0183	0.002	NS
Ed2	32.9200	28.2400	27.5000	1.710	NS
Ed5	22.6900	18.8300	19.3000	1.170	NS
Ed8	18.3600	15.3300	16.0800	0.880	NS
Pd	54.6600	58.6200	50.8400	1.830	NS
Corn grain starch					
a	3.4600	4.4300	5.5200	0.620	NS
b	99.7600	100.4300	96.6600	0.700	NS
c	0.0549	0.0472	0.0715	0.005	NS
Ed2	76.0700 ^{ab}	73.5500 ^b	80.5800 ^a	1.300	0.0642
Ed5	55.2000 ^{ab}	51.9900 ^b	61.9000 ^a	1.820	0.0582
Ed8	43.6900 ^{ab}	40.8100 ^b	50.7300 ^a	1.800	0.0499
Pd	103.2200 ^{ab}	104.8600 ^a	102.1800 ^b	0.530	NS
Soybean meal CP					
a	14.2000	12.5400	16.3000	0.710	0.0798
b	86.8500 ^b	91.2500 ^a	83.3800 ^b	1.180	0.0063
c	0.1087 ^a	0.0750 ^b	0.1278 ^a	0.008	0.0069
Ed2	87.4500	83.4500	88.3300	1.000	NS
Ed5	73.5500 ^{ab}	66.0400 ^b	76.1300 ^a	1.730	0.0296
Ed8	64.1000 ^{ab}	55.6300 ^b	67.4800 ^a	1.950	0.0296
Pd	101.0400 ^b	103.7900 ^a	99.6700 ^b	0.640	0.0080

¹a, b and c: Orskov and McDonald (1979) parameters; Ed: Effective Degradability for passage rates of 0.02, 0.05 and 0.08; Pd: Potential degradability; SEM: Standard Error of Mean, Prob: Statistical probability; NS: Non-significant; ²: Rows with different letters differ by Duncan test (5%)

Table 6: Apparent digestibility of diet DM and its nutrients obtained with treatments (DM %)

Nutrients ¹	Treatments ²			SEM	Prob.
	Control	Flavomycin	Monensin		
DM	67.69	70.49	64.17	2.51	NS
CP	69.23	71.33	69.00	2.21	NS
EE	69.65	69.79	64.89	3.09	NS
NFE	76.08	78.63	71.54	2.41	NS
NDF	40.70	53.74	33.91	5.51	NS
ADF	57.90	66.31	50.06	4.69	NS
Starch	95.51	97.81	91.21	2.22	NS
TDN	68.54	71.04	64.77	2.46	NS
GE	72.68	79.03	67.79	3.22	NS

¹Nutrients: DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; NFE: Nitrogen-Free Extractive; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; TDN: Total Digestible Nutrients; GE: Gross Energy; ²: Rows with different letters differ by Duncan test (5%)

For CP of soybean meal, the treatment with flavomycin decreased ($p < 0.05$) degradation rate (parameter c) in 31.0 and 41.3%, increased ($p < 0.05$) the potentially degradable fraction (parameter b) in 5.1 and 9.4% and the potential degradability (a + b) in 2.7 and 4.1%, in relation to control group and to the group treated with monensin, respectively. Flavomycin also resulted in lower ($p < 0.05$) effective degradabilities of CP of soybean meal, in relation to monensin, but not in relation to control. The decrease of effective degradability of soybean meal CP in relation to monensin varied between 13.25 and 17.56% (10.09 and 11.85% units), considering passage rates of 5 and 8% h^{-1} , respectively.

Data from dry matter digestibility and its nutrients are presented at Table 6. No effect of antibiotics on CP, EE, NDF, ADF, NFE, starch, GE digestibility or TDN was shown.

DISCUSSION

In general, dry matter feed intake, which on average was 1.37% of body weight, independently from treatment, was lower than expected when it was considered this animal category. This can be due to the low quality of sugarcane fiber, high body condition of animals at the beginning of the experiment or both factors.

Neither of tested antibiotics altered dry matter feed intake, which corroborated with Flachowsky and Richter (1991) that did not observe effects on dry matter intake when flavomycin was added (0 or 30 mg $animal^{-1} day^{-1}$) to heifer's diets. The same was observed by Zinn *et al.* (1994), when monensin was added to steers diets containing 10 or 20% of forage.

However, in a trial carried out by Alert *et al.* (1993), the addition of 50 mg $animal^{-1} day^{-1}$ of

flavomycin to the diets of feedlot young bulls resulted in higher feed intake in the treated group when compared to control. This finding contrasted with the concept that antibiotics generally decrease feed intake, improving feed conversion (Stock and Mader, 1984), where this decrease in feed intake was more evident in animals fed high-grain diets than high forage diets (Schelling, 1984).

