THE QUALITY OF MAIZE SILAGES FROM WEST REGION OF SLOVAKIA

KVALITA KUKURIČNÝCH SILÁŽÍ ZO ZÁPADOSLOVENSKÉHO REGIÓNU

Miroslav JURÁČEK*, Daniel BÍRO, Milan ŠIMKO, Branislav GÁLIK and Michal ROLINEC

Department of Animal Nutrition, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, tel. +421/37/6414332, e-mail: Miroslav.Juracek@uniag.sk* correspondence

ABSTRACT

The aim of this work was to determine the quality of maize silages from Western Slovak Region analyzed in 2009 and 2010 on the Department of animal nutrition, Faculty of agrobiology and food resources, Slovak university of agriculture in Nitra, Slovakia. Maize silages were evaluated on the base of nutritional value, the result of fermentation process and silage quality according to Regulation of the Government of Slovak Republic no. 439/2006, appendix no.7, part C – Silage. We found in maize silages the average dry matter content 357.87 $g.kg^{-1}$ (2009) and 340.00 $g.kg^{-1}$ (2010) while only in 2010 samples had got 15.4 % of dry matter content below 300 $g.kg^{-1}$. Content of crude fiber was lower than 260 $g.kg^{-1}$ of dry matter in all samples. Higher content of acid detergent fiber and neutral detergent fiber had maize silages from 2010. The average value of net energy of lactation was 6.32 $MJ.kg^{-1}$ of dry matter (2009) and 6.27 $MJ.kg^{-1}$ of dry matter (2010). Only in one sample from 2010 we found a lower lactic acid content than 10 $g.kg^{-1}$ of original matter. Content of acetic acid was lower in silages from 2009 (24.33 $g.kg^{-1}$ of dry matter) in comparison with silages from 2010 (28.92 $g.kg^{-1}$ of dry matter). Undesirable butyric acid was not found in maize silages. The value of pH fluctuated from 3.52 to 3.80 (2009) and from 3.58 to 4.14 (2010). Only 17 % of evaluated samples satisfied the criteria for silage of I. class in 2009 and 23 % in 2010 mainly because of the higher acetic acid content.

Keywords: maize, silage, nutritive value, fermentation, quality

DETAILED ABSTRACT IN NATIVE LANGUAGE

Cieľom práce bolo zistiť kvalitu kukuričných siláží zo západoslovenského regiónu analyzovaných v roku 2009 a 2010 na Katedre výživy zvierat, Fakulty agrobiológie a potravinových zdrojov, Slovenskej poľnohospodárskej univerzity v Nitre. Kukuričné siláže boli posudzované na základe výživnej hodnoty, výsledku fermentačného procesu a hodnotenia kvality siláží podľa Nariadenia vlády Slovenskej republiky č. 439/2006, príloha č.7, časť C – Siláže. V kukuričných silážach sme zistili obsah sušiny 357,87 $g.kg^{-1}$ (2009) a 340,00 $g.kg^{-1}$ (2010), pričom iba u vzoriek z roku 2010 malo 15,4 % siláží nižší obsah sušiny ako 300 $g.kg^{-1}$. U všetkých kukuričných siláží bol obsah hrubej vlákniny nižší ako 260 $g.kg^{-1}$ sušiny. Vyšší obsah acidodetergentnej a neutrálnedetergentnej frakcie vlákniny mali kukuričné siláže analyzované v roku

2010. Priemerná hodnota netto energie laktácie bola 6,32 MJ.kg^{-1} sušiny (2009) a 6,27 MJ.kg^{-1} sušiny (2010). Iba v jednej vzorke z roku 2010 sme zistili nižší obsah kyseliny mliečnej ako 10 g.kg^{-1} pôvodnej hmoty. Obsah kyseliny octovej bol nižší v silážach z roku 2009 (24,33 g.kg^{-1} sušiny) v porovnaní so silážami z roku 2010 (28,92 g.kg^{-1} sušiny). Prítomnosť nežiaducej kyseliny maslovej sme nezaznamenali v žiadnej kukuričnej siláži. Hodnota aktívnej kyslosti sa pohybovala v rozpätí od 3,52 do 3,80 (2009) a od 3,58 do 4,14 (2010). Iba 17 % hodnotených vzoriek siláží spĺňalo kritériá pre I. akostnú triedu v roku 2009 a 23 % v roku 2010 najmä v dôsledku vyššej koncentrácie kyseliny octovej.

