Short note [Nota corta]

RUMINAL DRY MATTER DEGRADABILITY OF HIGH CONCENTRATE DIETS WITH INCREASING LEVELS OF CALCIUM SOAPS OF TALLOW

[DEGRADABILIDAD RUMINAL DE MATERIA SECA DE DIETAS ALTAS EN CONCENTRADO CON NIVELES CRECIENTES DE JABONES DE CALCIO DE SEBO DE RES]

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SUMMARY

The present study measured the *in situ* digestibility and ruminal degradability of dry matter of rations with different levels of calcium soaps of tallow (CST). The samples of the four rations with CST at levels of 0% (T1), 1.5% (T2), 3.0% (T3) or 4.5% (T4) were incubated in the rumen of a fistulated yearling steer. The nylon bag technique was used to determine the *in situ* digestibility and ruminal dry matter degradability. A completely randomized design was used, with 4 treatment diets and 4 repetitions. Rapidly-soluble fraction (a) or *in situ* digestibility of DM at 0 h of incubation was higher in T1 than T3 ($P<0.05$). The non soluble but degradable fraction (b) and constant of degradation (c) were higher in T3 than T1 ($P>0.05$). Potential (a+b) degradability was similar ($P>0.05$) between treatments. Effective degradation modeled at low ruminal turnover (1%/h) was lower in T4 than T1 ($P<0.05$); however, at higher ruminal turnover (5 and 8% per h), CST did not influence effective degradation of dry matter ($P>0.05$). In conclusion, CST in the ration influenced ruminal fermentation during the first hours of incubation. However, effective degradability at medium and high ruminal turnover was not affected by CST level in diets.

Key words: Ruminal Degradability; Diets; Calcium Salts; Fats.

RESUMEN

En el presente estudio se midió la digestibilidad *in situ* (DISMS) y degradabilidad ruminal (DRMS) de la materia seca de raciones con diferentes niveles de jabones cálcicos de sebo (JCS). Las muestras de las cuatro raciones con JCS a niveles de 0% (T1), 1.5% (T2), 3.0% (T3) o 4.5% (T4) fueron incubadas en el rumen de un novillo fistulado. La técnica de bolsa de nylon se utilizó para determinar la DISMS y DRMS. Se utilizó un diseño completamente aleatorizado con 4 tratamientos y 4 repeticiones. La fracción rápidamente soluble (a) o la DISMS a 0 h de incubación fue superior en T1 que T3 ($P< 0.05$). La fracción no soluble pero degradable (b) y la constante de degradación (c) fueron superiores en T3 que T1 ($P > 0.05$). La degradabilidad potencial (a + b) fue similar ($P>0.05$) entre tratamientos. La degradación efectiva modelada en bajo flujo ruminal (1%/h) fue menor en T4 que T1 ($P<0.05$); sin embargo, a mayor flujo ruminal (5 y 8%/h) los JCS no influyeron en la degradabilidad efectiva de la materia seca ($P>0.05$). En conclusión, los JCS en la ración influyeron en la fermentación ruminal durante las primeras horas de incubación. Sin embargo, la degradabilidad efectiva en flujo ruminal medio y alto no se efecto por el nivel JCS en las dietas.

Palabras clave: Degradabilidad Ruminal; Dietas; Sales de Calcio; Grasas.

