

## Fatty acid composition of maize silages from different hybrids

Miroslav Juráček<sup>1\*</sup>, Daniel Bíro<sup>1</sup>, Milan Šimko<sup>1</sup>, Branislav Gálik<sup>1</sup>, Michal Rolínek<sup>1</sup>,  
Ondrej Hanušovský<sup>1</sup>, Ondrej Pastierik<sup>2</sup>, Adriana Pířová<sup>1</sup>, Norbert Andruška<sup>1</sup>

<sup>1</sup>Slovak University of Agriculture in Nitra, Nitra, Slovak Republic

<sup>2</sup>AGRORAMA Šaľa, Slovak Republic

Article Details: Received: 2016-12-13 | Accepted: 2016-12-18 | Available online: 2017-12-31

<http://dx.doi.org/10.15414/afz.2017.20.04.95–98>

The aim of this research was to determine the fatty acid content in maize silages of different hybrids. Grain hybrid with FAO number 420 and silage hybrid with stay-green maturation with FAO number 450 were evaluated. Maize hybrids were grown under the same agro-ecological conditions, and harvested on growing degree days 1277 (FAO 420) and 1297 (FAO 450). Whole-plant maize was chopped to 10 mm by harvester with kernel processor and immediately ensiled in plastic barrels (volume 50 dm<sup>3</sup>). Maize matter was ensiled without silage additives. For fatty acids analyses samples of maize silages were taken after 8 week of ensiling. Content of fatty acids was quantified by gas chromatography. Examined maize of both hybrids had the highest linoleic acid content, followed by oleic acid and third highest content of palmitic acid. The results confirmed differences in fatty acid content in maize silages of different hybrids. In silages of grain hybrid was detected significantly higher content of palmitic acid and cis-11-eicosenoic acid and significantly lower content of oleic acid in compared with silage of silage hybrid. This ultimately resulted in a higher polyunsaturated fatty acids content ( $P < 0.05$ ) in maize silage from grain hybrid and lower monounsaturated fatty acids content ( $P < 0.05$ ) in maize silage from stay green hybrid.

**Keywords:** fatty acid, maize, hybrid, silage

### 1 Introduction

Area of all forms of maize harvested green grown mainly for silage was 78.05 thousand of ha in Slovakia and 6,146.18 ha in European Union in 2016 (Eurostat 1). Maize silage is important carbohydrate feed, the uniqueness of which lies in the fact that it itself is a mixture of concentrate (grain) and forage (other parts of the plant). Maize silage is used not only in ruminant nutrition but also in non-ruminant nutrition, horses (Blažková et al., 2012), pigs (Capraro et al., 2017), rabbits (Guermah et al., 2016) and geese (Kokoszyński et al., 2014). The feeding of conserved feeds affect the quality of products of animal origin (Kalač and Samková, 2010; Oliveira et al., 2012; Galassi et al., 2016). The nutritional composition of maize silage affects the hybrid, so the decision to select it in a given location is very important. Hybrid influences the achievement of suitable silage maturity, nutrient digestibility, nutritional value, epiphytic microflora composition, yield of dry matter, nutrients and energy per 1 hectare, productive efficiency of 1 kg of silage, respectively of the area of 1 hectare and thus the overall production efficiency (Bíro et al., 2014). Fatty acid content and composition of maize silages are highly variable, and this variation is primarily caused by differences in

maturity at harvest (Khan et al., 2012). Except for harvest maturity (Khan et al., 2015) and garbage species (Van Ranst et al., 2009), the fatty acid content in silages also influences the hybrid (Mojica-Rodríguez et al., 2017), conservation method (Boufaied et al., 2003; Arvidsson et al., 2009; Glasser et al., 2013), length of storage (Han and Zhou, 2013), the use of silage additive (Alves et al., 2011) and exposure to air during the feed out period (Khan et al., 2009).

