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Effect of grinding of maize and level of starch on digestibility and lactation performance of Saanen goats

L. Rapetti# and L. Bava
Istituto di Zootecnia Generale, Facoltà di Agraria, Università degli Studi di Milano, via Celoria 2, 20133 Milano, Italy

Abstract

The purpose of this experiment was to evaluate the effects on intake, digestibility and lactational performance of goats when fed diets containing whole or ground maize grain at two different dietary starch levels through substitution of beet pulp for maize. Eight second parity Saanen goats in mid lactation were used in a digestibility trial. The experimental design was a duplicated 4 x 4 Latin square with a 2 x 2 factorial arrangement of treatments. The goats were fed four diets, with a forage:concentrate ratio of 40:60, containing: 33.5% (on dry matter basis) whole maize grain or 33.5% ground maize grain in the diets with high starch content; 22.5% dried beet pulp and 11.0% whole maize grain or 11.0% ground maize grain in the two diets with low starch content. The high starch diets significantly decreased DMI in comparison with the low starch diets (2333 and 2229 g/d, for low and high starch diets, respectively). Substitution of beet pulp for maize significantly improved NDF and ADF digestibility (56.4 and 55.5% and 42.2 and 38.9%, for low and high starch diets, respectively) due to the lower content of starch. Starch digestibility was influenced by the grinding of maize: whole grain (92.6%) was less utilized than ground grain (97.7%), despite not impairing total DM digestibility. The ground maize grain depressed feed intake and milk yield in the high starch content diets. The data obtained suggest that the grinding of maize is not likely to be worthwhile for lactating goats.

Keywords: Whole maize grain, beet pulp, goat, milk performance
#Corresponding author. E-mail: luca.rapetti@unimi.it

Introduction

Goats are classified as “intermediate feeders” due to their ability to change their feeding behaviour according to the availability of forage (Van Soest, 1994). In particular, Abijaoudè *et al*. (2000) demonstrated that goats tend to prefer diets rich in concentrate and this suggests some forms of adaptation to avoid ruminal acidosis.

Starch is an important source of energy for lactating ruminants and its digestion is affected by a variety of factors such as type of grain, processing method, conservation method and type of endosperm (Oba & Allen, 2003). This topic has been thoroughly researched for cattle, but very little research has been conducted on dairy goats. An alternative for maize grain is beet pulp because of the high content of non-fibrous carbohydrates (NFC), especially pectins and sugars, which is characterized by a high degradation rate (Rapetti, unpublished data). Broderick *et al*. (2003) demonstrated that dietary sources rich in pectins altered rumen fermentation through increased acetate and butyrate concentrations and acetate-to-propionate ratio, but also caused depressed dry matter intakes. This is in agreement with the results reported by Voelker & Allen (2003b) who substituted beet pulp for high-moisture maize. Furthermore, in contrast to starch, pectin fermentation does not inhibit cellulose and hemicellulose digestion, primarily because pectinolytic bacteria are also inhibited at a low rumen pH (Voelker & Allen, 2003a).

The purpose of this experiment was to evaluate the effects on intake, digestibility and lactational performance of goats when fed diets containing whole or ground maize at two different dietary starch levels through substitution of beet pulp for maize.

Materials and Methods

Eight second parity Saanen goats (57.4 ± 5.3 kg BW, on average) in mid lactation (83 ± 13 days in milk (DIM), on average) were used in a digestibility trial. The experimental design was a duplicated 4 x 4 Latin square balanced for carry-over effect with a 2 x 2 factorial arrangement of treatments. The four diets

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(Table 1) contained either ground maize grain (ground through a 3 mm screen) or whole maize grain at two different levels of starch (high or low). In the diets with low starch content, dried pelleted beet pulp substituted the same amount of maize grain.

