Postruminal degradation of crude protein, neutral detergent fiber and starch of maize and grass silages

M. Ali[a,b], J. W. Cone[a], G. van Duinkerken[b], M. R. Weisbjerg[c], W. H. Hendriks[a,d]

[a]*Animal Nutrition Group, Wageningen University,6700AH Wageningen, The Netherlands*
[b]*Wageningen UR Livestock Research, 8200 AB Lelystad, The Netherlands*
[c]*Department of Animal Science, Aarhus University, DK-8830 Tjele, Denmark*
[d]*Faculty of Veterinary Medicine, Utrecht University, 3508 TD Utrecht, The Netherlands*

Introduction

Different ruminant feed evaluation systems use assumptions and simple models to calculate the intestinal digestibility of crude protein (CP), neutral detergent fibre (NDF) and starch. The Dutch DVE/OEB_{2010} system (Van Duinkerken et al., 2011) uses data of different in situ experiments to derive regression equations to estimate the intestinal digestibility. These data are derived from experiments performed at different institutes, 20 to 50 years ago with different crop varieties, methods of ensiling and incubation protocols. Actually, data on intestinal digestibility of CP of maize and grass silages remain scarce (Cone et al., 2006; Tamminga et al., 2007) and even less is known about the intestinal digestibility of NDF and starch (Tamminga et al., 2007). It was assumed that the rumen undegraded starch from maize silage is completely digested in the small intestine (Tamminga et al., 2007).
The aim of this study was to investigate the relationship between the chemical composition and the determined intestinal digestibility for CP and NDF in maize and grass silages as well as starch in maize silages, in order to develop new regression equations.

Materials and Methods

Twenty samples of maize silage and 20 samples of grass silage were selected with a large variation in the chemical composition and silage quality parameters. Three multiparous Holstein Friesian cows fitted with ruminal, duodenal and ileal cannulas were used. All the samples were incubated in the rumen of three cows using nylon bag technique. The maize silage samples were incubated in the rumen for 6 h (starch), 12 h (CP) and 24 h (NDF). The grass silage samples were incubated in the rumen for 12 h (CP) and 24 h (NDF). The rumen incubated residues were transferred into the small mobile nylon bags. These bags were soaked in a 0.004 M HCl solution at pH 2.4 for one hour. Then the bags were incubated for two hours in a pepsin-HCl solution at 40°C in a shaking water bath. After that, 6 bags per sample (maize or grass silage) were inserted in the duodenal cannulas of three cows (2 bags per cow) for NDF. All bags were collected from the faeces by washing in a sieve bucket. Twelve bags per sample were incubated in the intestinal tract of the three dairy cows (4 bags per cow) for CP and starch. Half of the bags for CP and starch incubation were collected from the ileal cannula by placing a magnet, held by a rubber stopper into the ileal cannula. The remaining half of the bags was collected from the faeces by washing in the sieve bucket.
Regression equations were derived with significant predictors ($P<0.1$) to determine the relationship between chemical composition and the rumen degradable, the intestinal digestible and the undegradable fractions of CP, NDF and starch using PROC REG backward procedure in SAS 9.2.

Results

There was a large variation in the rumen degradability, intestinal digestibility (small and/or large intestine) and undegradable fraction of CP, NDF and starch of maize and grass silages (Table 1). Regression analysis showed that the rumen degradability, intestinal digestibility and undegradable fractions of CP, NDF and starch were influenced by the chemical composition of maize and grass silages (Table 2).

Table 1: Ruminal degradable (RD), small intestinal digestible (SID), large intestinal digestible (LID), intestinal digestible (ID) and undegradable fraction (UF) of crude protein (CP), neutral detergent fibre (NDF) and starch of maize and grass silages.

Variable	Maize silages				Grass silages			
	Mean	SEM	Minimum	Maximum	Mean	SEM	Minimum	Maximum
Crude protein (g/g CP)			n=19				n=19	
RD (12 h)	0.555	0.015	0.420	0.672	0.678	0.027	0.425	0.832
SID	0.353	0.015	0.250	0.503	0.237	0.023	0.109	0.451
LID	-0.033	0.002	-0.046	-0.015	0.004	0.003	-0.026	0.050
UF	0.124	0.004	0.095	0.152	0.082	0.006	0.049	0.150
Neutral detergent fibre (g/g NDF)	n=18						n=20	
RD (24 h)	0.329	0.019	0.156	0.447	0.513	0.012	0.437	0.625
ID	0.075	0.004	0.042	0.107	0.065	0.004	0.028	0.105
UF	0.596	0.018	0.501	0.762	0.423	0.013	0.279	0.511
Starch (g/g starch)			n=18					
RD (6 h)	0.654	0.025	0.500	0.815	-	-	-	-
SID	0.335	0.024	0.183	0.490	-	-	-	-
LID	0.005	0.002	-0.013	0.024	-	-	-	-
UF	0.005	0.001	0.000	0.016	-	-	-	-

Table 2: Regression equations for rumen degradable (RD), small intestinal digestible (SID), large intestinal digestible (LID) and undegradable fraction (UF) of crude protein (CP), neutral detergent fibre (NDF) and starch based on chemical composition of the maize and grass silages.

Maize silages	R2	Grass silages	R2
Crude protein			
RD = 118.76 - 0.14 DMa - 0.19 ash - 1.21 ADLb	0.69	RD = 94.05 + 0.70 CP - 0.19 NDF	0.86
SID = - 84.40 + 0.11 DM + 0.20 ash + 0.64 CP + 0.98 ADL	0.66	SID = - 281.82 - 0.09 DM + 0.49 ash + 0.36 CP + 0.31 sugar + 0.45 NDF	0.72
UF = 4.44 + 0.15 sugar + 0.01 NDF	0.48	LID = 51.11 + 0.02 DM - 0.07 ash - 0.03 CP - 0.08 sugar - 0.07 NDF	0.78
Neutral detergent fibre			
RD = - 155.83 + 0.72 NDF	0.81	RD = - 145.70 + 0.39 NDF + 0.60 ADFc	0.90
Starch			
SID = - 186.99 + 0.88 DM + 1.45 ash - 0.35 ADF	0.87		

aDry matter, bAcid detergent lignin, cAcid detergent fibre.

Conclusions

Rumen degradability, intestinal digestibility and undegradable fraction of CP, NDF and starch in maize and grass silage were affected by chemical composition of the silages. The present study proved the assumption of Dutch feed evaluation systems that rumen undegraded starch from maize silage is digested in the small intestine of dairy cows.

References

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