### 2 Material and methods

#### 2.1 Maize and ensiling

The experiment was conducted in Mojmirovce located 200 above sea level, in west part of Slovakia (+48° 10' 38.6394", +18° 4' 18.4794"), on a soil Anthrosolic Chernozems. Soil has been standard pre-treated, fertilized by mineral fertilizer. Nitrogen, phosphorus and potassium were applied at the rate of 160 : 23 : 23 kg ha<sup>-1</sup>. Hybrids were seed with plant density 78,000 plants per hectare and space between two rows was 760 mm. Each hybrid was seed in 6 rows. Sown hybrid was FAO 420 (grain hybrid, dent type of grain) and FAO 450 (silage hybrid with stay-green maturation type). Harvest dates of maize hybrids were established according to grain

\***Corresponding Author:** Miroslav Juráček, Slovak University of Agriculture in Nitra, Faculty of Agrobiolgy and Food Resources, Department of Animal Nutrition, Tr. Andreja Hlinku 2, 949 76, Nitra, Slovakia, phone, +421 37 641 43 32, e-mail: [miroslav.juracek@uniag.sk](mailto:miroslav.juracek@uniag.sk)

maturity and whole plant dry matter content. Hybrid FAO 420 was harvested on growing degree days (GDD) 1277 and hybrid FAO 450 on 1297 GDD. Fresh whole-plant maize was chopped to 10 mm length of cut by harvester with kernel processor (CLAAS Ltd., USA) and immediately ensilaged in plastic barrels with volume 50 dm<sup>3</sup>. Maize matter of different hybrids was ensilaged without silage additives. Plastic barrels were hermetically sealed and stored for 8 weeks in climatized laboratory (20 ± 1 °C). The samples of silage from each hybrid (*n* = 3) were taken for laboratory analysis after opening the plastic barrels.

## 2.2 Analysis

The contents of dry matter and crude fat was determined according to Commission Regulation (EC) No 152/2009. The analysis of fatty acid methyl esters (FAMES) was performed. For the characterization of the lipid fraction, the triglycerides were hydrolysed (saponified) into glycerol and free fatty acids. Fatty acids were derivatized to the methylesters (FAMES). After the FAMES preparation, they were separated according to the carbon number (number of carbon atoms in the fatty acid chain, excluding the methyl ester carbon) and the degree of unsaturation by gas chromatography (GC) with flame ionisation detector (FID). For column check-out, a 37-component mixture (Supelco 47885-U) was used. The standard was diluted with 10 ml hexane (final

concentration was 0.2–0.4 mg ml<sup>-1</sup> per FAME) before the use. The total of 200 mg of sample in a 20 ml test tube was used. Dissolution of the sample in 5 ml hexane and addition of 1 ml 2 N potassium hydroxide in methanol was used. The tube was closed and shaken for 30 sec. The tube was heated for 30 sec at 60 °C in a water bath. After 1 minute, 2 ml of 1 N HCl was added and the tube was shaken. The upper (organic) layer was transferred into a 2 ml autosampler vial after passing it through a bed of anhydrous Na<sub>2</sub>SO<sub>4</sub>. The analyses were performed on an Agilent 6890A GC (Agilent technologies, U.S.A.) analyser with a flame ionization detector (FID). Automated split injection was performed using an Agilent autosampler (Agilent technologies, U.S.A.). FAMES were separated on DB-23 analytical column and identified by FID.

## 2.3 Statistical analysis

The results were statistically analysed by an one-way ANOVA, the differences in average means of fatty acids between different maize silages were tested with T-test (SAS system 9.2, SAS Institute Inc. USA).