Table 1 Ingredient and chemical analysis of the experimental diets (DM basis)

	High starch		Low starch	
	Whole maize	Ground maize	Whole maize	Ground maize
Ingredients, %				
Permanent pasture hay, 2nd cut	39.45	39.66	39.22	39.47
Dried beet pulp	-	-	22.54	22.62
Whole maize	33.71	-	11.14	-
Maize meal	-	33.44	-	11.11
Barley meal	13.34	13.38	13.47	13.33
Soyabean meal	9.10	9.12	9.18	9.09
Maize gluten meal	1.41	1.41	1.42	1.40
Mineral-vitamin complex	2.99	3.00	3.04	2.98
Chemical analysis, g/kg				
Organic matter	924.4	922.3	914.1	915.3
Crude protein	129.3	133.4	130.1	130.2
Ether extract	27.0	23.6	19.9	19.0
Neutral detergent fibre(NDF)	313.4	317.6	394.8	398.8
Acid detergent fibre (ADF)	181.0	179.4	233.6	233.2
Acid detergent lignin (ADL)	28.8	26.1	30.2	29.0
NDFIP[1]	17.5	19.1	28.0	28.1
NFC[2]	476.4	471.1	401.4	400.0
Starch	332.0	321.8	169.9	170.3
Sugar	36.3	36.4	45.4	45.4

[1]NDFIP = NDF insoluble protein; [2]NFC (non fibrous carbohydrates) = 100-(ash + crude protein + ether extract + (NDF-NDFIP))

The diets were offered *ad libitum*, allowing for about 5% orts, twice daily at 8:30 and 18:30. The goats were milked at 8:00 and 19:00. Each experimental period lasted 21 d (13 d of adaptation and 8 d of collection). The goats were confined in individual metabolism cages. Diets, orts and faeces of each goat were weighed and sampled daily, pooled within period and animal, and frozen for analysis. Dry samples were analysed for dry matter (DM), ash, organic matter (OM), nitrogen (N), ether extract, and starch according to the Italian Scientific Association for Animal Production recommendations (ASPA, Commissione Valutazione degli Alimenti, 1980). Neutral detergent fibre, ADF and ADL were determined according to Van Soest *et al*. (1991). Milk samples were weighed, and stored at 4 °C before analyses. Total N, non-protein nitrogen (NPN), casein and fat concentrations (Gerber method) of milk were determined according to the Italian Scientific Association for Animal Production recommendations (ASPA, 1995). Milk samples were also analyzed for lactose (Milkoscan 605, Foss, Hillerod, Denmark), somatic cell count (SCC) (Fossomatic 360, Foss, Hillerod, Denmark) expressed as linear score (LS = $\log_2$ (SCC/12,500) and urea (CL10, Eurochem, Italy). Data were statistically analysed using the GLM procedure of SAS (2000).

Results and Discussion

The animals selected feeds, leaving hay as the sole orts. As a consequence, the forage:concentrate ratio (DM basis) of the ingested diets resulted 32:68 instead of the planned 40:60, on average for the four treatments. The dry matter intake (DMI) registered during the experimental trial (Table 2) was increased ($P < 0.05$) by low starch diets. The DM digestibility of the high starch diet with whole maize grain was significantly higher than the high starch and ground maize grain diet and the low starch and whole maize grain diet. Ether extract digestibility was influenced by starch level, due to the higher fat content and utilization in maize. Substitution of beet pulp for maize grain ($P < 0.05$) improved NDF and ADF

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digestibility due to the low content of starch, confirming the results obtained by Voelker & Allen (2003a) in a trial with dairy cows. Starch digestibility was influenced by the physical form of maize: whole grain was less digested than ground grain, even though it did not impair total DM digestibility. The high utilization of starch in diets with whole maize (94.2% and 90.9% for high starch and low starch, respectively) indicates a low passage of indigested grain through the gut. This seems to be due to extensive damage of maize kernels during mastication (Beauchemin *et al*., 1994) thus resulting in considerable grain utilization at rumen level. The comparison between treatments showed lower starch digestibility for the diet with beet pulp and whole maize grain.

