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The Effect of Rising Amounts of Energy Concentrate on Starch Digestibility and Fiber in Criollo X Nubian Cross Breed Goats

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ABSTRACT

A feeding trial was conducted to evaluate the effect of rising levels of ground maize on rumen pH and the intake, degradability, and digestibility of the dry matter in general, and starch and fiber in particular. Four fistulated goats were used in a 4X4 Latinbsquare. Four diets were delivered: alfalfa hay (M0); alfalfa hay + ground corn to 0,5 % BW/day (M1); 1% BW/day (M2) and 1,5% BW/day (M3). Alfalfa hay was delivered *ad* libitum. No effects (p > 0,05) of the diet on the TDMI were registered. Forage intake, NDF, and the F/I relationship decreased linearly (p < 0,05), and starch increased (p < 0,05) with rising levels of concentrate. IVTAD of DM, OM, and starch increased linearly (p<0,05) with the incorporation of the energy concentrate. If we analyze the relative increments of starch IVTAD among treatments, M_2 registered the lower increase, verified by the adjustment to a cubic model. Both starch amount in excrement and NDF digestibility showed minimum values for M_2, adjusted to cubic and quadratic models respectively. *In situ* degradability of alfalfa hay NDF, after 24 and 48 hs, registered the lowest value for M_2, adjusted to the quadratic model (p < 0,05). Rumen pH decreased (p < 0,05) with the increment of maize in the diet. Given that the total digestion of starch is the result of a balance between its ruminal and intestinal phase, rising levels of energy concentrate increase the total digestibility of starch. However, a lower pH determined by a higher ruminal amylolytic activity may affect NDF digestibility with negative consequences on the intestinal digestibility of starch due to carry-over effects.

INTRODUCTION

Whereas digestibility is the amount of food that disappears into the digestive tract, degradability is the amount of food that decomposes using biological or chemical processes (1).

Ruminal degradability mainly depends on two aspects: the degradation rate and rumen transit rate. Feed solubility and molecular structure also affect degradation rate, for their effects on the microbial activity. Other factors that come into play are rumen pH, particle size, forage-concentrate relation, and water and dry matter intake (2). The food weighing rate through the rumen is affected by the rate of intake and the food particle size. It was observed that the greater the rate of intake is, the lesser the degradability becomes (3).

The use of energy concentrates on the consolidation of production systems has caused an increment of metabolic and nutritional disorders (4). Proof of that is the frequent subacute rumen acidosis cases diagnosed in dairy herds (5). The incorporation of maize grain to ruminant diets increases the digestibility of the total dry matter intake (6). However, it may decrease the digestibility of the forage (7). A wide range of food intake and starch-based foods, such as maize, sorghum, and barley, showed a linear relationship between starch intake and starch rumen digestion (8). A 77 % starch intake corresponds to a rumen digestibility of 71 %. However, the higher the starch levels, the greater the variability in its digestibility (9).

The shape of the grain and its concentration levels may affect several rumen activities (10). The food source and the amount of starch determine the microbial species and rumen pH (11, 12). Grain processing is the most employed technology to maximize total starch digestion and increase its availability within the rumen, for it modifies its interaction with other components of the endosperm (13, 14, 15).

There is plenty of documentation that considers a pH value 6 as the value up to which fiber digestibility in rumen decreases (16, 17). As starch amounts increase, acetate concentration decreases propionate concentration increases, and rumen pH increases, affecting the molar proportions of volatile fatty acids (18, 19). The starch which fails to be digested in the rumen fermentation can be digested enzymatically in the small intestine (20) or can go to the large intestine to be fermented by volatile fatty acids or microbial protein. The remaining starch is excreted in feces (21).

Fattening steers fed low forage / concentrate diet, the effect of the diet type significantly increased the enzymatic activity of the ruminal fluid (22, 23).

The goat activity developed in the area of influence of the Faculty of Agricultural and Forestry Sciences of the University of La Plata is characterized by small-scale production units. One of the factors responsible for this is the high value of land due to its proximity to large urban centers and the progressive subdivision of land from generation to generation. Simultaneously, the economic need to achieve high production rates has led producers to incorporate complementary food resources into the available pastures. Improper use of concentrated food supplementation could lead to digestive disorders resulting in worse economic results.

This work aimed to evaluate the effect of rising levels of ground maize on the rumen pH and the intake, degradability, and digestibility of the dry matter in general, and starch and fiber in particular.

MATERIALS AND METHODS

Workplace

The trial was carried out at the Goat Experimental Unit of the School of Agricultural and Forest Sciences of the National University of La Plata (UNLP) Province of Buenos Aires, Argentina.