Kľúčové slová: kukurica, siláž, výživná hodnota, fermentácia, kvalita

INTRODUCTION

Forages are major component in the feeding rations for ruminants, especially for dairy. Forage quality can vary depending on variety (Jung, et al., 1998), stage of maturity at harvest (Coors, et al., 1997; Bal, et al., 2000), crop management and hybrid (Orosz, et al., 2003; Bíro, et al., 2007; Tyrolová and Výborná,2008) and hygienic quality (Suchý and Straková, 2006). From the point of global importance maize represents in all forms elementary and important feed for farm animals. Feed products from maize are characterized by high energetic nutrients and relatively low content of crude protein with low biological value (Summers, 2001; Mlynár, et al., 2004). In conditions of Slovakia (Bíro, 2002) consider the plant of maize from aspect of utilizable energy as the most important crop for feeding. Its plasticity for different technology of harvest and storage provides wide scale of feed with different dietetic and energetic features. Exactly the energy involved in feeding ration for ruminants is the limiting nutrient (DePeters and Cant, 1992). The silage hybrid, phonological stage of harvest, dry matter content, addition of additives (Lauková, et al. 2006), technological discipline of silage making and method of unloading silage affects the quality of maize silage (Labuda and Kráčmar, 1987).

MATERIAL AND METHODS

We determine the quality of maize silages from Western Slovak Region farms analyzed in 2009 (n=26) and 2010 (n=23) on the Department of animal nutrition, Faculty of agrobiology and food resources, Slovak university of agriculture in Nitra, Slovakia. Maize silages were evaluated on the base of nutritional value, the result of fermentation process and silage quality according to Regulation of the Government of Slovak Republic no. 439/2006 about Feed Sources, Appendix no.7, part C – Silage. For analyzing organic (crude protein, crude fiber, fat) and inorganic nutrients (ash) we used standard analytical methods (Regulation of the Slovak Ministry of Agriculture no. 2136/2004-100 about sampling of feeds and about laboratory testing and evaluation of feeds). Content of dry matter (DM) we determined gravimetric by drying of sample to constant weight by temperature 103±2 ^{o}C (predrying by t 60 ^{o}C). Content of nitrogen free extract (NFE) and organic matter (OM) was calculate (NFE = dry matter-crude protein-crude fiber-fat-ash, OM = dry matter-ash).Crude protein was measured using the micro-Kjeldahl method, crude fat: extraction by light petroleum, ash: ashing to the use of a muffle furnace by 550 ^{o}C, starch: by polarimetric method, crude fiber: gravimetrically as the residue remaining after extraction in acid and alkali reagent, acid detergent fiber: gravimetrically as the residue remaining after extraction

in acid detergent solution, acid detergent lignin: gravimetrically as the residue remaining upon ignition after 72 % H_2SO_4 treatment, neutral detergent fiber: gravimetrically as the residue remaining after extraction in neutral detergent solution. Energy (NEL, NEG) and protein values (PDI) were calculated by regression equations (Regulation of the Government of Slovak Republic no. 439/2006, appendix no.7, part G Nutritive value of feeds). Silage extracts we prepared from 200 g of sample and overflowed by 2000 ml of distilled water, after 20 hours stained. Contents of fermentation acids (formic, lactic, acetic, butyric, propionic) we detected on analyzer EA 100 (Villa Labeco, SR) using the ionic electrophoresis method. Active acidity we determined by electrometric method. Fermentation products were calculated by count of fermentable acids without alcohols. The results were statistically processed using one-factorial variance analysis (ANOVA) of SAS (SAS Institute INC, 1985). Means were separated using Fischer LSD multiple range test.

