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Ground and Whole Grain Corn: Effect on Ruminal pH in Goats Diets

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Abstract: The objective of this study was to evaluate the effects of whole and ground corn grain in ruminal pH and total dry matter intake in diets for goats. Eight crossbreed goats (Creole x Nubian) was fitted with a rumen cannula and assigned in a replicated 4 × 4 Latin square experimental design. Two experiments were conducted; in the first test we used whole grain corn and second, ground corn grain. Ruminal pH data was measured for each goat as average pH, area between the curve and a horizontal line at pH 6, and duration less than pH 6. In the first experiment, there were not differences ($p > 0.05$) on area between the curve and a horizontal line at pH 6, average pH and duration less than pH 6 among diets. A tendency was observed ($p = 0.08$) to decrease in DMI and the F/C decreased linearly ($p < 0.05$) with increasing whole corn in ration. In the second experiment, a significant linear increase was observed ($p < 0.05$) on area between the curve and a horizontal line at pH 6, with increasing ground corn. A linear decrease ($p < 0.05$) was observed in average ruminal pH and linear increase ($p < 0.05$) in duration less than pH 6. There was no difference in DMI and linear decrease ($p < 0.05$) in F/C with increasing whole. The milling corn grain, increase the hydrolysis rate of the starch, possibly because to increased bacterial colonization of the horny endosperm surface, lowering ruminal pH.

Keywords: whole corn, ground corn, ruminal pH

INTRODUCTION

The demand for animal products is increasing in developing countries (Delgado et al., 1999), and, as a consequence, the demand for cereals for animal feed competes with that for human consumption. In addition, there is growing use of cereals in biofuel production, which has pushed the prices of most cereals to record levels (FAO, 2008). These facts highlight the need to design diverse strategies in animal nutrition to utilize alternative sources of nutrients and decrease cereal use.

The meat-goat industry has grown recently (Oman et al., 1999; Cameron et al., 2001), providing many new opportunities for additional income on diversified farming operations. Meat-goat producers will need feeds that are economical and easily managed. Grain-based commercial supplements may not be economical for growing and finishing meat goats, and feeding these traditionally high-starch supplements may lead to reduced ruminal pH and fiber digestibility (Garces-Yepezurces et al., 1997).

When animals eat grains usually decreases forage intake. This is known as substitution rate (Stockdale, 2000a). The incorporation of concentrates into ruminant diets is intended to increase dietary energy, proteins, minerals, and vitamins and to optimize the efficiency of feed utilization (Morand-Fehr and Sauvant, 1987). However, grain supplementation may decrease ruminal degradability of alfalfa hay in diets for goats (Arias et al., 2013). The degree which concentrates affect fiber digestion may depend on the nature and proportion of the concentrate as well as the quality of the forage (Matejovsky and Sanson, 1995).

The goat production systems traditionally developed based on grazing, in the present time there is a tendency toward intensification (Castel et al., 2003) and, hence, to the use of increasing amounts of concentrate in diets. The world goat population has been steadily increasing (39% increase from 1986 to 2000; FAO, 2008), but research into digestibility, ruminal fermentation, or microbial protein synthesis (Cerrillo et al., 1999; Yanez-Ruiz et al., 2004) in

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goats fed different quality forages is scarce compared with that carried out with other animal species.

Cereal ground grains in the rumen causes insufficient saliva secretion to maintain the pH between 6 and 7 and stimulate rumen motility (Gonçalves, 2001).

The protein matrix around the starch granules explains the differences of cereal grains digestibility (Stern, et al., 1994).

Changes in eating habits of rumiants in intensive systems may cause fermentation disturbances as ruminal acidosis (Afonso, 2005). Cases of subacute acidosis in dairy cattle are caused by improper management in animal nutrition (Noro, et al., 2010).