Animals and premises

Four five-year-old crossbreeds Criollo-Anglo Nubian non-pregnant non-lactating goats were used. Goats were fistulated with permanent 5 ’’ diameter *Bar Diamond Inc.* cannulas of a 5’’ diameter and put in a 4x4 Latin square experimental design with one repetition and seven days of washout in between terms. During determination periods, the goats were put in individual boxes (0.80 m x 1.50 m) with slatted wooden flooring, feeding troughs, slow feeders, and automatic nipple drinkers with free access to water. This work was regulated and authorized by the Institutional Committee for the Care and Use of Laboratory Animals of the Faculty of Veterinary Sciences of the National University of La Plata, whose file number is 0600-008961 / 12-000.

Treatments

Four diets containing alfalfa hay (M0), alfalfa hay + ground corn (0.5 % of BW/day) (M1), alfalfa hay + ground corn (1 % of BW/day) (M2), and alfalfa hay + ground corn (1.5 % of BW/day) (M3) were provided. The chemical composition of the used feed was registered in Table 1. Each animal's weight was registered at the beginning of each term and the average weight was 39,77 ± 1,07 Kg. A 15-day adaptation period was implemented for each diet before sampling. The amounts of ground corn were delivered increasingly, starting from 70 g per animal per day, until reaching the proportions of each treatment at the beginning of the second week of the adaptation period. Diets were delivered once a day at 9 is each day.

Determination of dry matter total intake, forage/concentrate relationship, *in vivo* total apparent digestibility of dry matter, organic matter, neutral detergent fiber, and starch

Individual food intake was determined using the difference between the delivered and rejected feed, after the adaptation period to the different diets.

To ensure the ad libitum nature of the supplies, feeders were kept stocked and hay amounts added to such end were recorded with Croma Systel electronic scale (min.weight 0,1 kg max.weight 30 kg). Excreted hay was collected and weighed daily in kg of dry matter. DM determination was accomplished with SOMCIC heater at a 90 - 95 ºC drying temperature during 24 hours (24). Total dry matter intake (TDMI), alfalfa hay dry matter intake (AHDMI), and the different fractions (OM), neutral detergent fiber (NDF), and starch were calculated. The forage/concentrate relationship was calculated as the hay and concentrate proportion consumed in relation to the total dry matter intake. After the adaptation period, excreted fecal matter was collected and quantified for five days, by means of a collecting bag and harness. The bags were emptied once per day, and the feces amount obtained was weighed. *In vivo* total dry matter intake (IVTDMI) and its fractions (OM, NDF and starch) were calculated by means of the difference between ingested and excreted amounts in relation to the ingested amounts, expressed in percentage (%).

Chemical analyses

A subsample of 10 % of each animal's excretions, after five days of collection, was dried in a SOMCIC heater at 90-95ºC drying temperature, during 24 h, to determine the dry matter. The obtained sample was then burnt at 500 °C, for three hours, for an ashes determination and subsequent OM determination (25). FDN was determined (26, 27) using an Ankom fiber analysis device (Model 200, USA). Starch was determined using the Holm technique (28).

Rumen pH determination

Rumen liquor was removed by cannula with a vacuum pump at 0, 2, 4, 6, 8, 12, and 24 h after feed ration. Collected samples were filtered using four layers of cheesecloth. pH was determined using a digital pH meter (Silver Cap pH 5045-3B, USA) equipped with a puncture electrode and thermoprobe calibrated with a buffer solution at pH 4 and 7. The area under the curve was calculated as the sum of partial areas defined by the absolute value of the deviation below pH 6 and the real-time interval between subsequent sampling, covering a 4 hours total span, accounted as pH × sampling time/day (29). The average value of rumen pH and the time in hours with pH below 6 were calculated using a repeated measures design (30). Also, the effect of time (hours) after a feed and the hour/treatment interaction was calculated using the mentioned design.

Determination of *in situ* rumen degradability

In situ rumen degradability was determined using Ørskov (31) technique. Ankom 10 x 10 cm polyester bags with 40 to 60-micron pores were used. The tiny pores block food escape and allow for the flow of microorganisms. Inside the bags, 10 mg/cm2 alfalfa hay samples were put to provide adequate contact between sample and rumen fluid (32). Forage was incubated for periods of 24 and 48 h (33). Then, it was removed from the rumen, washed clean during 10 minutes, and dried on heater at 90-95 ºC for 24 h (25). Degradability was determined from the difference of weight between the samples before and after *in situ* incubation inside nylon bags. After the incubation, rumen degradability of dry matter and alfalfa hay NDF fractions were determined following the Van Soest technique mentioned before.