RESULTS AND DISCUSSION

Dry matter (DM) content of corn silage depends greatly on the maturity of the corn at time of harvest often reflecting the proportion and development of kernels in the silage [6]. We detected the average content of dry matter 357.87 $g.kg^{-1}$ (2009) and 340.00 $g.kg^{-1}$ (2010) in maize silages from West region of Slovakia. We found lower content of dry matter than 300 $g.kg^{-1}$ and higher than 400 $g.kg^{-1}$ (with the same portion from all samples – 15.4 %) only in samples of maize silages analyzed in 2010. According to Lád et al. (2003) is the optimal content of dry mater 280 - 340 $g.kg^{-1}$ for maize silage and according to Loučka (2010) 280 - 340 $g.kg^{-1}$. Content of crude protein ranged from 71.00 to 83.90 $g.kg^{-1}$ of DM (2009) and from 69.90 to 97.40 $g.kg^{-1}$ of DM (2010). We determined in maize silages almost the same content of fat in both years (31.28 and 31.72 $g.kg^{-1}$ of DM in 2009 and 2010). Compared to the silages from 2010 (45.48 $g.kg^{-1}$ of DM), we detected the significantly ($P<0.05$) lower content of ash in silages from 2009 (39.85 $g.kg^{-1}$ of DM). Ferreira and Mertens (2005) reported average content of ash 51 $g.kg^{-1}$ of DM in maize silage from Wisconsin (n=32). In one kg of dry matter we found average content of nitrogen free extract 669.80 g (2009) and 650.85 g (2010), the differences were significant ($P<0.05$), with content of starch 365.67 and 356.60 $g.kg^{-1}$ of dry matter. Since the main reason for including forages in livestock diets is to supply fiber and energy, some of the most important indices of forage nutritive value include the crude fiber or neutral detergent fiber (NDF) content and the NDF digestibility (Adesogan, 2006). All maize silages had lower content of crude fiber than 260 $g.kg^{-1}$ of DM (Regulation of the Government of Slovak Republic no. 439/2006 about Feed Sources, Appendix no.7, part C – Silage), with average value 182.67 (2009) and 187.62 $g.kg^{-1}$ of DM (2010). In collection of samples analyzed in 2009 was the highest content of crude fiber 206.40 $g.kg^{-1}$ of DM and 212.90 $g.kg^{-1}$ of DM (2010). Lád et al. (2003) recommend the optimal content of crude fiber into 210 $g.kg^{-1}$ of DM in maize silages. Lower values of ADF and NDF were determined in analyzed sampled from 2009, with higher average content of dry matter, than in samples from 2010. Average content of ADF was 247.97 g (2009) and 279.16 $g.kg^{-1}$ of DM (2010). Podkówka and Podkówka (2011) reported average content of ADF in maize silages 231.1 $g.kg^{-1}$ of DM (2004-2006). According to Adesogan (2006) is target level of NDV in maize silage ≤ 47 %. Only maize silages from 2010 had higher value by 10.33 %. We determined average value of NEL in silages analyzed in 2009 6.32 $MJ.kg^{-1}$ of DM (min. 6.26 and max. 6.37 $MJ.kg^{-1}$ of DM), in silages analyzed in 2010 6.27 $MJ.kg^{-1}$ of