There was no effect of treatment was observed for ruminal pH when the analyses were performed inside each time of sampling. These results agreed with Rodrigues *et al.* (2004) who did not observe effect of monensin administration on total concentration of SCFA. However, Mbanzamihigo *et al.* (1995) studied monensin infusion in the rumen of cannulated sheep and observed decrease in total concentration of SCFA and increase in ruminal pH. Still related to ruminal pH, Rodrigues *et al.* (2004) studied the effects of monensin and different proportions forage/concentrate in diet on ruminal fermentation in cattle and verified an increase in this variable, but only in the most concentrate-based diet. These data opposed those presented by Zinn *et al.* (1994), who observed that with an increase in the forage proportion of diet, monensin increased ruminal pH. So diversified results obtained with this ionophore were also reported by Rodrigues *et al.* (2004), who affirmed that the response to this product depends on experimental conditions, such as type of diet, product dose and others.

Differently from what was observed in the present study, Edwards *et al.* (2005) added 20 mg day^{-1} of flavomycin to a TMR for sheep and observed that total concentration of SCFA (acetate, propionate, butyrate, valerate and isobutyrate) decreased. A decrease in total concentration of SCFA was also observed by other authors with this antibiotic (Alert *et al.*, 1993; Marounek *et al.*, 1998; McKain *et al.*, 2000), although they did not observe any change in ruminal pH. Murray *et al.* (1990) compared the effect of flavomycin in two different diets and verified an increase in ruminal pH in the diet that contained alfalfa plus lupine. Also, total concentration of SCFA increased, but only when this product was added to the diets based on wheat and fishmeal. Therefore, results obtained with flavomycin seem to be as variable as those obtained with monensin, at least for these variables.

In general, sodium monensin increased molar proportion of propionate in 27.2% (equivalent to 5.26% units) in relation to control group, considering all measurement times. Flavomycin did not alter this variable in relation to control group. This report is in agreement with an experiment carried out by Ramanzin *et al.* (1997) who fed diets with 50 or 30% of

concentrate to dairy cows and observed greater effects of monensin on molar proportion of propionate, also this effect was more pronounced in the most concentrate-based diet (26.7% versus 8.9%, respectively). Garcia-Lopez *et al.* (1996) worked with different proportions of concentrate (0, 50 and 90%) in an *in vitro* experiment and noticed that monensin increased the molar proportion of propionate in 17.1 and 47.9% for diets that contained 0 and 50% of concentrate, respectively, but did not alter this variable when the diet contained 90% of concentrate. These last authors cited that the low dose used could be the cause of lack of effect in concentrate-based diet.

When monensin was administered in a diet composed of corn silage and concentrate, the rate of propionate production increased in 65% (Rogers and Davis, 1982) and, when administered in a diet composed of wheat straw and concentrate, the increase was of 44% (Prange *et al.*, 1978). According to Chen and Wolin (1979), these effects of monensin are due to its inhibitory effect on formate and hydrogen-producing bacteria and stimulatory effect on succinate and propionate-producing bacteria. This phenomenon is doubly advantageous in metabolic terms for the animal, as ruminal production of propionate is energetically more efficient than acetate (Chalupa, 1977; Hungate, 1966).

In relation to flavomycin, the present data are compatible to the absence of results on SCFA observed by Marounek *et al.* (1998) and Alert *et al.* (1993).

Flavomycin or monensin, in the doses used in this experiment, did not cause any response on ruminal concentration of $\text{NH}_3\text{-N}$. Normally, in experiments with monensin, a reduction in production or concentration of this metabolite was observed (Rodrigues *et al.*, 2004), due to an inhibition caused on a small population of Gram-positive bacteria with high proteolytic activity and desamination (Chen and Russell, 1989; Russell *et al.*, 1988).

Differently from what was observed in the present trial, Murray *et al.* (1990) reported that flavomycin decreased ammonia ruminal concentration in the diet that contained wheat plus fishmeal. This decrease was about 14% in sheep that received wheat and concentrate (Edwards *et al.*, 2002). Although this decrease in ammonia ruminal concentration can indicate an increase in bacterial protein synthesis or a decrease in desamination, Van Der Merwe *et al.* (2001), cited that, in the case of flavomycin, what occurs is a restriction of desamination, caused by a direct suppression of some bacteria with high activity of ammonia production in rumen (Edwards *et al.*, 2005).