Statistical analysis:

To evaluate the effect of rising amounts of ground corn grain, the following model was used:

$$Y = \mu + T + UE + P + e$$

Y: dependent variable

µ: general mean of trial

T: treatment

EU: experimental unit

P: period

e: error

Data were analyzed by MIXED SAS procedure (34) for a Latin 4x4 replicated square, using a mixed model which included the fixed sampling effect (treatment, period) and the random effect of the animal. Orthogonal contrasts were used to determine the linear (L), quadratic (Q) and cubic (C) effects of the different levels of maize used. Linear regressions were performed to determine the degree of correlation between the analyzed variables. Differences were considered significant for values p <0.05 and tendencies with a p-value between 0.05 and 0.10.

RESULTS AND DISCUSSION

Results show no significant effects (p>0,05) of the diet on the TDMI and TOMI. However, FDMI, FDNTI decreased linearly (p< 0,05) and ASTI increased significantly (p<0,05) with rising amounts of ground maize. Moreover, a significant linear decrease (p<0,05) of the F/C relationship was observed. IVTAD of DM, OM, and starch increased linearly (p< 0,05) with the incorporation of energy concentrate on the diet. However, if we analyze the relative increments of IVTAD of starch between treatments, M2 registered the lowest increment. This was corroborated for its statistical adjustment to a cubic model (Figure 1). Both the amount of starch in the fecal matter and the digestibility of NDF showed minimal values for a tenor of 1 % of BW of ground maize in the diet, adjusting (p<0,05) to a cubic and quadratic model respectively (Table 2).

In situ degradability of alfalfa hay DM for the 24 h of the rumen, incubation increased linearly (p<0,05) with an increment of ground maize concentrate between 0 and 1.5 % of BW. For 48 h of incubation, no significant differences were observed (p>0,05). Both *in situ* degradability of alfalfa hay NDF 24 h and 48 h after registered their minimal value in the treatment with 1 % of BW of ground maize in the diet, adjusting (p<0,05) both variables to a quadratic model. The area under the curve and the time during which the pH was under 6 showed a significant linear increase (p<0,05) about the ground maize content. The rising amounts of the grain produced a significant linear decrease ($p<0,05$) of the mean daily rumen pH (Table 3). The lowest value was registered between the 6 and 8 h after intake of the ration, showing a significant effect ($p<0,05$) of time (hours) on the daily pH rumen evolution (Table 4). No significant interactions ($p<0,05$) between time and treatment were observed (Figure 2).

A simple linear regression analysis between starch and forage intake showed a significant correlation ($p<0,05$), though moderately weak, between the analyzed variables (correlation coefficient = -0,492), attributable to a substitution effect of alfalfa hay for ground maize (Figure 3). The same regression analysis on excreted NDF and excreted starch showed a moderately strong relationship between the variables ($p<0,05$) and (correlation coefficient = 0,514) (Figure 4). Substitution effect takes place when ruminants consume forage and receive supplements, forage intake generally decreases (35, 36, 37). The decrease of alfalfa hay intake in the treatments including rising ground corn corroborated the substitution phenomenon as part of the intake behavior typical of goats. Goats modify their feeding behavior according to forage or concentrate availability, which makes them more versatile than other domestic ruminants (38). Likewise, in the present trial, goats showed certain adaptation ability, especially in diets with low F/C relationships, without altering the total dry matter intake. The total digestibility of dry matter intake increased with the presence of maize in the diet, due to it having an elevated amount of non-structural carbohydrates of high digestibility (6). Despite the differences observed among the treatments, starch digestibility was higher than 87 % (39, 40). When we analyzed the amount of starch present in the fecal matter, we observed that diet M2 showed a higher value, coinciding with the higher presence of excreted NDF. It also showed the lowest interaction between the rumen pH effect, as a result of the degradation of starch (7, 16, 17, 18, 19) and the amount of hay provided in the diet (41, 42). Despite having observed a greater amylolytic activity of the rumen as a result of the amount of concentrate in the diet (22, 23) the greater presence of NFD in the faeces may have altered the intestinal instance in the total digestion of starch (20, 21). In relation to what was mentioned by several authors (10, 11, 12) about the physical form / form / manner, the use of ground corn resulted in ruminal parameters notably different from those found in other investigations with the use of whole corn (44).

CONCLUSION

Given that the total starch digestion is the result of a balance between the ruminal and intestinal phase, rising amounts of energy concentrate on diets increase the total digestibility of starch. However, a lower pH resulting from a higher amylolytic activity may affect the local digestibility of the FDN, affecting the intestinal digestibility of starch as a consequence of a carry-over effect.