DM (min. 6.05 and max. 6.36 MJ.kg^{-1} DM). The differences were significant (P<0.05). Petrikovič et al. (2000) report average value of NEL in 3838 samples of maize silages 6.35 MJ.kg^{-1} of DM. Values of PDIE was almost the same with content 67.33 and 66.95 g.kg^{-1} of DM (2009 and 2010). Only in one sample we detected lower content of lactic acid than 10 g.kg^{-1} of DM (Regulation of the Government of Slovak Republic no. 439/2006 about Feed Sources, Appendix no.7, part C – Silage). Content of lactic acid in maize silages ranged from 37.40 to 80.20 g.kg^{-1} of DM (2009) and from 22.90 to 114.10 g.kg^{-1} of DM (2010). We don't found undesirable butyric acid in any sample. Content of acetic acid was lower in silages analyzed in 2009 (24.33 g.kg^{-1} of DM) in comparison with silages from 2010 (28.92 g.kg^{-1} of DM). Content of acetic acid together with propionic acid under 20 g.kg^{-1} of DM is by one of parameters for classification of silage in 1st qualitative class (Regulation of the Government of Slovak Republic no. 439/2006 about Feed Sources, Appendix no.7, part C – Silage), this condition satisfied 33.3 % of samples (2009) and 30.8 % (2010). According to Kaiser and Weiβ (2003) have the excellent silage contain of acetic acid under 30 g.kg^{-1} of DM. The ideal ratio of lactic acid to acetic acid should not be less than 3:1 and higher is better (Jalč, et al., 2010). Active acidity (pH) ranged from 3.52 to 3.80 (2009) and from 3.58 to 4.14 (2010). Vranić et al. (2004) who analyzed 96 maize silages detected average value of pH 3.7. According to Kolver et al. (2001) targets for good quality maize silage include a dry matter content of 28 – 35 %, an energy content of 10.8 MJ ME.kg^{-1} of DM, a protein content of 7 – 8 %, and a pH of 3.8 to 4.5. Values of pH from 3.7 to 4.2 are target levels for maize silage (Adesogan, 2006). Sum of lactic acid, volatile fatty acids and alcohols composed fermentation products (Sommer, et al, 1994). Bencová (1999) reported range of fermentation products in maize silages from 37.4 to 209.3 g.kg^{-1} of DM. In our experiment was average content of fermentation products (without alcohols) 78.11 g.kg^{-1} of DM (2009) and 93.57 g.kg^{-1} of DM (2010). Doležal and Dvořáček (2003) reported of fermentation products content 79.7 g.kg^{-1} of DM in maize silage with dry matter content 330 g.kg^{-1}. From maize silages analyzed in 2009 (n=26) were in 1st class only 17 % of samples. The same percentage of samples satisfied conditions of 2nd class and 50 % were in 3rd class for very low pH value and higher content of acetic acid. 16 % of samples were in the worst 4th class for the higher acetic acid content. From maize silages analyzed in 2010 (n=23) were 23 % of samples in 1st class, 31 % in 2nd class, the same percentage of samples satisfied conditions of 3rd class and 15 % of samples were in 4th class. Direct cause of maize silages worse quality was especially higher content of acetic acid.

Table 1 Nutritive value of maize silages (in g.kg^{-1} of dry matter)

parameters	2009 (n=26)	2010 (n=23)
	$\bar{x}$ ± S.D.	$\bar{x}$ ± S.D.
dry matter	357.87 ± 2.86	340.00 ± 4.30
crude protein	76.45 ± 0.56	84.35 ± 0.94
crude fat	31.28 ± 0.18	31.72 ± 0.30
crude fiber	182.67 ± 1.78	187.62 ± 1.85
acid detergent fiber	247.97*± 20.34	279.16*± 34.70
neutral detergent fiber	459.40 ± 29.95	480.33 ± 48.91
ash	39.85*± 0.59	45.48*± 1.13
nitrogen free extract	669.80*± 1.69	650.85*± 2.94
starch	365.67 ± 44.13	356.60 ± 29.65
organic matter	960.15*± 0.59	954.52*± 1.13

$\bar{x}$: mean, S.D.: standard deviation, *the values with identical superscripts in row are significantly different at P<0.05

Table 2 Energy and protein value of maize silages (NEL, NEG in MJ.kg^{-1} of dry matter and PDIN, PDIE in g.kg^{-1} of dry matter)

n=26 (2009) n=23 (2010)		NEL	NEG	PDIN	PDIE
2009	$\bar{x}$	6.32*	6.29	46.33	67.33
	S.D.	0.04	0.04	3.41	2.28
2010	$\bar{x}$	6.27*	6.24	51.13	66.95
	S.D.	0.07	0.08	5.69	2.83