INTRODUCTION

High percentages of concentrates are included in rations to satisfy the high energy requirements of feedlot animals. Lipids increase dietary energy content (Jenkins and Jenny, 1989), and when they are in diets the productive performance is satisfactory in beef steers (Zinn, 1989a) and dairy cattle (Chow *et al*., 1990). Also, the inclusion of dietary restaurant fat improved lamb performance without detrimental effects on nutrient digestibility or meat quality (Awawdeh *et al*. 2009). Dietary lipids are hydrolyzed (lipolysis) by ruminal microorganisms. Saturated fatty acids do not change in the rumen; however, unsaturated fatty acids are hydrogenated by microorganisms in the rumen through the biohydrogenation process. The magnitude of lipolysis depends on the amount and characteristics of dietary fat, in addition to diet characteristics related to rumen pH (Martínez-Marín *et al*. 2010). Because of the antimicrobial nature of fatty acids, they must be used at low levels in ruminant diets to minimize ruminal fermentation (Jenkins, 1994). At levels of 5% or higher, fats decrease digestibility of fat and other nutrients. Plascencia *et al*. (2003), using 0, 3, 6, and 9% yellow grease in finishing diets for cattle, reported that high levels of supplemental fat decreased ruminal digestion of organic matter (OM), neutral detergent fiber (NDF), and postruminal fatty acids. These results are consistent with those of Zinn (1989b).

To avoid the negative effects of fat on rumen digestion, Jenkins and Bridges (2007) pointed out the application of a rumen protection technology of fat to resist the action of microbial enzymes, by changing fatty acid structure through the formation of calcium salts (soaps) of fatty acids. Naik *et al*. (2009) tested total mixed rations supplemented with or without rice bran fatty-acid-oil or calcium salts of long chain fatty acids as a rumen inert fat; they found no effect on *in vitro* DM degradability; however, calcium salts increased total volatile fatty acid indicating improvement in rumen fermentation. Naik *et al*. (2010) using calcium salts of long chain fatty acids prepared by an indigenous method by treating rice bran fatty acid oil, did not observe adverse effects on ruminal metabolism in adult buffaloes fed wheat-straw based diets, at a roughage:concentrate ratio of 65:35. Saijpaul *et al*. (2010) used similar protected fats in different combinations in dairy rations on *in vitro* studies*;* they concluded that protected fats can substitute up to 40% of the natural fat in the ration (total ration with 6% of natural fat). However, when they used rations with limited grain (5–10%) and 4.8% protected fats, they observed that the addition of 1% urea reduced in vitro dry matter digestibility (IVDMD). Salinas *et al*. (2006) concluded that calcium soaps of tallow did not affect growth or carcass of feedlot lambs. However, compared to common tallow, protected fats (PF) have several advantages: no special equipment is required for storing or mixing feed and they do not need to be maintained in liquid form for mixing in rations. In addition, calcium soaps of tallow have digestive and physiological advantages over common tallow, and are easily consumed by ruminants.

Protected fats have been more extensively studied in dairy cattle; however research on their use in feedlot cattle or lambs has been limited. In particular, reports on ruminal digestion of high concentrate diets with calcium soaps of tallow are lacking. The objective of present study was to evaluate the *in situ* digestibility and ruminal dry matter degradability of high concentrate diets with different levels of calcium soaps of tallow.

MATERIAL AND METHODS

The present research was carried out at the cattle facilities at the Universidad Autónoma Agraria Antonio Narro - Unidad Laguna, in Torreón, Coahuila, in the Northern Mexico. They are located at 25° 32′ N, and 103° 27′ W. The area is located at an altitude between 1100 and 1400 m, the mean annual rainfall is 190 mm (the rainy season is from August to September) and the annual average temperature is 21 ˚C (García, 1980; CIAN, 1984).

For the study, a yearling steer was fitted with a permanent ruminal cannula (10 cm in diameter) to evaluate DM degradability of high concentrate diets containing four levels of protected fat as calcium soaps of tallow. Four treatment (T) rations were formulated using soybean meal and sorghum grain with similar crude protein (14%) and metabolizable energy (2.6 Mcal/kg DM) content (Table 1). Rations were formulated based on tabular values for feed ingredients (NRC, 1996).Treatments T1, T2, T3 and T4 contained 0, 1.5, 3.0 and 4.5% calcium soaps of tallow, respectively. Samples of these rations were incubated in the rumen as described below.

Before the trial started, the steer was treated with ivermectin for internal and external parasites, and injected with a vitamin ADE preparation. The steer was housed in an individual well-ventilated draft-free pen and fed alfalfa hay *ad libitum* plus 2 kg of ration 4. Water was available *ad libitum*.