REFERENCES

1. Giraldo, C., E. Valderrama, L. Montoya & I. Armbrecht. (Asteraceae) sobre herbivoría de Atta cephalotes (Hymenoptera: Formicidae). En: Resúmenes IV Congreso Latinoamericano de Agroforestería para la producción animal sostenible y III Simposio sobre sistemas silvopastoriles para la producción ganadera sostenible. EEPF "Indio Hatuey". 2006. Matanzas, Cuba. Enero. pp.113.
2. Rosero, R. & S. Posada. Modelación de la cinética de degradación de alimentos para rumiantes. Rev.Colom. de Cien. Pecu. 2007. 20: 174-182.
3. Eliman, M.E & Ørskov, E.R. Factors affecting the outflow of protein supplement from the rumen. Animal Production. 1984. 38: 45-51.
4. Afonso, J. A. B. Doenças carenciais e metabólicas e sua influência na exploração de caprinos e ovinos. Seminário norte-rio grandense de caprinocultura e ovinocultura. 2005. Mossoró. In: Miranda Neto, E; Afonso, J.A.B; Saulo de Tarso Gusmão da Silva, S.T; Lopes de Mendonça, C. Utilização da Monensina sódica na Prevenção da Acidose Láctica Ruminal induzida em caprinos Ciencia Animal Basileira. 2009. Disponible http://www.revistas.ufg.br/index.php/vet/article/view/7737/5508.
5. Noro M., R. Chihuailaf & F. Wittwer. Diagnóstico de alteraciones ácido-básicas ruminales en vacas lecheras a pastoreo mediante ruminocentesis dorsal. En: Contreras PA, Noro M (eds). *Rumen: Morfofisiología, trastornos y modulación de la actividad fermentativa*. América, Valdivia, Chile. 2010. pp. 111-118.
6. Rapetti, L., L. Bava, A. Tamburini & G.M. Crovetto. Feeding behavior, digestibility, energy balance and productive performance of lactating goats fed forage-based and forage-free diets. Italian. Journal of Animal Science. 2005. 4:71–83.
7. Archimède, H., D. Sauvant, J. Hervieu, C. Poncet & M. Dorleans. Digestive interactions in the ruminant relationships between whole tract and stomach evaluation. Anim. Feed Sci. Technol. 1995, 54:327–340.
8. Harmon, D. L., R. M. Yamka, and N. A. Elam. Factors affecting intestinal starch digestion in ruminants: A review. Can. J. Anim. Sci. 2004. 84:309–318.
9. Offner, A., and D. Sauvant. Prediction of in vivo starch digestion in cattle from in situ data. Anim. Feed Sci. Technol. 2004. 111:41–56.
10. Oba, M., and M. S. Allen. Effects of corn grain conservation method on feeding behavior and productivity of lactating dairy cows at two dietary starch concentrations. J. Dairy Sci. 2003. 86:174–183.
11. Klieve AV, Hennessy D, Ouwerkerk D, Forster RJ, Mackie RI & Attwood GT. Establishing populations of Megasphaera elsdenii YE 34 and Butyrivibrio fibrisolvens YE 44 in the rumen of cattle fed high grain diets. J Appl Microbiol. 2003. 95: 621–630.
12. Schwartzkopf-Genswein, K. S., K. A. Beauchemin, T. A. McAllister, D. J. Gibb, M. Streeter, and A. D. Kennedy. Effect of feed delivery fluctuations and feeding time on ruminal acidosis, growth performance, and feeding behavior of feedlot cattle. J. Anim. Sci. 2004. 82:3357–3365.
13. Stevnebø, A., S. Sahlströmb and B. Svihus. Starch structure and degree of starch hydrolysis of small and large starch granules from barley varieties with varying amylose content. Anim. Feed Sci. Tech. 2006.130: 23-38.
14. Vasconcelos, J.T., Galyean, M.L. Nutritional recommendations of feedlot consulting nutritionists: the Texas Tech University survey. J. Anim. Sci. 2007. 85, 2772–2781.

15. Svihus, B., A. K. Uhlen and O. M. Harstad. Effect of starch granule structure, associated components and processing on nutritive value of cereal starch: A review. Anim. Feed Sci. Tech. 2005. 122: 303-320.

16. Kovacik, A.M., S.C. Loerch & B.A. Dehority. Effect of supplemental sodium bicarbonate on nutrient digestibility and ruminal pH measured continuously. J. Anim. Sci. 1986. 62:226–234.

17. Grant, R.J. & D.R. Mertens. Development of buffer of pH effects on fiber systems for pH control and evaluation digestion in vitro. J. Dairy Sci. 1992. 75:1581–1587.

