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NUTRIENT CONTENT AND DEGRADABILITY OF DRY MATTER IN WHOLE PLANTS OF MAIZE

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ABSTRACT

The objective of our study was to determine the nutrients content and dry matter degradability in whole plants of maize hybrids dent and dent x flint. Hybrids dent x flint − Mesnil, Chambord, Queen, and hybrids dent − Aude, Meridien, KX 1393, Omero were used. Concentration of crude protein (CP) was higher in dent hybrids (85.0 $g.kg^{-1}$ DM) compared to dent x flint hybrids (78.3 $g.kg^{-1}$ DM). Content of starch ranged from 205.2 $g.kg^{-1}$ DM (KX 1393 − dent) to 329.4 $g.kg^{-1}$ DM (Mesnil), higher for hybrids dent x flint. ADF and NDF were higher in hybrids dent and content of lignin was similar. *In sacco* experiment was carried out in three rumen-cannulated cows with large rumen cannulas. Hybrids dent x flint had in average higher effective dry matter degradability (DMD) − 56.8 % than dent hybrids 54.7 %.

Key words: maize plants; *in sacco* method; degradability

INTRODUCTION

Maize has specific characteristics compared to other feeds. It exceeds all feed crops in yield and net high biological value of corn starch and can be used as fodder and concentrate feed (Sommer, 2001). There are differences in the content of structural and non-structural carbohydrates among hybrids and these differences affect the overall digestibility of organic matter (Gálik *et al.*, 2004). According to Verbič *et al.* (1995), there are big differences among maize hybrids in the content of NDF and ADF in the individual morphological parts of the plant. In particular, the ADF content of the plant (without the cob) significantly affects the effective dry matter degradability (R^2 = 0.99).

From a nutritional point of view, whole maize plant is a mixture of fodder and grain, comprising two components of different nutritional value. The maize plant is characterized by high production of organic matter, the substances which are important for animal nutrition.

The objective of this work was to determine dry matter degradability of whole plants of different maize hybrids by *in sacco* method and their nutrition contents.

MATERIAL AND METHODS

Maize hybrids of the dent type (Aude, Meridien, KX 1393, Omero) and dent x flint (Mesnil, Chambord, Queen) were used in our experiment. Hybrids were grown in the same climatic location (district Trnava – Slovakia). Dry matter degradability in whole maize plants was determined by *in sacco* method (Čerešňáková *et al.*, 2005).

The samples of maize hybrids were harvested at the time of milk-waxy maturity. In the whole plants, original dry mater (DM) and chemical composition

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were determined. Material designed for the determination of degradability was freeze-dried and ground.

These samples were weighed (approx. 2.50 g dry matter) into bags (9 x 15 cm) made of Uhelon 120T with pore size of 48 µm. Minimum of three separate bags for hybrids, incubation time and animals were used. The bags with samples were incubated for 6, 9, 16, 24, 48, 72 and 96 hours. The 0 h time bags were only washed in washing maschine to determine washing losses.

In sacco experiments were carried out in three non-lactating heifers (Holstein Fresian cattle) with large rumen cannulas (an average of 10 cm). The animals were fed twice a day a diet consisting of 70 % forage and 30 % concentrate on a dry matter basis at maintenance level. The ration consisted of maize silage, alfalfa hay, wheat, barley meal (1:1) and vitamin – mineral premix. Nutrient intake to one cow.day^{-1} in our experiment was followed: 9770 g dry matter; 1170 g crude protein; 5050 g nitrogen free extract; 2660 g fibre; 1980 g starch and 650 g ash. Access to water was *ad libitum*.

The content of nutrients was analysed according to the directive of the Commission Regulation (EC) no. 152/2009 from 27th January 2009, which defines the methods of sample collection and analysis for the purposes of official feed quality control. Content of ADF, NDF and lignin was determined according to Van Soest (Lutonská and Pichl, 1983). The parameters of degradability (a: rapidly soluble fraction; b: potentially degradable fraction; c: rate constant of degradation; Edg: effective degradability) were calculated using the equations by Ørskov and McDonald (1979) with outflow rate of 0.06.h^{-1}.