## 3 Results and discussion

In maize silages of FAO 420 was determined average content of dry matter 331.4 g kg<sup>-1</sup> and in maize silages of FAO 450 313.7 g kg<sup>-1</sup>, with content of crude fat 31.3 g kg<sup>-1</sup> (FAO 420) and 27.6 g kg<sup>-1</sup> of dry matter (FAO

**Table 1** Fatty acid content in maize silages of different hybrids after 8 week of ensiling

Fatty acid (g 100 g <sup>-1</sup> total fatty acids)		FAO 420		FAO 450	
		mean	S.D.	mean	S.D.
C12:0	lauric acid	0.19	0.039	0.20	0.061
C14:0	myristic acid	0.21	0.054	0.24	0.037
C16:0	palmitic acid	14.61*	0.776	13.68*	0.810
C16:1	palmitoleic acid	0.28	0.059	0.27	0.042
C18:0	stearic acid	2.30*	0.149	2.62*	0.177
C18:1	oleic acid	21.58*	0.514	22.96*	0.758
C18:2	linoleic acid	47.83	1.930	46.05	2.252
C18:3	α-linolenic acid	7.11	1.848	6.45	0.811
C20:0	arachidic acid	0.63	0.062	0.63	0.053
C20:1	cis-11-eicosenoic acid	0.23*	0.005	0.22*	0.010
C22:0	behenic acid	0.37	0.060	0.36	0.057
C24:0	lignoceric acid	0.55	0.084	0.60	0.097
PUFA		55.45*	1.510	53.20*	1.179
MUFA		22.10*	0.463	23.45*	0.733
SFA		18.96	1.185	18.33	1.283
n6:n3		6.68:1	/	6.60:1	/

PUFA – polyunsaturated fatty acids; MUFA – monounsaturated fatty acids; SFA – saturated fatty acids; \* – values with the same index in row are significant at *P* < 0.05

450). According to Zeman et al. (2006) is the optimal content of dry matter 280–340 g kg<sup>-1</sup> for maize silage and according to Loučka and Tarolová (2013) is ideal content 330 g kg<sup>-1</sup>. Although most of the energy acquired by the ruminant is from the starch and fiber fractions of silage, the fat content also has significant impact. Maize silage with 50% grain has from 2 to 7% fat depending upon the variety and maturity at harvest (Mir, 2004). Forages, even though containing a relatively low level of lipids, are the cheapest and often the major source of beneficial unsaturated fatty acids in ruminant diets (Kalač and Samková, 2010). In maize silages of FAO 450 statistically significant ( $P < 0.05$ ) lowest content of polyunsaturated fatty acids, but statistically significant ( $P < 0.05$ ) highest content of monounsaturated fatty acids (Table 1) was found. The difference between saturated fatty acids was not statistically significant ( $P > 0.05$ ). In experiment, the higher content of PUFA and lower content of MUFA in comparison to the results of Alezones et al. (2010) was found, which detected the fatty acid content of different maize hybrids. The results of Khan et al. (2011) confirmed that the maximum PUFA content in silage maize is harvested at an ear dry matter content of 440 g kg<sup>-1</sup>, which is before the onset of rapid senescence. Any further delay in harvesting will cause a rapid decline in C18:3 content in maize silages. In maize silage, the highest content of linoleic acid was detected from all fatty acids, while lower content by 3.72% was found in silages with FAO 450. However, the differences were not statistically significant. The second highest content was oleic acid. In silages FAO 450 was statistically significant higher oleic acid content by 6.39%. In accordance with our results Alezones et al. (2010) found the highest linoleic acid content and the second highest oleic acid content in different maize hybrids. Han and Zhou (2013) determined content of linoleic acid 41.6 g and content of oleic acid 13.0 g 100 g<sup>-1</sup> in maize silages on 28<sup>th</sup> day of fermentation. The linoleic acid content and oleic acid content was detected at values 47.83 g (FAO 420) and 46.05 g 100 g<sup>-1</sup> (FAO 450). The meta-analysis of Glasser et al. (2013) include 44 studies showed a similarly average content of these fatty acids (linoleic acid: 45.8 g 100 g<sup>-1</sup> and oleic acid: 21.4 g 100 g<sup>-1</sup>). Palmitic acid was the fatty acid with the third highest content in maize silages, with a statistically significant lowest content in the silages of hybrid FAO 450. Alezones et al. (2010) also reported statistically significant differences in palmitic acid content between maize hybrids. In the content of essential fatty acid  $\alpha$ -linolenic acid statistically nonsignificant differences were found.  $\alpha$ -linolenic acid formed fourth highest content of total fatty acid content, what is identical with results of Balušíková et al. (2017). Different of our results Glasser et al. (2013) found lower content of  $\alpha$ -linolenic acid in maize silages (5.04 g vs. 6.45 g and 7.11 g 100 g<sup>-1</sup>). Otherwise Alves et al. (2011)

