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Intake, digestibility and ruminal fermentation of ground and whole maize bran fed to American Alpine goats

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Abstract

A study was conducted to determine the effect of quantity and physical form of maize bran (CB) in diets of goats, on intake, digestibility and rumen fermentation. Sixteen male American Alpine goats weighing *ca*. 24 kg, were randomly assigned to four groups in a completely random design with a 2 x 2 factorial arrangement of treatments (two levels of CB, 15 and 30%; and two physical forms, whole and ground). Quantity and physical form of CB did not affect DM intake or digestibility. DM intake was 96.6 and 87.2 g/kg$^{0.75}$ for goats on the 15 and 30% CB diets, respectively. For treatments with whole and ground CB, intake was 93.4 and 90.4 g/kg$^{0.75}$, respectively. DM digestibility was 72.4 and 71.9% for 15 and 30% CB in the diet. Grinding CB did not improve digestibility (71.9% and 72.4%) for whole and ground CB, respectively. Time spent eating (min/day) was not affected by quantity or physical form of CB. Time spent ruminating was significantly greater for goats fed the 15% CB diets (397 min/day) than for those fed diets with 30% CB (338 min/day). Grinding of CB did not significantly change the time goats spent ruminating. Whereas total time spent masticating was significantly lower for 30% CB diets, no effect of grinding of CB was observed. As CB increased from 15 to 30%, total VFA production increased significantly from 85.5 to 112.1 mmoles/L. Increasing CB from 15 to 30% in the diet increased concentrations (mmoles/L) of acetate (from 55.7 to 72.6), propionate (from 19.9 to 26.1) and butyrate (from 85.5 to 112.1). Grinding CB had no effect on total volatile fatty acid production (101.7 *vs*. 95.9 for whole and ground, respectively). Molar percent propionate increased from 19.9 to 26.1 when CB increased from 15 to 30%. Molar percent of other VFA (acetate, 65.1 *vs*. 64.8; butyrate, 11.7 *vs*. 11.8) did not change. Grinding CB had no effect on VFA molar percent.

Keywords: Alpine goats, maize bran, intake, digestibility, ruminal fermentation
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Introduction

In the semi-arid regions of México annual precipitation is generally lower than 250 mm and forage in rangelands is scarce (Kawas, 1990). Feeding goats in confinement is a common practice during the most critical months of the year. In the production of tortilla flour (nixtamal) for human consumption, maize bran (CB), a by-product of the industry, is available as an animal feed. Maize bran is high in cell wall content (600 g NDF/kg), primarily hemi-cellulose (90% of NDF). Van Soest (1994) suggested a discount on the nutritive value of 18% for CB.

Feeds that contain a high cell wall content, but are poorly lignified such as CB or soyabean bran, are generally considered to have higher discount values. Grinding these by-products may increase the surface area for microbial activity in the rumen, which could increase digestibility. On the other hand, whole bran has a larger particle size that can be more easily ruminated by small ruminants (Van Soest, 1994).

The objective of this study was to determine the effect of quantity and physical form of maize bran on DM intake and digestibility, mastication activities (eating and rumination) and VFA concentrations in rumen fluid.

Materials and Methods

Sixteen American Alpine young male goats, six weeks of age, were randomly assigned to four groups in a completely randomized design with a 2 x 2 arrangement of treatments (2 levels and 2 physical forms of

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CB). The study lasted 28 days, 21 days for adaptation to the metabolism crates and feed, and seven days for collection of samples and data. The goats were confined to individual metabolism cages (1.5 m^2). Animals were de-wormed and injected with vitamins A, D and E. Water was offered free choice. Animals were weighed on two consecutive days at the beginning and the end of the sampling phase. Diets are presented in Table 1. Chemical composition of the diets containing 15% and 30% CB were, respectively: crude protein (CP) - 151 and 154 g/kg; NDF - 466 and 531 g/kg; ADF - 217 and 227 g/kg and hemi-cellulose - 249 and 302 g/kg diet. Feed was offered *ad libitum* three times during the day. Samples of offered and rejected feed and faeces were dried in an oven at 60 °C and ground through a 1 mm sieve in a Wiley mill, before analysis. Total faeces were collected and daily weight recorded every morning to determine DM excretion and digestibility. Samples were analysed to determine residual DM at 105 °C (AOAC, 1997). Ash content was obtained after combustion of samples in a muffle furnace at 550 °C for three hours. Neutral detergent fibre and its constituents were analyzed according to procedures reported by Goering & Van Soest (1970). The nitrogen (N) concentrations of samples were determined using the micro-Kjeldahl method (AOAC, 1997) and CP was calculated as N x 6.25. During a 24 h period, eating and ruminating activities were recorded every five minutes to determine total mastication time. Rumen fluid was obtained 2 h postprandial using a stomach tube. The VFA concentrations were determined by means of gas chromatography (Goetsch & Galyean, 1983). Results were statistically analysed by means of analysis of variance for a completely randomized design with a 2 x 2 factorial arrangement of treatments. Sources of variation were level (LE) and physical form (PF) of CB in the diet, and the corresponding error term.