Subacute ruminal acidosis (**SARA**) is a common health and production problem occurring in ruminants and is often triggered by low ruminal pH from a low-fiber diet. In addition to the quantity of fiber consumed, the physical form of feed also plays an important role in the cause of SARA. Feed with shorter particle sizes usually result in reduced chewing time and ruminal pH (Grant et al., 1990). Goats have different feeding behavior, intake, diet selection, and rate of eating from other ruminants (Lu et al., 2005); thus, knowledge obtained from different species may not extrapolate well to goats.

The objective of this study was to evaluate the effects of whole and ground corn grain in ruminal pH and total dry matter intake in diets for goats.

MATERIALS AND METHODS

Eight crossbreed goats (Creole x Nubian) with an average BW of 39.2 $\pm$ 0.6 kg was fitted with a rumen cannula (i.d. = 4 cm) and assigned in a replicated 4 × 4 Latin square experimental design. Goats were housed indoors under continuous light in individual metabolism crates (1 m × 1.5 m). Two experiments were conducted; in the first test we used whole grain corn and second, ground corn grain.

Diets Exp. 1

Four diets were tested: alfalfa hay (E_0), alfalfa hay + whole corn grain at 0.5% LW / day (E_1), alfalfa hay + whole corn grain at 1% LW / day (E_2) and alfalfa hay + whole corn grain at 1.5% LW / day (E_3).

Diets Exp. 2

Four diets were tested: alfalfa hay (M_0), alfalfa hay + ground corn grain at 0.5% LW / day (M_1), alfalfa hay + ground corn grain at 1% LW / day (M_2) and alfalfa hay + ground corn grain at 1.5% LW / day (M_3).
Alfalfa hay was offered ad libitum and implemented to adapt period of fifteen days diet.
Was calculated the total dry matter intake (DMI) and forage concentrate ratio (F/C).

On d 16, a 50-mL sample of rumen contents was individually collected at 0, 2, 4, 6, 8, 12, and 24 h after the morning feeding. Ruminal pH was measured with pH transmitter puncture electrode incorporated. The electrodes were calibrated using pH 4.0 and 7.0 standards and suspended in the fluid rumen extracted from the cannula using a hand breast pump. Ruminal pH data was measured for each goat as average pH, area between the curve and a horizontal line at pH 6, and duration less than pH 6 (Yang and Beauchemin, 2007).

Statistical Analyses

Intake and area between the curve and a horizontal line at pH 6, duration less than pH 6, and average ruminal pH data were analyzed as a 4 × 4 Latin square (Steel and Torrie, 1980) using a mixed model that included the fixed effect of sampling (treatment, period) and the random effect of the animal. Orthogonal contrasts were used to determine linear (L) cubic (C) and quadratic (Q) effects of increasing levels of concentrate. All statistical computations were conducted using the GLM procedure of SAS.