No tested treatment altered ruminal degradability parameters of sugarcane NDF. These results contrasted

with those presented by Vagnoni *et al.* (1995), who observed decrease in NDF degradability of diet with sodium monensin utilization in cattle. This decrease was higher in diets containing wheat straw without ammonia treatment when compared to treated straw. The absence of effects on fiber degradability is compatible with degradability data found in the present experiment, as will be forward discussed.

Increases on effective degradability of starch as observed in the present study can be considered useful, once an increase in degradation rate of corn grain starch can result in higher availability of nutrients in rumen and consequently to the animal. Potential degradabilities over 100%, as seen in the present experiment, are commonly observed when a non-linear statistic procedure is used in degradation curves of some feed.

The results observed for CP degradability of soybean meal can be considered valuable in certain conditions, since they can provide to animal better utilization of protein from diet reaching the small intestine. The results from the present trial corroborated with those observed by Edwards *et al.* (2005) who reported that flavomycin can lead to an increase of quantity of aminoacids available for the animal through a decrease in ruminal proteolysis, increasing the dietetic protein available for intestinal absorption.

No tested antibiotics altered dry matter digestibility. Similar results were obtained by Thornton and Owens (1981) and Zinn *et al.* (1994) where monensin did not affect DM or OM digestibility respectively, independently on diet characteristics. But, several authors reported an increase in DM and OM digestibility with ionophores antibiotics use (Duff *et al.*, 1995; Horton *et al.*, 1980; Richter and Flachowski, 1990). The present findings also agreed with Flachowsky and Richter (1991) who worked with cattle and reported that flavomycin did not influence OM apparent digestibility or TDN, as well as, ruminal fermentation parameters. However, Alert *et al.* (1993) mentioned, in an experiment with young bulls, an increase in OM, CF and NFE with flavomycin supplementation.

It was expected that a decrease in the degradation rate of protein fraction, observed in group that received flavomycin and discussed before, could result in lower $\text{NH}_3\text{-N}$ productions and, therefore, lower losses of nitrogen in rumen. Consequently, an increase in the digestibility of this fraction was expected. Bergen and Bates (1984) reported similar finding for monensin. These authors observed that this product, despite frequently decreased protein degradation in rumen, caused variable impact on DM

or CP digestibility, based on basal diet used. According to Bateman *et al.* (2004), if an increase in microbial efficiency occurs due to monensin addition associated with an increase in aminoacids flux to small intestine, an improvement in protein status of the animal could occur. Another point to mention is that, in the present trial, the apparent digestibility was evaluated not the true digestibility. This could have contributed for the lack of antibiotic effect on digestibility.

The tested antibiotics did not alter NDF or ADF digestibility. The results of the present experiment agreed with De Schrijver *et al.* (1991) who did not observe any effect of flavomycin on DM, NDF or NFE digestibility in castrated sheep, fed with a mixed of sugar beet pulp plus concentrate and flavomycin. Therefore, the lack of effect of this antibiotic on NDF digestibility could be valid for feed that had high digestible fiber, such as sugar beet pulp (De Schrijver *et al.*, 1991), but also, low digestible fiber, such as sugarcane that was used in this experiment.

The effect of monensin on fiber digestibility is contradictory in literature. It could be observed positive or negative effects. The effects of ionophores on fiber digestibility are explained in part by an increase in DM retention time in rumen (Ellis *et al.*, 1983), lower voluntary feed intake (Rogers and Davis, 1982), improvement in ruminal conditions (Branine and Galyean, 1990) or by increase in rumination stimulus (Knowlton *et al.*, 1996).

Although ionophores cause low to moderate improvement in feed digestibility (Schelling, 1984), these conditions are not defined at the present moment and may suffer influence of several factors such as feed intake, rumen filling, passage rate and others. Also, it is worth to mention that the present study used non-pregnant dry cows, animals that have lower feed intake and consequently lower passage rates of feed in gastrointestinal tract. It is possible that these experimental conditions help to explain the lack of results observed in this study.

CONCLUSION

In conditions of concentrate-based diets with sugarcane as the single forage, it was possible to show the beneficial effects of monensin but not of flavomycin, on rumen fermentation. As flavomycin decreased crude protein ruminal degradability, it can improve the utilization of this nutrient.

ACKNOWLEDGEMENT

This study was supported by Sao Palo Research Foundation, FAPESP, Brazil. The researchers thank FAPESP for providing financial support. Moreover, E. Lazaro and G. Botteon for animal care and A. Castro, G. Godoy, S. Robassini and I. Ramos for assistance with laboratory analysis.

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