Table 2 Effect of processing and level of starch on dry matter intake and digestibility (means of values)

	High starch		Low starch			P-value	
	Whole maize	Ground maize	Whole maize	Ground maize	SE	Starch[1]	Maize[2]
DMI, g/d	2295	2162	2336	2329	114.8	0.014	0.070
Digestibility, %							
Dry matter	71.60[a]	69.02[b]	69.05[b]	69.72[ab]	0.845	0.123	0.204
Organic matter	73.44	71.21	71.28	72.23	0.836	0.300	0.402
Ether extract	80.99[a]	79.29[a]	66.03[b]	68.41[b]	2.620	<0.0001	0.638
Crude protein	69.58	64.03	65.37	65.08	2.420	0.323	0.156
NDF	44.78	39.67	56.24	56.46	1.763	<0.0001	0.098
ADF	42.03	35.74	54.57	56.46	2.516	<0.0001	0.249
Starch	94.24[b]	97.78[a]	90.88[c]	97.53[a]	1.000	0.012	<0.0001

[1]Effects of starch concentration; [2]Effects of type of maize; DMI – dry matter intake
[a, b, c] Tukey's test was conducted if $P < 0.05$ for interaction of main effects. Treatment means in the same row followed by different superscript letters differ significantly at $P < 0.05$

Table 3 Effects of the diet on milk yield and milk composition of Saanen goats

	High starch		Low starch			P-value	
	Whole maize	Ground maize	Whole maize	Ground maize	s.e.	Starch[1]	Maize[2]
Yield, g/d	4570[a]	4075[b]	4349[a,b]	4307[a,b]	341.9	0.784	0.033
3.5% FCM, g/d	3718	3474	3612	3683	301.0	0.589	0.392
Fat, g/d	107.4	105.5	106.8	112.2	10.291	0.329	0.921
Protein, g/d	123.1[a]	108.1[b]	112.9[a,b]	114.1[a,b]	9.725	0.325	0.074
Casein N, g/d	14.52	13.01	13.15	13.75	1.320	0.418	0.464
NPN, g/d	1.68	1.55	1.63	1.47	0.133	0.214	0.016
Fat, %	2.39	2.59	2.47	2.61	0.152	0.123	0.123
Protein, %	2.72	2.65	2.61	2.67	0.095	0.264	0.859
Lactose, %	4.48[a]	4.50[a]	4.36[b]	4.42[a,b]	0.123	0.001	0.276
Casein on total N, %	75.09	76.38	74.52	76.91	1.331	0.900	0.101
NPN on total N, %	8.82[a,b]	9.50[a]	9.23[a,b]	8.22[b]	0.799	0.239	0.501
LS	4.98	6.22	5.23	4.87	0.715	0.277	0.430
Urea, mg/dL	21.45	24.45	20.49	19.66	3.290	0.063	0.531

[1]Effects of starch concentration. [2]Effects of type of maize; FCM – fat corrected milk
[a, b, c] Tukey's test was conducted if $P < 0.05$ for interaction of main effects. Treatment means in the same row followed by different superscript letters differ significantly at $P < 0.05$

The milk production (Table 3), expressed both as measured milk yield and 3.5% fat corrected milk (FCM), was not affected by the level of starch. This was probably due to the higher DMI by goats fed low starch diets. On the other hand, looking at the effect of the type of maize in the diets with high starch content, it is evident that ground maize grain depressed feed intake and milk yield. Milk fat was not affected by starch

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level or by maize type and its percentage for all treatments resulted in lower than protein percentages. This might be due to the low ether extract content of the diets. The level of starch significantly influenced the proportion of lactose. This could be ascribed to the presumably higher rumen propionate production from amylolytic microbes on these diets.

Conclusion

In diets rich in concentrates the substitution of beet pulp for maize significantly improved DMI and NDF and ADF digestibility due to its high content of soluble fibre. Moreover, the utilization of whole grain instead of ground maize grain does not depress diet digestibility while it does increase milk yield. In conclusion, the data obtained suggest that the grinding of maize is not likely to be worthwhile for lactating goats.

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