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Use of Ionophores in Goat Feeding

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Abstract: The objective of this study was to evaluate the effect of monensin addition on the total dry matter intake, in goat diets, composed of 30 % alfalfa hay and 70 % corn. Four fistulated cross breed goats (Nubian x Creole), 39.77 ± 1.07 kg live body weight (BW), were used in experimental design. Two experiments were carried out: I) Determining total dry matter intake (TDMI), pasture dry matter intake (PDMI), total daily and hourly intake (TDHI) and total dry matter digestibility (TDMD); II) Determining ruminal pH. Treatments consisted of an instance without monensin (D0), and another one with monensin (D1). In both cases, intake level was adjusted to 3 % of BW. There were no significant effects ($p < 0.05$) on TDMI, PDMI, TDHI, TDMD and BW. The registered TDHI during the 12 h after feed had an effect on time. The area below the curve, with a 5.8 and 6 pH threshold, proved a significant linear drop-off ($p < 0.05$) for D1. As regards the hours with pH value below pH threshold, there were no significant differences ($p > 0.05$) between treatments, only a tendency ($p = 0{,}074$) to keep pH values below 5.8 for a greater number hours in D0. The average pH of the day showed a tendency to be higher ($p = 0{,}056$) for D1. The lowest ruminal pH was observed between the 8 and 12 h after food intake, and with significant differences ($p > 0.05$) between hours, but the treatment had no effects on the evolution of pH in time. Therefore, we can conclude that the addition of monensin in highly energetic diets for goats had a moderating effect in the ruminal pH, and in the number of daily food concentrate meals. However, there was no register of acute acidosis with these diets.

Keywords: Monensin, Goats, Intake

Introduction

Ground cereal grains produce in sufficient saliva secretion to maintain pH values between 6 and 7 and low ruminal motile stimuli in all ruminant species (Gonçalves, 2001). Ramos (2005) and Milleo *et al.*, (2006) claim that when starch consumption increases, the ruminal pH can get below 6 and fiber digestion and microbial development can decrease. Arias *et al.*, 2013 proved that goat diets including energetic grains from 1 % of BW produced a significant linear decrease of ruminal pH and rumen degradability of the forage. Another digestive problem, ketosis, also seen in dairy cows or sheep, may also be encountered in goats (Harwood, 2004). One potential way to help reduce the negative energy balance may be through the addition of ionophores. Ionophores act altering rumen microflora through ion transfer across cell membranes. The presence of ionophores (monensin, lasalocide, etc.) in goat diets is necessary to avoid excessive consumption, ruminal acidosis, and ketosis, as mentioned above (Pordomingo *et al.*, 1999; Raun *et al.*, 1976). The most commonly used ionophore is monensin, which acts on the ruminal bacteria that produces acetate and butyrate and increases the presence of microbes producing gluconeogenic precursor propionate (Bergen & Bates, 1984; Church, 1988; Pordomingo *et al.*, 1990; Santini & Di Marco, 1983; Duff *et al.*, 1990). One of the most important factors in the growth of ruminant bacteria population is pH. Monensin has an indirect effect on ruminal pH: it inhibits the development of lactate producing Gram-positive bacteria (Dennis *et al.*, 1981). It was observed that the use of monensin produces a decrease in daily intake and amount of food consumed in individual meals, and an increase in the number of meals per day, without modifying weight gain, which implied a better food conversion (Erickson *et al.*, 2003; Bergen & Bates, 1984). The use of monensin in wool sheep breeds showed no significant differences as regards intake reduction, and no improvements on digestibility of the diet consumed (Baran&Žitňan 2002; Mouro *et al.*, 2006; Mazza *et al.*, 2001; Plata *et* al., 2004; Araújo *et al.*, 2006). Rasool Sadjadian *et al.*, (2013) evaluated the impact of monensin on metabolic parameters, dry matter intake and milk production in periparturient dairy goats. Monensin use caused a reduction of serum of β-Hydroxybutyrate concentration in the

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postpartum period. However, this improved energy metabolism did not result in a greater amount of milk production, or in improved dry matter intake. On the other hand, milk fat percentage significantly decreased in monensin fed goats, which is considered an undesirable quality for goat milk. Monensin use significantly decreased dry matter intake during the pre-partum period. However, Monensin is a promising tool for improving the energy status of dairy goats during a transition period. The objective of this study was to evaluate the effect of monensin addition to goat diets on the total dry matter intake and the ruminal pH.