The obtained data on nutrients, the losses with time of incubation and degradability of dry matter in maize hybrids were evaluated statistically using models in statistical package Statistix 8.0.

RESULT AND DISCUSION

Nutrients content is presented in Table 1. Chemical analyses showed that dent hybrids had in the whole plants a higher content of ADF, NDF and crude protein compared to dent x flint hybrids. The highest crude protein content was determined in the KX 1393 hybrid (dent) and the lowest in the Chambord hybrid (dent x flint). An average crude protein content in whole plants was higher in dent hybrids than in dent x flint hybrids (85.0 g.kg^{-1} vs. 78.3 g.kg^{-1} DM), the quality of maize proteins is poor because they are deficient in the essential amino acids, lysine and tryptophan (Shewry, 2007).

Content of starch in WP (whole plants) was the highest in hybrid Mesnil (329.4 g.kg^{-1} DM) and the lowest in Meridien (192.5 g.kg^{-1} DM). The average starch content was higher in hybrids dent x flint. Jurjanz *et al.* (2005) determined the starch content in WP to be 372.0 g.kg^{-1} DM, in our experiment it was less.

Fat content in the whole plants was higher in dent x flint hybrids compared to dent (Table 1).

Using one-factor analysis of variance we determined significant differences between the nutrients content of the studied hybrids (Table 2). Differences among hybrids in the nutrients content of whole plants as well as the dry matter are caused not only by the actual differences between the morphological parts, but also by the share of

Table 1. Content of nutrients in whole plants of different maize hybrids (g.kg^{-1} DM)

Hybrid	Type of hybrids	Dry matter	Crude protein	Fat	Starch	ADF	NDF	Lignin
Mesnil	dent x flint	374.2	78.3	29.8	329.4	232.3	429.2	22.6
Chambord	dent x flint	372.2	73.5	23.2	245.9	231.2	435.8	28.4
Queen	dent x flint	402.5	83.0	30.2	311.7	251.8	454.8	31.9
Aude	dent	436.2	79.5	14.9	260.8	245.8	480.3	26.9
KX 1393	dent	374.5	89.9	19.5	205.2	257.6	489.8	28.5
Meridien	dent	374.7	83.9	22.5	192.5	287.2	565.7	23.7
Omero	dent	375.8	86.7	24.5	253.3	279.8	548.7	30.1

Table 2. One factor analysis of variance in whole plants of different maize hybrids

Parameters		Whole plant		
		Hybrid, A $f_A = 6$	Error $f_e = 7$	Significant comparisons
ADF	MS	944.996	2.914	1:(3,4,5,6,7)**, 2:(3,4,5,6,7)**,3:(7,6)**, 4:(5,6,7)**, 5:(6,7)** , 6:7*
	F	324		
NDF	MS	5682.99	13.20	1:(3,4,5,6,7)**, 2:(4,5,6,7)**, 3:(4,5,6,7)**, 4:(6,7)**, 5:(6,7)**, 2:3*
	F	431		
Lignin	MS	22.4230	1.8354	3:(1,6)**, 7:1**, 1:(2,5)*
	F	12.2		
Crude protein	MS	59.8303	0.8030	1:(5,6,7)**, 2:(3,4,5,6,7)**, 3:5**, 4:(5,7)**, 5:6**, 1:(2,3)*, 3:7*, 4:6*
	F	74.5		

1. Mesnil, 2. Chambord, 3. Queen, 4. Aude, 5. KX-1393, 6. Meridien, 7. Omero
Means with the same letters in the same row are significantly different at P < 0.01++ p < 0.05+
Error – error of experiment

various morphological parts and their ripeness at harvest (Verbič *et al.*, 1995).

Kohler *et al.* (1990) found differences in the content of ADF, NDF and lignin among the cultivars. It corresponds with our results. Among the morphological parts of maize plants and also among maize hybrids there are differences in the chemical composition and it results in differences of the effective dry matter degradability. The nutritional value of maize plants decreased with increasing maturity (Gross and Pesche, 1980). Content of ADF and NDF was higher in hybrids dent and content of lignin was similar (Table 1).