reported higher content of  $\alpha$ -linolenic acid in maize silages after 9 week of ensiling (10.64 g 100<sup>-1</sup>). In silages with FAO 450, higher stearic acid content was detected (by 13.91%). The differences were statistically significant. The representation of the other fatty acids was less than 1%, while the differences were not statistically significant except for cis-11-eicosenoic acid. In silages FAO 420, a higher cis-11-eicosenoic acid content was determined as compared to silages FAO 450.

#### 4 Conclusions

The aim of this research was to determine the fatty acid content in maize silages of different hybrids with FAO 420 (grain hybrid) and FAO 450 (silage stay green hybrid) after 8 week of ensiling. Examined maize of both hybrids had the highest linoleic acid content, followed by oleic acid and third highest content of palmitic acid. The results confirmed differences in fatty acid content in maize silages of different hybrids. In silages of grain hybrid was detected significantly higher content of palmitic acid and cis-11-eicosenoic acid and significantly lower content of oleic acid in comparison with the silage of silage hybrid. This ultimately resulted in a higher polyunsaturated fatty acids content ( $P < 0.05$ ) in maize silage from grain hybrid and lower monounsaturated fatty acids content ( $P < 0.05$ ) in maize silage from stay green hybrid. Maize breeding is one of the options to improve fatty acids composition. Choosing a suitable hybrid is one of the possibilities which could influence the fatty acid content of feeds and subsequently, products of animal origin.

#### Acknowledgments

The project was supported by the Slovak National Scientific Grant Agency VEGA, Grant No. 1/0723/15.

#### References

- ALEZONES, J. et al. (2010) Caracterización del perfil de ácidos grasos en granos de híbridos de maíz blanco cultivados en Venezuela. In *Archivos Latinoamericanos de Nutrición*, vol. 60, no. 4, pp. 397–404.
- ALVES, S.P. et al. (2011) Effect of ensiling and silage additives on fatty acid composition of ryegrass and corn experimental silages. In *Journal of Animal Science*, vol. 89, no. 8, pp. 2537–2545. doi: <https://dx.doi.org/10.2527/jas.2010-3128>
- ARVIDSSON, K., Gustavsson, A.-M. and Martinsson, K. (2009) Effects of conservation method on fatty acid composition of silage. In *Animal Feed Science and Technology*, vol. 148, no. 2–4, pp. 241–252. <http://dx.doi.org/10.1016/j.anifeedsci.2008.04.003>
- BALUŠÍKOVÁ, L. et al. (2017) Fatty acids of maize silages of different hybrids. In *NutriNet 2017*. České Budějovice: University of South Bohemia in České Budějovice, pp. 13–19.
- BÍRO, D. et al. (2014) Conservation and adjustment of feeds. Nitra: Slovak University of Agriculture. 223 p. (in Slovak).
- BLAŽKOVÁ, K. et al. (2012) Comparison of *in vivo* and *in vitro* digestibility in horses. In *Koně 2012*. České Budějovice: University of South Bohemia in České Budějovice, pp. 1–7.