Table 1 Composition of diets for goats, with two levels of maize bran (QU) and two physical forms, whole and ground

	15% Maize bran		30% Maize bran	
	Ground	Whole	Ground	Whole
Ingredient, g/kg				
Grass hay	400	400	400	400
Sorghum, ground	227	227	64	64
Maize bran	150	150	300	300
Cottonseed meal	62	62	75	75
Soyabean meal	80	80	80	80
Molasses	60	60	60	60
Dicalcium phosphate	10	10	10	10
Calcium carbonate	9	9	9	9
Premix[1]	2	2	2	2

[1]Premix: contained essential trace minerals and vitamins A, D_3 and E

Results and Discussion

The DM intake and digestibility of Alpine goats fed two levels of CB, whole and ground, are presented in Table 2. The DM intake was not affected ($P > 0.05$) by quantity or physical form. Dry matter intake was 1022 (96.6 g/$kg^{0.75}$) and 967 g/d (87.2 g/$kg^{0.75}$) for goats fed the 15% and 30% CB diets, respectively. Apparently, particle size of CB did not physically limit DM intake. Dry matter intake was 1015 g/d (93.4 g/$kg^{0.75}$) and 975 g/d (90.4 g/$kg^{0.75}$) for whole and ground CB diets, respectively. Although no difference in DM intake was observed, numerically the intake (g/$kg^{0.75}$) was lower (9.7%) in goats fed the diet with the higher CB (30%) content.

Faecal DM excretion was not affected ($P > 0.05$) by quantity or physical form of CB. Dry faeces were 281.8 and 272.4 g/d in goats fed diets with 15% and 30% CB, respectively, and 284.7 and 269.5 g/day for diets containing whole and ground CB, respectively. The DM digestibility was not affected ($P > 0.05$) by level of CB in the diet. For goats fed diets with 15% or 30% CB, DM digestibility was 72.4 and 71.9%, respectively. Grinding CB did not improve ($P > 0.05$) DM digestibility. The DM digestibility was 71.9 and 72.4% for whole and ground CB, respectively. Although Van Soest (1994) suggested an 18% reduction in the nutritive value of CB, in the present study, DM digestibility of diets with 15% and 30% CB was not different.

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Mastication includes both eating and rumination (Table 5). The time (min/day) spent eating diets with 15% and 20% CB (194 *vs*. 168 min) was not different (P > 0.05). Eating time of whole (179 min/d) or ground (183 min/d) CB was not different (P > 0.05). Time spent ruminating depends primarily on level of DM intake and the fibre content of the diet (Barros *et al*., 1986).

Table 2 Dry matter (DM) intake and digestibility of Alpine goats fed diets with two levels of maize bran (QU) and two physical forms, whole or ground

	Quantity		Physical form			< P		
	15%	20%	Whole	Ground	s.e.	QU	PF	QU x PF
Body weight, kg	23.2	25.0	24.4	23.9	0.93	0.35	0.78	0.81
DM intake								
g/d	1022	967	1015	975	39.6	0.50	0.63	0.78
$g/kg^{0.75}$	96.6	87.2	93.4	90.4	3.15	0.16	0.65	0.89
Faecal excretion, g/d	281.8	272.4	284.7	269.5	11.5	0.69	0.52	0.33
DM digestibility, %	72.4	71.9	71.9	72.4	0.55	0.67	0.67	0.16