MATERIALS AND METHODS

This production was regulated and authorized by the Institutional Committee for the Care and Use of Laboratory Animals of the School of Veterinary Sciences of the National University of La Plata. Whose file number is 62-6-17 T.

The study was conducted in the goat's experimental unit of the School of Agricultural and Forestry Sciences of the National University of La Plata.

Experiment I: *determining total dry matter intake (TDMI), pasture dry matter intake (PDMI), total daily and hourly intake (TDHI) and total dry matter digestibility (TDMD).*

Four five year old, non-pregnant, non-lactating, cross breed goats (Nubian x Creole), 39.77 ± 1.07 kg live weight (BW), were used. They were fistulated with specific permanent cannulae for small ruminants in crossover design with two replicates and a 7-day washout period in between treatments. Goats were housed in individual compartments (0.80 m x 1.50 m) that counted with feeders and automatic drinking devices. Each animal's weight was recorded at the beginning of each period. Ionophore monensin was added and the diets tested were composed of: 30 % alfalfa hay plus 70 % ground corn, without monensin (D0); and 30 % alfalfa hay plus 70 % ground corn, with monensin (D1).Table 1 shows diets chemical composition. The level of intake was adjusted to 3 % of the BW, and an assimilation 21-day period was implemented prior to determinations. Ground corn was provided in an increasing manner (70 g per animal per day) until reaching the corresponding quantity at the beginning of the third week of the adaptation period. Alfalfa hay and ground corn samples were taken and heat dried for determination of dry matter. (AOAC, 1995). Individual intake of alfalfa hay and ground corn was calculated considering the difference between provided and rejected food, expressed in kg of DM. Alfalfa hay and ground corn intake was determined. For the latter, a repeated measure model was used in order to evaluate the time effect post feeding and the hour/treatment interaction.

TDMD was determined by a methodology consisting in providing food and collecting the total amount of stool by means of a collection bag and a harness (Moore *et. al*, 2002). Collection bags were emptied once a day and the total amount of stool was weighted. DM content and consumed TDMD were determined, with a 10 % aliquot of the animal's stools, by the porcentual difference of total portion consumed and the excreted amount in relation to the consumed one, expressed in percentage.

Experiment II: *ruminal pH determination. Time effect post feeding and hour/treatment interaction*

Four five year-old, non-pregnant, non-lactating, cross goats (criolla x Nubian) were used. They were fistulated with permanent cannulas for small ruminants.

The ruminal fluid was taken out through cannula at 0, 2, 4, 6, 8 and 12 h after feed, and a digital pH meter (Silver Cap pH 5045-3B), equipped with a puncture electrode, and calibrated with buffer solutions to pH 4 and 7, was used. The area under the curve was calculated as the sum of the absolute value of the pH deviations below 5.8 and 6 values, registered as pH x hour/day (Pitt y Pell, 1997). The mean value of ruminal pH and the time in hours with pH below 6 were determined. The effect of post-feed time and the time/treatment interaction were determined using a repeated measurements model (Littell *et al*., 1998).

Experimental design and statistical analysis:

Data were analyzed by the MIXED procedure (SAS, 2004) for a crossover design using a mixed model that included the fixed effect of sampling (treatment, period) and the random effect of the animal. Significant differences were considered with a P value < 0.05 and tendencies $0.05 > P < 0.10$.

RESULTS AND DISCUSSION

There were no significant effects ($p > 0.05$) on the total intake of dry matter (TDMI) -alfalfa hay, corn grain-, goat BW, and total digestibility of dry matter (TDMD) (table 2). The intake of energy concentrate recorded during the 8 hours after feeding showed a treatment effect with regard to time, verified by the hour/treatment interaction ($p < 0.05$) (table 3; figure 1). As regards ruminal pH, the areas under the curve with a pH threshold of 5.8 and 6 verified a significant linear decrease ($p < 0.05$) for the D1 treatment. The treatment without monensin showed a tendency ($p = 0.074$) to a greater number of hours with pH below 5.8 and the average pH of the day showed a tendency to be higher ($p = 0.056$) for the D1 treatment (table 4). The minimum ruminal pH was observed between the 8 and 12 hours after food intake (figure 2), with significant differences ($p > 0.05$) between hours, and without treatment effects in the evolution of pH over time, evidenced in lack of interaction ($p > 0.05$)

(table 5).