RESULTS AND DISCUSSION

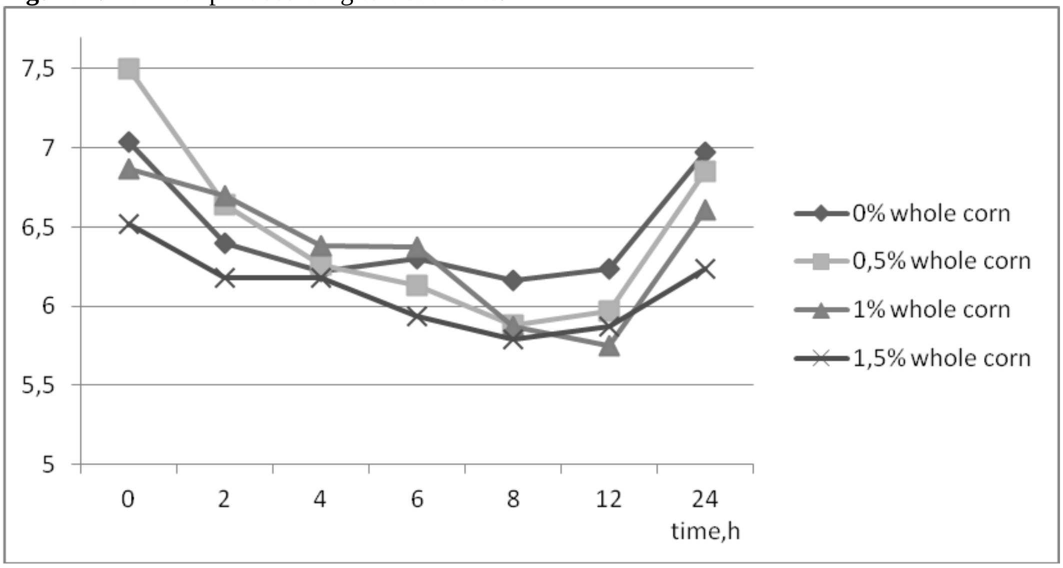
In the first experiment, there were not differences ($p > 0.05$) on area between the curve and a horizontal line at pH 6, average pH and duration less than pH 6 among diets. A tendency was observed ($p = 0.08$) to decrease in DMI with increasing concentrate. The F/C decreased linearly ($p < 0.05$) with increasing whole corn in ration. Low ruminal pH was observed between 8 and 12 hours after intake of the ration (Figure 1).

Table1. Orthogonal polynomial contrasts to determine linear, quadratic and cubic effects on ruminal pH, DMI and F/C with whole corn in the diet.

Item	Diets				SEM	Contrast		
	E_0	E_1	E_2	E_3		L	Q	C
pH (h/d)	0,00	0,91	0,95	1,77	0,694	0,589	0,710	0,753
pHm	6,48	6,42	6,37	6,10	0,125	0,267	0,455	0,733
Hr pH<6	0,00	2,25	3,25	6,25	2,565	0,613	0,838	0,331
Intake, Kg/d	1,58	1,60	1,46	1,38	0,232	0,080	0,556	0,548
F_C	1	0,89	0,71	0,48	0,035	0,001	0,101	0,998

pH (h/d): area between the curve and a horizontal line at pH 6.
pHm: Means pH during 24 hours of measurement, according to treatment.
Hr pH<6: duration less than pH 6.
F_C: forage: concentrate, according to treatment.
Intake, Kg/d: total dry matter intake.
L: Probability value associated with a linear effect of level of supplementation with whole corn in an orthogonal polynomial contrast.
Q: Probability value associated with a quadratic effect of level of supplementation with whole corn in polynomial orthogonal contrast.
C: Probability value associated with a cubic effect of level of supplementation with whole corn in polynomial orthogonal contrast.

Figure 1. Ruminal pH according to treatments.