NEL: net energy of lactation, NEG: net energy of gain, PDIN: protein digestible in intestine when degradable N is limiting microbial protein synthesis in the rumen, PDIE: protein digestible in intestine when rumen fermentable energy (organic matter) is limiting microbial protein synthesis in the rumen, $\bar{x}$: mean, S.D.: standard deviation, *the values with identical superscripts in column are significantly different at P<0.05

Table 3 Fermentation products in maize silages (in g.kg^{-1} of dry matter)

n=26 (2009) n=23 (2010)		formic acid	lactic acid	acetic acid	propionic acid	butyric acid	fermentation products^{x}	pH
2009	$\bar{x}$	0.92	53.16	24.33	0.63	0.00	78.11*	3.69
	S.D.	1.46	16.60	10.06	1.54	-	20.03	0.11
2010	$\bar{x}$	0.43	60.58	28.92	3.13	0.00	93.57*	3.87
	S.D.	0.62	21.27	14.41	4.87	-	26.53	0.17

^{x} without alcohols, $\bar{x}$: mean, S.D.: standard deviation, * the values with identical superscripts in column are significantly different at P<0.05

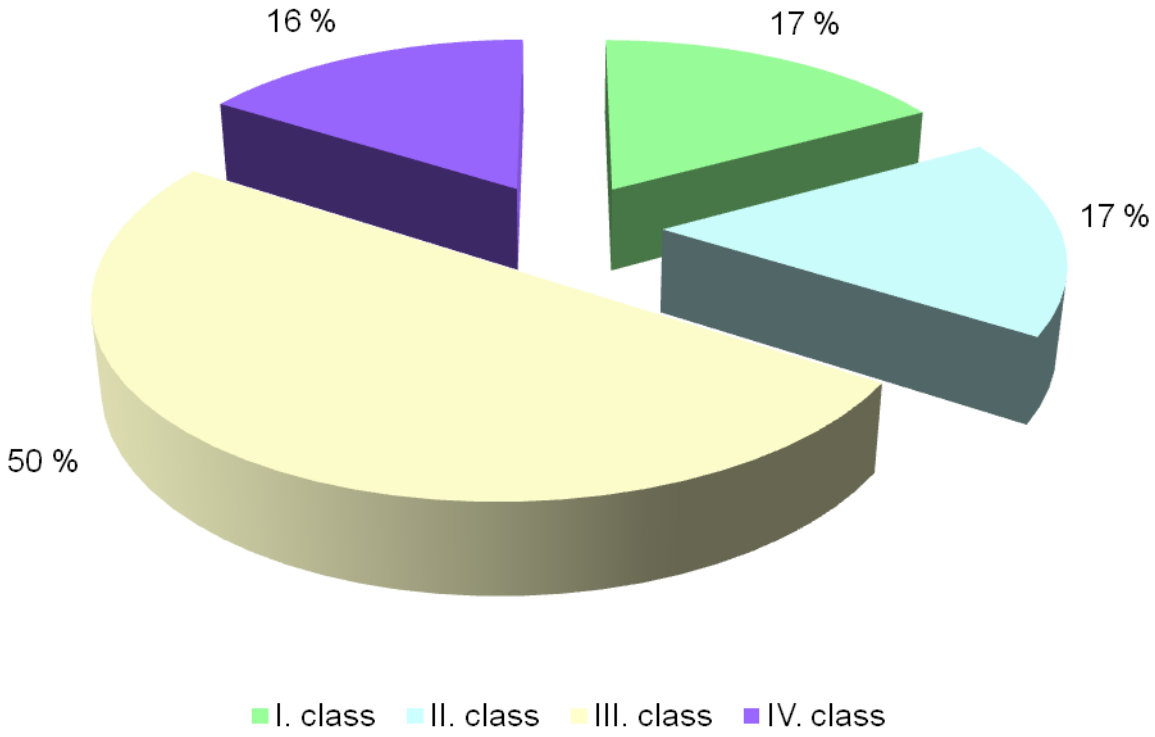

Figure 1 The quality of maize silages in 2009