We determined significant differences for parameters of degradability and effective degradability of dry matter of whole plants, with the exception of parameter "b". Dent hybrids in whole plants were less degraded than dent x flint hybrids (Table 4).

The losses with time of incubation were determined for each incubation. For dry matter, higher average losses were determined after 6, 9, 16, 48, and 72 hour incubation in hybrid Mesnil (dent x flint), after 96 hour incubation for dent hybrids – Meridien and Omero (Table 3). With longer incubation time, the differences between hybrids decrease. Higher differences between hybrids were

Table 3. Dry matter disappearance from whole plants of maize hybrids during rumen incubation

Incubation (h)		0	6	9	16	24	48	72	96
Hybrid	Type of hybrids								
Mesnil	dent x flint	30.3	53.9^{abcde}	56.2^{ab}	68.4^{abcdef}	69.2^{b}	81.0^{cde}	82.3^{d}	79.6
Chambord	dent x flint	34.7	47.3^{chjk}	53.1	59.1^{ci}	65.5	74.6	81.4^{c}	79.1
Queen	dent x flint	33.1	45.3^{bgjl}	52.7	62.2^{bgh}	70.0^{a}	76.4^{b}	82.2^{b}	80.7
Aude	dent	34.6	47.1^{aflm}	52.7	58.7^{aj}	65.7	77.2^{a}	80.8^{a}	78.5
Meridien	dent	36.5	52.5^{fghik}	54.6^{c}	58.0^{ek}	66.8	69.2^{abd}	79.7	82.1
KX 1393	dent	34.1	45.2^{dimn}	50.7^{a}	50.9^{dgijk}	60.6^{abc}	72.2^{c}	75.5^{abcd}	80.6
Omero	dent	32.3	47.1^{en}	48.9^{bc}	53.6^{fh}	67.7^{c}	72.1e	79.8	81.9

Means with the same letters in the same row are significantly different at P < 0.01++ p < 0.05+

Table 4. Parameters of degradability and effective dry matter degradability (Edg) of different maize hybrids (whole plants)

Parameters of degradability		a (%)	b (%)	c (%.h^{-1})	Edg DM (%)
Hybrid	Type of hybrids				
Mesnil	dent x flint	42.1^{f}	40.3	0.056^{c}	57.0^{d}
Chambord	dent x flint	38.6^{c}	42.7	0.042	56.6^{c}
Queen	dent x flint	29.9^{bf}	51.1	0.063^{ab}	56.9^{b}
Aude	dent	36.3^{a}	44.6	0.047	56.3^{a}
Meridien	dent	48.4^{abcde}	41.2	0.020^{bc}	55.3
KX 1393	dent	38.6^{d}	47.3	0.027^{a}	52.9^{abcd}
Omero	dent	36.8	47.9	0.036	54.3

Means with the same letters in the same row are significantly different at P < 0.01++ p < 0.05+

determined after 6 and 16 hour incubation (P < 0.01 resp. P < 0.05). The lowest losses were determined for hybrid KX 13 93 in all incubation, except 0 and 48 hour incubation. This hybrid had the lowest dry matter degradability (52.9 %).

Effective degradability of dry matter WP of maize was higher for dent x flint type hybrids (56.8 %) compared to dent hybrids (54.7 %) as well as rate of degradation of fraction "b", parameter "c" (Table 4.). The effective degradability is affected by the rate of degradation "c". Lower degradation values were determined by Jurjanz *et al.* (2005) in whole plants of maize (52.1 %) and "b" parameter was 41.6 %.

CONCLUSION

The content of nutrients was different in hybrids. We found higher effective DMD in WP in hybrid dent x flint compare to dent hybrids. From our results follows that there are differences between maize hybrids in chemical composition and differences in effective DM degradability of maize. The determined results are important, because based on the effective degradability of dry matter as well as other nutrients, it is possible to predict their passage into the small intestine.

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