18. Ørskov, E. R. Starch digestion, and utilization in ruminants. J. Anim. Sci. 1986. 63: 1624-1633.

19. Dijkstra J. Production and absorption of volatile fatty acids in the rumen. Livest Prod Sci. 1994. 39: 61-69.

20. Reynolds, C. K., P. C. Aikman, B. Lupoli, D. J. Humphries & D. E. Beever. Splanchnic metabolism of dairy cows during the transition from late gestation through early gestation. J. Dairy Sci. 2003. 86:1201–1217.

21. Huntington, G.B., Harmon, D.L., Richards, C. J. Sites, rates, and limits of starch digestion and glucose metabolism in growing cattle. J. Anim. Sci. 2006. 84, E14–E24 E. Suppl.

22. Hristov, A.N., McAllister, T.A., Cheng, K.-J. Effect of diet, digesta processing freezing and extraction procedure on some polysaccharide degrading activities of ruminal content. Can. J. Anim. Sci. 1999. 79, 73–81.

23. Hristov, A.N., McAllister, T.A., Cheng, K.J. Intraruminal supplementation with increasing levels of exogenous polysaccharide-degrading enzymes: effects on nutrient digestion in cattle fed a barley grain diet. J. Anim. Sci. 2000. 78, 477–487.

24. AOAC. Official Methods of Analysis. AOAC 923.03. Meted ICC Nº 104/1. Association of Official Analytical Chemists. 1990**.** Arlington, VA, USA.

25. AOAC. Dry mater in Animal Feed. Method number 934.01. In: Official Methods of Analysis of AOAC International. 16th edn. vol. I. Association of Official Analytical Chemists, Arlington. 1995, VA, USA, pp, I (Chapter 4).

26. Van Soest, P.J, J.B. Robertson & B.A. Lewis. Methods for dietary fiber neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sc. 1991. 74:3583-3597.

27. Komarek, A. R., J. B. Robertson & P. J. Van Soest. Comparison of the filter bag technique to conventional filtration in the Van Soest Analysis of 21 feeds. In: Proc. Natl. Conf. on Forage Quality, Evaluation and Utilization, Lincoln, NE. 1994. pp. 78.

28. Holm, J., I. Bjorck, A. Drews and NG Asp. A rapid method for analysis of starch. Starch / Starke.1986.7: 224–226.

29. Pitt, R. E. & A. N. Pell. Modeling ruminal pH fluctuations: Interactions between meal frequency and digestion rate. J. Dairy Sci. 1997. 80:2429–2441.

30. Littell, R. C., P. R. Henry & C. B. Ammerman. Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci. 1998. 76:1216-1231.

31. Ørskov, E. R., F. D. De b Hovell & F. Mould. The use of the nylon bag technique for evaluation of feedstuffs. Tropical Animal Production. 1980. 5: 195-213.

32. Galyean, M. L. Laboratory Procedures in Animal Nutrition Research. Texas Tech Univ. 2010. **http://apps.depts.ttu.edu/afs/home/mgalyean/lab_man.pdf.**

33. Li, Y. L., T. A. McAllister, K. A. Beauchemin, M. L. He, J. J. McKinnon & W. Z. Yang. Substitution of wheat dried distillers grains with soluble for barley grain or barley silage in feedlot cattle diets: Intake, digestibility, and ruminal fermentation. J. Anim. Sci. 2011. 89:2491-2501.

34. SAS Institute Inc. SAS Online Doc* 9.1.3. Cary, NC: SAS Institute. Inc. 2004.

35. Kellaway, R. & S. Porta. Feeding concentrates supplements for dairy cows. Dairy Research and Development Corporation. Australia. 1993. 176 pp.

36. Stockdale, C. R. Levels of pasture substitution when concentrates are fed to grazing dairy cows in northern Victoria. Aust. J. Exp. Agric. 2000. 40:913-921.

37. Arias, R.O; M.G. Muro, M.S. Trigo, S. Deschamps, J. Origlia, D. Gornatti Churria, A. C. Cattáneo & C.A. Cordiviola. Effect of type of hay and concentrate level in intake and digestibility in diets for goats. International Journal of Sciences. 2017. Vol 6:2, 35-42.

38. Rapetti, L & L. Bava. In: Antonello Cannas and Giuseppe Pulina Editores. Feeding Management of Dairy Goats in Intensive Systems. Italy, Milan. 2008. pp. 221-337.

39. Pordomingo, A. J., Jonas, O., Adra, M., Juan, N. A. y Azcarate, M. P. Evolución de dietas basadas en grano entero, sin fibra larga, para engorde de bovinos a corral, RIA. 2002. 31:1- 22.