According to Elías (1983), Ramos (2005), Milleo et al., (2006), Arias et al., (2013) the incorporation of energy concentrates in diets for goats produces a decrease in ruminal pH. Probably, as explained by Gonçalves (2001), ground cereal grains might cause insufficient salivary secretion at the ruminal level in order to maintain pH values between 6 and 7. According to Pordomingo *et al.*, (1999); Raun *et al.*, (1976) and Dinius *et al.*, (1976) the addition of 33 mg of monensin/kg of DM consumed avoids over-consumption. In this study, results demonstrate an increase in the number of daily concentrate meals in the treatment including the ionophore (Erickson *et al*., 2003). As regards intake regulation there are controversies among authors. In this sense, we disagree with Bergen & Bates (1984), Schwartzkopf-Genswein *et al.*, (2003), Forbes, (2003), in that the use of monensin contributes to a decrease in the total intake, as demonstrated in this study. In relation to intake regulation, there are controversies among different authors as well. This study has shown that the use of monesine does not involve a decrease in the client's total intake therefore; we disagree with Bergen & Bates (1984), Schwartzkopf-Genswein *et al.*, (2003), and Forbes, (2003). According to Baran & Žitňan (2002), Mouro *et al.*, (2006), whose studies include sheep, the use of ionophores caused no alterations in dry matter intake compared to control treatments. In relation to ruminal pH, the dose of monensin used in this investigation can be related to a decrease in hours with pH below 6 (Dennis *et al.*, 1981).

Finally, it is worth mentioning that monensin showed no improvements on the total digestibility of the diet consumed (Mazza *et al.*, 2001; Plata *et al.*, 2004; Araújo *et al.*, 2006).

CONCLUSIONS

The use of an ionophore such as monensin in goat diets with high concentration of starch had a moderating effect on the ruminal pH, and on the number of energy concentrate daily meals. Results also showed no acute ruminal acidosis in any of the treatments, which may be attributed to goat's high adaptability to a wide range of food conditions.

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TABLES AND FIGURES

Table1. Food chemical composition (*)

Item	Alfalfa hay	Corn
DM (%)	87.0	89.0
OM (%)	91.9	98.7
CP (%)	13.7	7.3
CF (%)	24.9	2.1
EE (%)	2,4	3,9
ENF (%)	37.3	72.8
NDF (%)	58.87	14.55
ADF (%)	44.03	3.68
TDN (%)	50.0	83.0

(*) Animal Nutrition Laboratory of the School of Veterinary Sciences. UNLP.
DM: dry matter.
OM: organic matter.
CP: crude protein.
CF: crude fiber.
EE: ether extract.
ENF: extractive nitrogen-free.
NDF: neutral detergent fiber.
ADF: acid detergent fiber.
TDN: total digestible nutrients.

Table 2. Linear effect and average comparison analysis of DMI, DMIF, DMIC and BW, according toeach treatment.

Item	Diets		SE	P values
	D_0	**D_1**		**L**
DMI (% BW)	2.80^{a}	2.81^{a}	0.173	0.951
DMIah (g/d)	387.78^{a}	426.58^{a}	34.42	0.425
DMIc (g/d)	800.78^{a}	798.44^{a}	47.96	0.972
BW	43.75^{a}	43^{a}	2.43	0.833
TDMD (%)	77.85^{a}	76.79^{a}	1.59	0.645

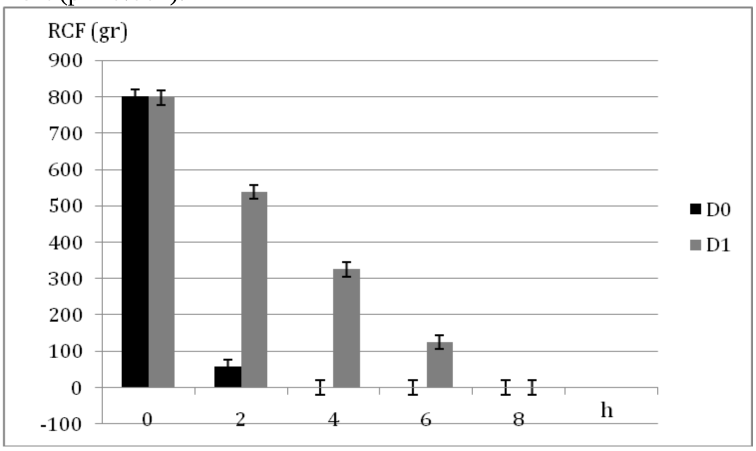
D_0: withoutmonensin.
D_1: withmonensin.
DMI (BW %): dry matter intake relative to BW.
DMIah: dry matter intake alfalfa hay gr/day.
DMIc: dry matter intake corn gr/day.
BW: live weight.
TDMD: total dry matter digestibility.
SE: standard error.
L: Probability value associated with a linear effect.
P values: The p values of the effects of monensin.
Equal letters indicate non-significant differences for the 5 % probability.