The incubation of bags in the rumen was carried out after the steer received the 15-day adaptation period, during which the steer was fed with alfalfa hay *ad libitum* plus 2 kg of ration 4. For rumen incubation, 53-μm mesh nylon bags measuring 5 x 10 cm were used (ANKOM Technology, Macedon, NY, USA.). For each incubation time, 4 bags containing 6 g of sample per treatment were incubated in the steer's rumen (each bag represented a repetition). Feed samples were ground in a No. 4 Wiley mill equipped with a 2.0-mm retaining screen. Bags with feed-sample were tied to a 30-cm nylon cord with a metal weight at the end to ensure they were immersed in the ventral ruminal sac. Bags were incubated for 0, 4, 8, 12, 24, 48 and 72 h. After removing the bags from the rumen, they were washed under tap water at low pressure until clear water came out of the bag, and dried in an air-forced oven (60^{o}C for 48 h).

The *in situ* dry matter degradability for samples from each incubation time was calculated by the weight loss of samples in bags during ruminal incubation, applying the model described by Ørskov and McDonald (1979), modified by McDonald (1981):

$P = a + b\,(1 - e^{-c*t})$

where:

a = washing loss or soluble fraction (%)

b = non soluble but degradable fraction (%)

P = degradation of DM (%)

a + b = potential degradability (%)

c = fractional degradation rate (h^{-1}) of "b"

t = time (h)

Ruminal turnover constants (k) at 1, 5, and 8% h^{-1} were used to model effective degradation (ED; Ørskov and McDonald, 1979): $ED = a + (b*c)/(c+k)$.

Data were analyzed as a completely randomized model with the procedures of GLM (SAS, 2007), using 4 treatments rations with 4 repetitions. Significance was declared at α= 0.05. Tukey's test was used for mean comparison if significant differences among treatments were found.

RESULTS AND DISCUSSION

Results of *in situ* DM digestibility of rations are shown in Table 2**.** Ruminal DM degradability parameters of diets with CST are shown in Table 3. Rapidly soluble fraction (a) or *in situ* digestibility of DM at 0 h of incubation was higher in T1 ($P<0.05$) than T2 and T4 which were similar between them ($P>0.05$); the lower value corresponded to T3 ($P<0.05$). Both non soluble but degradable fraction (b) and constant of degradation (c) were higher in T3 than T1 ($P<0.05$). Potential degradability (a+b) was similar ($P>0.05$) between treatments. Effective degradation modeled at low ruminal turnover (1% h^{-1}; Table 3) was lower in T4 than T1 ($P>0.05$); however, at higher ruminal turnover (5 and 8% h^{-1}), CST did not affect ruminal dry matter degradability ($P>0.05$).

Dry matter of rations was more fermented in the rumen during the first hours of incubation. In the present study, rumen degradation of DM of the soluble fraction was influenced by CST level in diet; however the other ingredients of the ration also influenced ruminal disappearance of DM. The greater digestion of soluble fraction in T1 than T2 and T3 was due to the CST level. However, T4, with the highest content of CST, exhibited a greater digestion of soluble fraction than T3. This was due to the fact that ruminal degradation is not only affected by CST, but also by diet composition. To have diets similar in energy and protein content was necessary to change the diet composition. The greater percentage of wheat bran and molasses in diets provoked greater ruminal dry-matter disappearance of soluble fraction in T4 than T3. This is in agreement with Rosales *et al*. (2005) who found that ruminal degradation of diets for feedlot lambs was influenced by sugarcane molasses and wheat bran.

Table 1. Experimental diets used in study (% dry matter).

	Levels of calcium soaps of tallow in the diet			
Ingredients	0%	1.5%	3.0%	4.5%
Urea	0.3	0.3	0.3	0.3
Sorghum, grain	62.8	58.5	50.9	41.6
Soybean meal	17.5	16.9	17.0	16.7
Molasses, sugar cane	4.0	4.0	7.4	11.5
Minerals, premix	2.0	2.0	2.0	2.0
Sorghum, straw	10.0	10.0	10.0	10.0
Wheat bran	3.4	6.8	9.4	13.4
Bypass fat as CST[a]	0.0	1.5	3.0	4.5
Total	100.0	100.0	100.0	100.0

[a]Mega engorda® (Procesadora de Alimentos para Ganado, S. A .de C. V.). Contains bypass fat (calcium soaps of tallow).