40. Maresca, S., santini, F. J y Pavan, E. Comportamiento productivo de terneras alimentadas a corral con grano de maíz entero y partido. Rev. Arg de Prod. Anim. 2003. NA 672 (1).

41. Liu X., Z. Wang & F. Lee. Influence of concentrate level on dry matter intake, N balance, nutrient digestibility, ruminal outflow rate, and degradability in sheep. Small Rumin. 2005. Res. 58: 55-62.

42. Lefrileux Y., P. Morand-Fehr & A. Pommare. Capacity of high milk yielding goats for utilizing cultivated pasture. Small Rumin. Res. 2008. 77: 113-126.

43. Reynolds, A.M. y O´Doherty, J.V. Livestock Science. 2006. 104: 112-122.

44. Arias R.O; Cordiviola, C.A; Muro, M.G; Trigo, M.S; Cattáneo, A.C; Calonge, F.S; Antonini, A. G. Ground and whole-grain corn: effect on ruminal ph in goats diets. *International Journal of Sciences*. 2015. (3). Vol (4). Pp. 11-15.

Table No. 1: Feed chemical composition*

Item	Alfalfa	Maize
DM (%)	87,0	89,0
OM (%)	91,9	98,7
CP (%)	13,9	8,1
EE (%)	2,4	3,9
S (%)	2,34	72,8
A (%)	8,1	1,3
NDF (%)	55,33	14,55
ADF (%)	42,53	3,68

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DM: Dry Matter.

OM: Organic Matter.

CP: Crude Protein.

CF: Crude Fiber

EE: Ethereal Extract

NDF: Neutral Detergent Fiber.

ADF: Acid Detergent Fiber.

Table No. 2: Polynomial Orthogonal Contrasts to determine linear, quadratic, and cubic effects on TDMI, TOMI, FDMI, TNDFI, SDMI, F/C, IVTAD of the DM, OM, NDF, and starch (*).

Item	Diets				SE	Contrasts		
	M_0	M_1	M_2	M_3		L	Q	C
TDMI (Kg/day)	1,156	1,255	1,222	1,022	0,109	0,389	0,189	0,946
TOMI (Kg/día)	1,040	1,129	1,099	0,920	0,117	0,350	0,177	0,851
FDMI (Kg/day)	1,156	0,892	0,736	0,522	0,089	0,001	0,736	0,707
TNDFI (Kg/day)	0,548	0,480	0,392	0,274	0,042	0,001	0,572	0,960
SDMI (Kg/day)	0,023	0,104	0,168	0,220	0,013	0,001	0,266	0,929
F/C	1,00	0,797	0,662	0,416	0,042	0,001	0,596	0,337
IVDMTAD (%)	70,76	72,60	78,82	82,96	2,253	0,000	0,616	0,523
IVOMTAD (%)	73,63	75,66	80,27	83,32	2,386	0,005	0,835	0,703
IVNDFTAD (%)	75,23	77,27	63,76	72,79	2,952	0,156	0,253	0,016
starch IVTAD (%)	87,32	90,39	90,65	91,54	0,375	0,000	0,006	0,045
starch excret (g/day)	1,190	1,853	2,406	1,089	0,255	0,809	0,003	0,099

TDMI: Total dry matter intake per day expressed in Kg per day.

TOMI: Total organic matter intake expressed in Kg per day.

FDMI: Forage dry matter intake, expressed in Kg per day.

TNDFI: Total neutral detergent fiber intake expressed in Kg per day.

SDMI: Starch dry matter intake expressed in Kg per day.

F/C: Concentrate forage relationship of the consumed diet, according to treatment.

IVDMTAD: *In vivo* total apparent digestibility of dry matter expressed in percentage.

IVOMTAD: *In vivo* total apparent digestibility of organic matter expressed in percentage.

IVNDFTAD: *In vivo* total apparent digestibility of neutral detergent fiber expressed in percentage.

Starch IVTAD: *In vivo* total apparent digestibility of starch expressed in percentage.

Almidón excret: almidón excretado en materia fecal expresado en gramos.

SE: Standard error.

L: linear effect.

Q: quadratic effect.

C: cubic effect.

Table No. 3: Polynomial orthogonal contrasts to determine linear, quadratic, and cubic effects and analysis of means comparison in the *in-situ* degradability of the dry matter and the NDF fractions of alfalfa hay, and on rumen pH on the use of ground maize as an energy supplement.