Time spent ruminating was greater (P < 0.05) for goats fed the diet with 15% (397 min/d) than with goats fed the 30% (338 min/d) CB diet (Table 3). Apparently, the greater time spent ruminating with goats fed the 15% CB diet was due to a greater DM intake. Goats fed the 15% CB diet spent 17% more time ruminating than those fed the 30% CB diet. Grinding the CB did not significantly reduce (P > 0.05) time spent ruminating. Total time spent masticating was reduced (P < 0.05) when CB in the diet was increased from 15% and 30%. However, grinding CB did not affect (P > 0.05) total mastication time. Rumen acidosis is defined as a drastic reduction in rumen pH in response to an excessive fermentation of non-structural carbohydrates. Mastication of feed causes a massive flow of saliva into the rumen, preventing fluctuations of rumen pH (Owens *et al*., 1998).

Table 3 Time dedicated to mastication activities of Alpine goats fed diets with two levels of maize bran (QU) and two physical forms (PF), whole or ground

Item	Quantity		Physical form			P <		
	15%	30%	Whole	Ground	s.e.	QU	PF	QU x PF
Mastication, min/day								
Eating	194	168	179	183	11.3	0.28	0.85	0.85
Ruminating	397	338	380	354	13.7	0.05	0.37	0.70
Total	591	506	559	538	16.8	0.03	0.54	0.66

Table 4 Volatile fatty acid (VFA) concentration in rumen fluid of American Alpine goats fed diets with two levels of maize bran (CB) and two physical forms (PF), whole or ground

	Quantity		Physical form			< P		
	15%	30%	Whole	Ground	s.e.	QB	PF	QB x PF
Concentration, mmoles/L								
Acetate	55.7	72.6	67.1	61.2	3.7	0.04	0.43	0.43
Propionate	19.9	26.1	22.6	23.3	1.4	0.05	0.82	0.22
Butyrate	10.0	13.1	11.6	11.5	0.6	0.03	0.91	0.29
Total VFA	85.5	112.1	101.7	95.9	5.5	0.03	0.60	0.31
Molar percent								
Acetate	65.1	64.8	66.0	63.9	0.54	0.77	0.08	0.13
Propionate	19.9	26.1	22.6	23.3	1.42	0.05	0.82	0.22
Butyrate	11.7	11.8	11.5	11.9	0.33	0.93	0.56	0.90

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The VFA concentration in rumen fluid of the goats is presented in Table 4. Increasing CB in the diet from 15% to 30% increased ($P \leq 0.05$) concentration (mmoles/L) of total VFA from 85.5 to 112.1, of acetate from 55.7 to 72.6, of propionate from 19.9 to 26.1 and butyrate from 10 to 13.1. Grinding CB had no effect ($P > 0.05$) on the total VFA production (101.7 and 95.9 mmoles/L for whole and ground CB, respectively).

Percent molar propionate increased ($P < 0.05$) from 19.9 to 26.1 mmoles/L whereas other VFA did not change (acetate, 65.1 *vs*. 64.8; butyrate, 11.7 *vs*. 11.8). Grinding CB had no effect ($P > 0.05$) on the molar percent of VFA in rumen fluid. For goats eating diets with whole and ground CB, molar percent was: acetate, 66.0 *vs*. 63.9; propionate, 22.6 *vs*. 23.3; and butyrate, 11.5 *vs*. 11.9, respectively.

Conclusions

In this study no differences were observed ($P > 0.05$) in DM intake of goats fed diets with 15% or 30% maize bran (96.6 *vs*. 87.2 g/kg$^{0.75}$), or DM digestibility (71.9 *vs.* 72.4%). These results contrast with those reported by Van Soest (1994) in applying a discount in the nutritive value of maize bran of 18%. On the other hand, grinding improved intake and digestibility of maize bran. However, goats fed the diet with 30% CB spent 17% more time ruminating than those fed the 15% CB diet. Increasing CB from 15% to 30% in the diet increased acetate, propionate, butyrate and total VFA concentration in rumen fluid. Molar percent propionate increased as maize bran increased in the diet. Grinding CB did not affect molar percent VFA in rumen fluid. These results suggest that levels of up to 30% CB can be included in goat diets without affecting nutritive value.

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