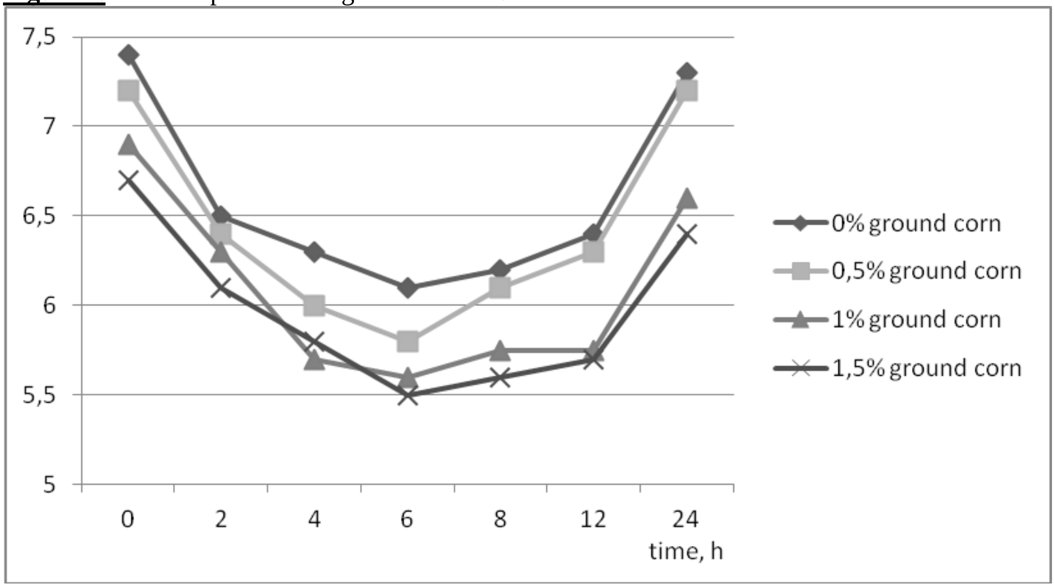
In the second experiment, with ground corn as supplement, a significant linear increase was observed ($p < 0.05$) on area between the curve and a horizontal line at pH 6, with increasing ground corn. A linear decrease ($p < 0.05$) was observed in average ruminal pH and linear increase ($p < 0.05$) in duration less than pH 6. There was no difference in DMI and linear decrease ($p < 0.05$) in F/C with increasing whole (Table 2). Low ruminal pH was observed between 6 and 8 hours after intake of the ration (Figure 2).

Table2. Orthogonal polynomial contrasts to determine linear, quadratic and cubic effects on ruminal pH, dry matter intake and forage: concentrate with ground corn in the diet.

Item	Diets				SEM	Contrast		
	M_0	M_1	M_2	M_3		L	Q	C
pH (h/d)	0,00	0,80	3,06	4,18	1,037	0,025	0,813	0,529
pH m	6,48	6,38	6,08	5,88	0,125	0,007	0,705	0,576
Hr pH<6	0,00	3,90	7,45	8,00	1,170	0,003	0,865	0,262
Intake, Kg/d	1,12	1,25	1,21	1,19	0,245	0,612	0,417	0,659
F_C	1,00	0,81	0,64	0,45	0,044	0,001	0,904	0,875

pH (h/d): area between the curve and a horizontal line at pH 6.
pHm: Means pH during 24 hours of measurement, according to treatment.
Hr pH<6: duration less than pH 6.
F_C: forage: concentrate, according to treatment.
Intake, Kg/d: total dry matter intake.
L: Probability value associated with a linear effect of level of supplementation with ground corn in an orthogonal polynomial contrast.
Q: Probability value associated with a quadratic effect of level of supplementation with ground corn in polynomial orthogonal contrast.
C: Probability value associated with a cubic effect of level of supplementation with ground corn in polynomial orthogonal contrast.

Figure 2. Ruminal pH according to treatments.



Goat production has increased in the last years (FAO, 2008). This could be due to a need for livestock diversification whit a tendency toward intensification (Oman et al., 1999; Cameron et al., 2001; Castel et al., 2003). Therefore, in agree to Morand-Fehr and Sauvant (1987); Grant et al., (1990) Afonso, (2005) and Noro, et al., (2010) that incorporating concentrates in diets, for increased productivity, causes fermentative ruminal diseases as SARA, and whit pH recorded in these studies employing corn as energetic concentrate, probably decreased ruminal degradability and fiber digestibility of alfalfa hay (Matejovsky and Sanson, 1995; Gonçalves, 2001; Arias, et al., 2013).

The lower ruminal pH observed in experiment 2 may be attributed to increased exposure of the starch of ground corn (Stern, et al., 1994).

In both experiments a substitution of corn whit forage was observed while decreasing F / C (Stockdale, 2000a).

CONCLUSION

In conclusion, the process of milling corn grain, increase the hydrolysis rate of the starch, possibly because to increased bacterial colonization of the horny endosperm surface, this effect was noticed by a lower value of ruminal pH.

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