Item	Diets				SE	Contrasts		
	M_0	M_1	M_2	M_3		L	Q	C
ISDAHDM 24	53,10	55,00	56,13	59,15	1,502	0,030	0,706	0,429
ISDAHDM 48	70,00	67,10	63,30	64,00	2,785	0,122	0,499	0,469
ISDAHNDF 24	45,59	40,20	39,14	46,90	2,456	0,422	0,016	0,589
ISDAHNDF 48	67,36	56,45	49,42	52,13	1,914	0,002	0,019	0,475
pH h/d	0,00	0,79	3,07	4,09	1,047	0,036	0,700	0,478
Average pH	6,51	6,40	6,07	5,90	0,112	0,003	0,808	0,540
Hr pH<6	0,35	3,85	6,60	8,08	1,108	0,006	0,775	0,513

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ISDAHDM24: *in-situ* degradability of the alfalfa hay dry matter after 24 h of incubation.

ISDAHDM48: *in-situ* degradability of the alfalfa hay dry matter after 48 h of incubation.

ISDAHNDF24: *in-situ* degradability of the alfalfa hay NDF after 24 h of incubation.

ISDAHNDF48: *in-situ* degradability of the alfalfa hay NDF after 24 h of incubation.

pH (h/d): pH expressed as the surface under the curve of a threshold pH of 6.

Average pH: average pH during 24 h of measuring, according to treatment.

H pH<6: Time in hours with pH under 6.

SE: Standard Error.

L: linear effect.

Q: quadratic effect.

C: cubic effect.

Table No. 4: Effect of time (h) on rumen pH during 12 h after feeding on the use of ground maize as an energy supplement.

Item							**SE**
Hour	0	2	4	6	8	12	
Nº of goats	4	4	4	4	4	4	
pH[1]	7,04[a]	6,27[b]	5,92[bc]	5,75[c]	5,88[d]	5,91[d]	0,079

pH: rumen pH.

1: Effect of time (h) on rumen pH (p<0,0001).

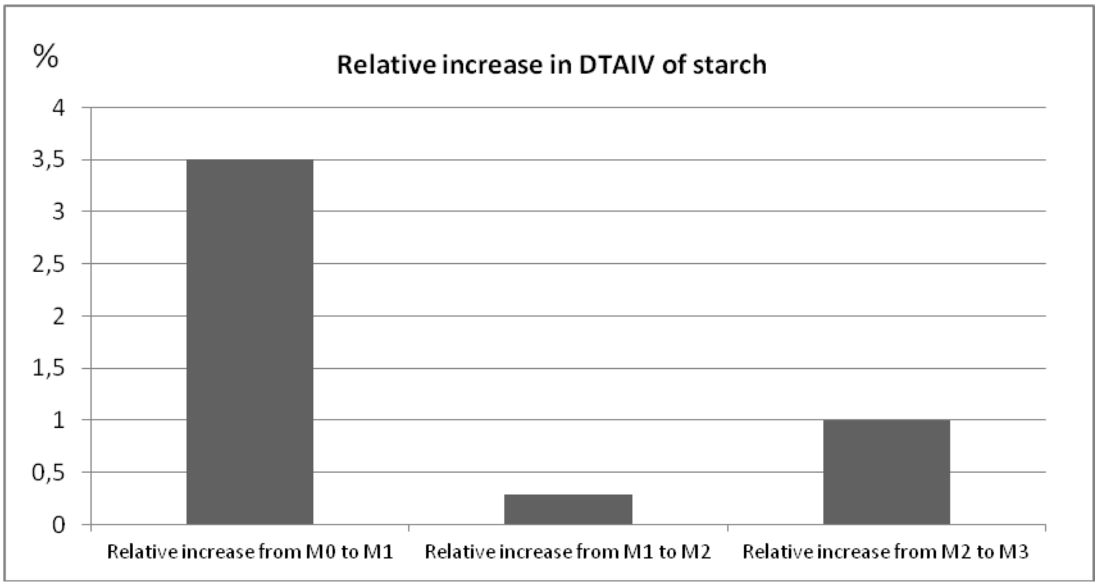

Figure No. 1: Relative increase of the IVTAD of starch among the different treatments.