Table 3. Effect of time on corn intake during 8 h after feeding in a model of units repeated over time.

Item						SE
Hours	0	2	4	6	8	
Nº goats	4	4	4	4	4	
DMIc[1]	0^{a}	262^{b}	473^{c}	673^{d}	798^{d}	19.57

DMIc: dry matter intake corn for 8 h.
1 = effect of hours on corn intake ($p < 0.001$).
SE: standard error.
Equal letters indicate non-significant differences for the 5 % probability.

Figure 1: Analysis of feeder during 8 hours after concentrate was provided. Effect of treatment ($p = 0.003$). Interaction hour * treatment ($p < 0.001$).



RCF: remnant corn in feeder.
D0: without monensin.
D1: with monensin.

Table 4. Effect of monensin on ruminal pH.

Item	Diets		SE	Contrast
	D0	D1		L
pH < 5.8 h/d	1.58[a]	0.12[b]	0.326	0.019
pH < 6 h/d	2.73[a]	0.94[b]	0.513	0.049
AveragepH	6.01[a]	6.34[a]	0.102	0.058
H pH < 6	6.5[a]	5[a]	1.233	0.423
H pH <5.8	4	1.5	0.820	0.075

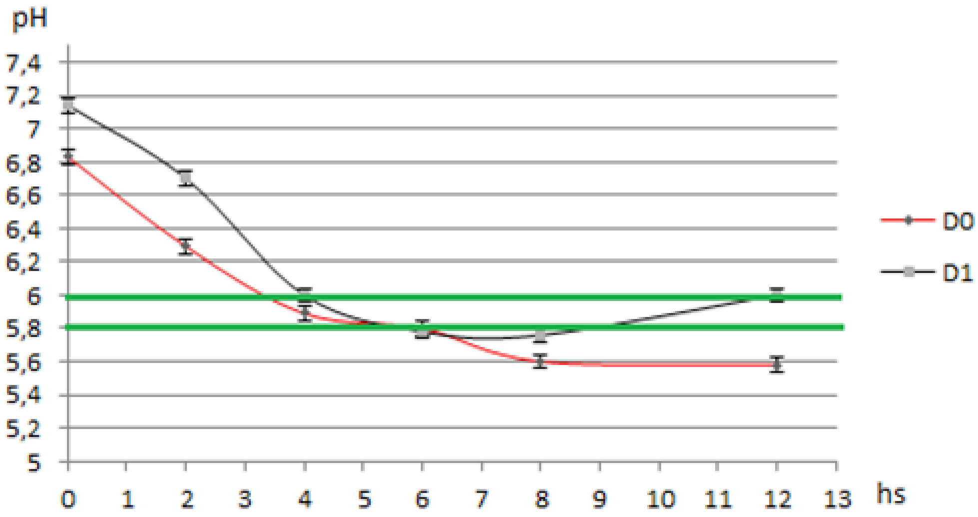
D0: without monensin.
D1: with monensin.
pH < 5.8 (h/d):pH expressed as area under the curve of a pH threshold of 5.8.
pH < 6 (h/d): pH expressed as area under the curve of a pH threshold of 6.
pH Prom:average pH day.
Hr pH < 6: hours with pH below 6.
Hr pH < 5.8: hours with pH below 5.8.
SE: standard error.
L: Probability value associated with a linear effect.
P values: The p values of the effects of monensin.
Equal letters indicate non-significant differences for the 5 % probability.

Table 5. Effect of time on ruminal pH during 12 hours.

Item							SE
Hours	0	2	4	6	8	12	
Nº goats	4	4	4	4	4	4	
pH[1]	7[a]	6.53[b]	6.03[c]	5.92[cd]	5.79[cd]	5.79[d]	0.053

pH: pH ruminal.
1= effect of hours on ruminal pH ($p < 0.001$).
SE: standard error
Equal letters indicate non-significant differences for the 5 % probability.

Figure 2. pH variation during 12 hours.Treatment effect (p = 0.005). Interaction hour * treatment (p=0.354).



D0: without monensin.
D1: with monensin.