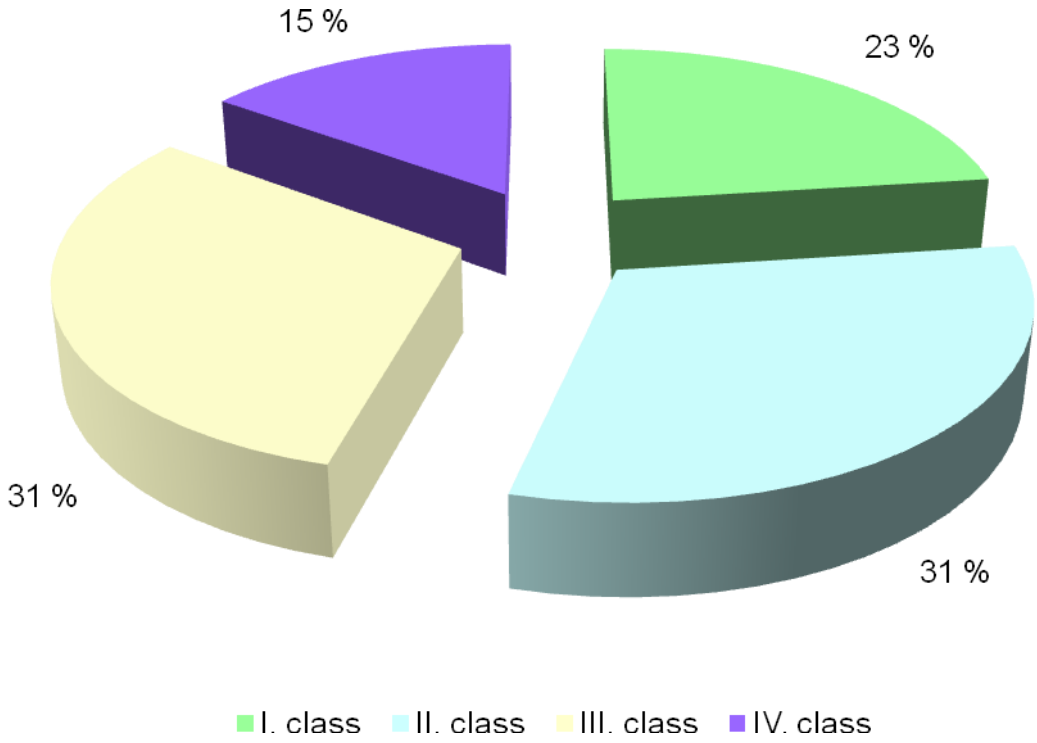

Figure 2 The quality of maize silages in 2010

CONCLUSIONS

Maize silage provides a important source of energy in the form of starch and fibre fractions for dairy cows nutrition. In classified maize silages from Western Slovak Region analyzed in 2009 and 2010 we found average dry matter content 357.87 $g.kg^{-1}$ and 340.00 $g.kg^{-1}$, content of starch 365,67 and 356,60 $g.kg^{-1}$ of DM. Higher content of acid detergent fiber and neutral detergent fiber had maize silages with higher dry matter content from 2010. The value of net energy of lactation was very similar (6.32 and 6.27 $g.kg^{-1}$ of DM). Only in one sample from 2010 we found a lower lactic acid content than 10 $g.kg^{-1}$ of original matter. Content of acetic acid was lower in silages from 2009 in comparison with silages from 2010. According to evaluation system valid in Slovakia only 17 % of evaluated samples satisfied the criteria for silages of 1^{st} class (2009) and 23 % (2010) mainly for the higher acetic acid content.

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