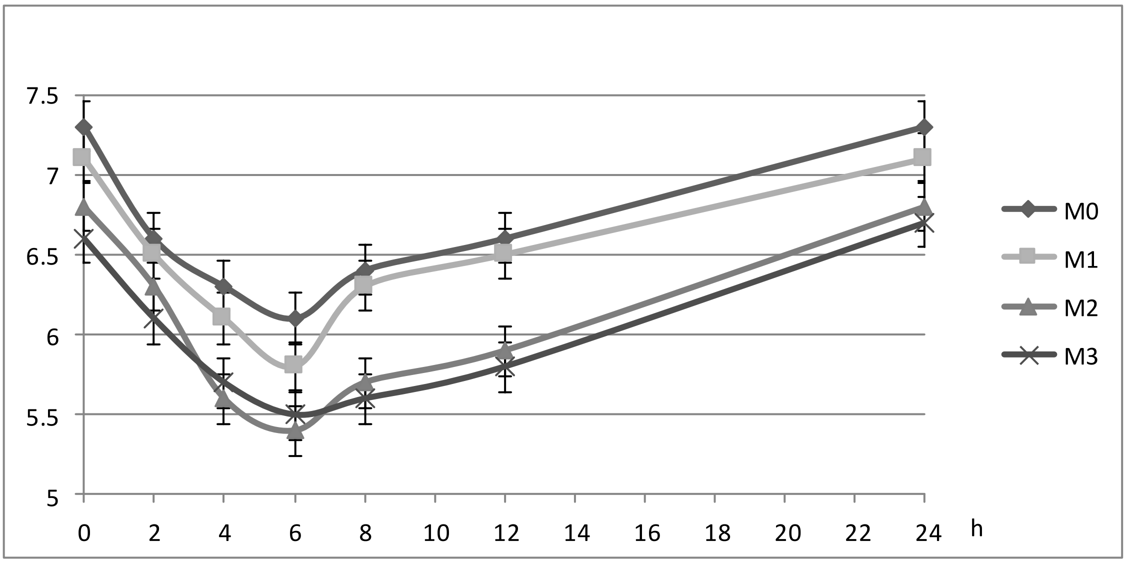

Figure No. 2: Rumen pH values during 24 h of measuring on the use of ground maize as an energetic supplement. Treatment effect (p=0,005). Hour*treatment interaction (p=0,862).

M_0: 100% alfalfa hay ad libitum.

M_1: 0,5% of ground maize and alfalfa hay BW *ad libitum* in the diet.

M_2: 1% of ground maize and alfalfa hay BW *ad libitum* in the diet.

M_3: 1,5% of ground maize and alfalfa hay BW *ad libitum* in the diet.

SE: standard error.

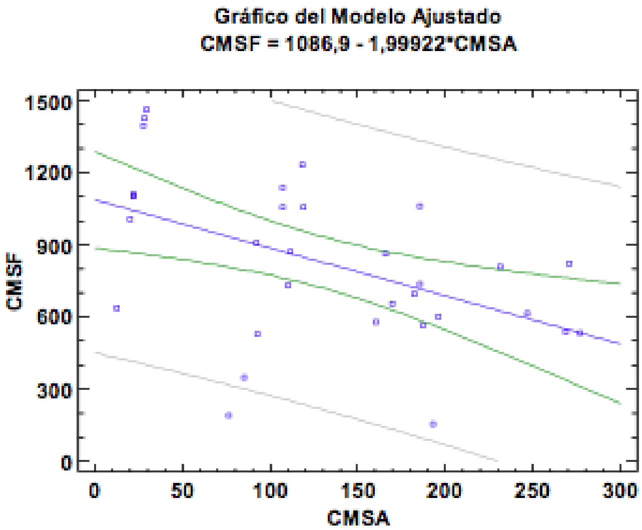

Figure No. 3: Linear regression between starch and alfalfa hay intake.

CMSF: forage dry matter intake.

CMSA: starch dry matter intake.

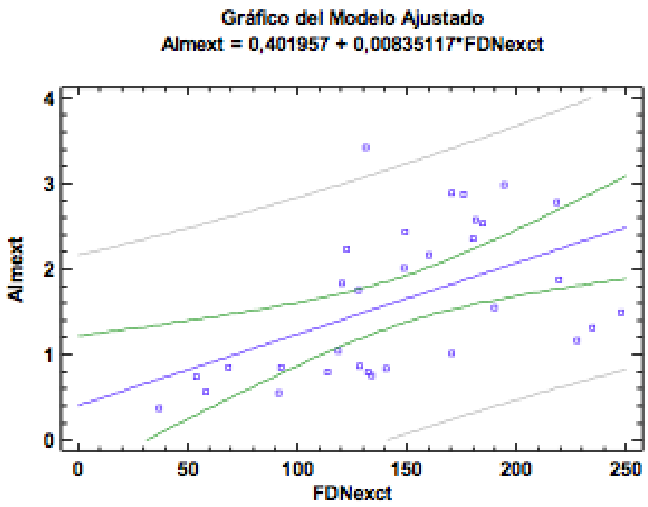

Figure No. 4: Linear regression between excreted starch and FDN.

Almext: starch excreted in faecal matter.

FDNexct: neutral detergent fiber excreted in fecal matter.