Table 2. In situ DM digestibility of studied rations.

	Levels of calcium soaps of tallow in the diet				
Incubation time (h)	0% (T1)	1.5% (T2)	3.0% (T3)	4.5% (T4)	SEM
0	28.21a	21.05b	12.31c	18.93b	0.81
4	39.19a	40.45a	25.26b	35.00ab	2.77
8	44.24	43.39	42.87	45.37	1.59
12	56.94ab	58.78a	52.56ab	51.63b	1.52
24	71.79ab	74.30a	75.07a	65.60b	1.53
48	87.88a	89.00a	89.22a	83.96b	0.81
72	90.49a	89.57a	87.41b	85.91b	0.50

[abc]Different literals in the same row, differ (P<0.05)

Table 3. Ruminal DM degradability parameters of the experimental diets.

	Levels of calcium soaps of tallow in the diet				
Variables	0% (T1)	1.5% (T2)	3.0% (T3)	4.5% (T3)	SEM
Washing loss (a)	28.21[a]	21.05[b]	12.31[c]	18.93[b]	0.81
Non soluble but degradable fraction (b)	65.36[b]	71.60[ab]	77.39[a]	71.44[ab]	1.65
Potential degradability (a+b)	93.57[a]	92.65[a]	89.70[a]	90.37[a]	1.35
Constant of degradation (c)	0.05[b]	0.05[ab]	0.07[a]	0.04[b]	0.005
Effective degradability modeled at fractional passage rate (h^{-1}) of:					
0.01	81.85[a]	82.18[a]	79.43[ab]	78.00[b]	0.76
0.05	59.10[a]	61.40[a]	55.20[a]	55.80[a]	1.56
0.08	51.40[a]	54.65[a]	45.35[a]	48.78[a]	2.41

[abc]Different literals in same row, differ (P<0.05).

At low ruminal turnover (1% h^{-1}), effective degradability was lower in T4 than T1 and T2 (P<0.05); T4 was similar to T3 (P>0.05). At higher ruminal turnover (5 and 8% h^{-1}), all diets showed similar (P>0.05) effective rumimal degradation. For the present study, the diets contained a high percentage of concentrate (90% DM); in which, ruminal turnover could be from medium to high: where there were no differences in effective degradability. This may be explained by the high effective ruminal degradability in high concentrate diets, in addition to the ingredient composition of the diets. T4 included the highest proportion of CST, but also contained higher levels of sugar cane molasses and wheat bran, which are rapidly degraded in the rumen. The result was a similar rumen degradation of the diets. Under these conditions, CST does not influence effective ruminal degradability of diets. In agreement with this, Barajas and Flores (1993) found no effect of different lipids on digestibility. Naik *et al*. (2009) using total mixed rations supplemented with calcium salts of long-chain fatty acids found no effects on *in vitro* DM degradability; however, calcium salts increased total volatile fatty acids, indicating improvement in rumen fermentation. Naik *et al*. (2010) tested calcium salts of long chain fatty acids prepared by an indigenous method; they did not observe adverse effects on the rumen metabolism in adult buffaloes fed wheat straw-based diets. Saijpaul *et al*. (2010) added similar protected fats in different combinations in dairy rations. On *in vitro* studies, they concluded that protected fats can substitute up to 40% of the natural fat. However, rations with limited grain (5–10%) and high levels of protected fats, they observed that 1% urea can reduce IVDMD.

CONCLUSIONS

The inclusion of CST in high concentrate diets allowed changes in the ingredient composition that influenced rumen fermentation only during the first hours of incubation. The effective degradability at medium and high ruminal turnover was not influenced by CST level in diets.

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