- BOUFAÏED, H. et al. (2003) Fatty acids in forages. I. Factors affecting concentrations. In *Canadian Journal of Animal Science*, vol. 83, no. 3, pp. 501–511. doi:<http://dx.doi.org/10.4141/a02-098>
- CAPRARO, D. et al. (2017) Feeding finishing heavy pigs with corn silages: effects on backfat fatty acid composition and ham weight losses during seasoning. In *Italian Journal of Animal Science*, vol.16, no. 4, pp. 588–592. doi:<http://dx.doi.org/10.1080/1828051x.2017.1302825>
- COMMISSION Regulation (EC) No 152/2009 of 27 January 2009 laying down the methods of sampling and analysis for the official control of feed. L 54/1. 130 p.
- EUROSTAT 1 Green maize by area, production and humidity. [Online] Available from: <http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tag00101&plugin=1> [Accessed: 2017- 10-30].
- GALASSI, G. et al. (2016) Digestibility, metabolic utilisation and effects on growth and slaughter traits of diets containing whole plant maize silage in heavy pigs. In *Italian Journal of Animal Science*, vol. 16, no. 1, pp. 122–131. doi:<http://dx.doi.org/10.1080/1828051x.2016.1269299>
- GLASSER, E. et al. (2013) Fat and fatty acid content and composition of forages: a meta-analysis. In *Animal Feed Science and Technology*, vol.185, no. 1–2, pp. 19–34. doi:<http://dx.doi.org/10.1016/j.anifeeds.2013.06.010>
- GUERMAH, H., Maertens, L. and Berchiche, M. (2016) Nutritive value of brewers' grain and maize silage for fattening rabbits. In *World Rabbit Science*, vol. 24, no. 3, pp. 183–189. doi:<http://dx.doi.org/10.4995/wrs.2016.4353>
- HAN, L. and Zhou, H. (2013) Effects of ensiling process and antioxidants on fatty acids concentrations and compositions in corn silages. In *Journal of Animal Science and Biotechnology*, vol. 4, no. 1, pp. 1–7. doi: <http://dx.doi.org/10.1186%2f2049-1891-4-48>
- KALAC, P. and Samková, E. (2010) The effects of feeding various forages on fatty acid composition of bovine milk fat: A review. In *Czech Journal of Animal Science*, vol. 55, no. 12, pp. 521–537.
- KHAN, N.A., Cone, J.W. and Hendriks, W.H. (2009) Stability of fatty acids in grass and maize silages after exposure to air during the feed out period. In *Animal Feed Science and Technology*, vol. 154, no. 3–4, pp. 183–192. doi:<http://dx.doi.org/10.1016/j.anifeeds.2009.09.005>
- KHAN, N.A. et al. (2011) Changes in fatty acid content and composition in silage maize during grain filling. In *Journal of Science of Food and Agriculture*, vol. 91, no.6, pp. 1041–1049. doi:<http://dx.doi.org/10.1002/jsfa.4279>
- KHAN, N.A. et al. (2012) Causes of variation in fatty acid content and composition in grass and maize silages. In *Animal Feed Science and Technology*, vol. 174, no. 1–2, pp. 36–45. doi: <http://dx.doi.org/10.1016/j.anifeeds.2012.02.006>
- KHAN, N.A. et al. (2015) Effect of species and harvest maturity on the fatty acids profile of tropical forages. In *The Journal of Animal & Plant Sciences*, vol. 25, no. 3, pp. 739–746.
- KOKOSZYŃSKI, D. et al. (2014) Effect of corn silage and quantitative feed restriction on growth performance, body measurements, and carcass tissue composition in White Kolduda W31 geese. In *Poultry Science*, vol. 93, no. 8, pp.1993–1999. doi:<http://dx.doi.org/10.3382/ps.2013-03833>
- LOUČKA, R. and Tyrolová, Y. (2013) *Good practice for maize silaging*. Praha: Institute of Animal Science.
- MIR, P.S. (2004) Fats in Corn Silage. Advanced Silage Corn Management 2004. [Online] Available from: <http://www.farmwest.com/chapter-8-quality-of-corn-silage> [Accessed: 2017- 10-30].
- MOJICA-RODRÍGUEZ, J.E. et al. (2017) Effect of stage of maturity on fatty acid profile in tropical grasses. In *Corpoica Ciencia Tecnología Agropecuaria*, vol. 18, no.2, pp. 217–232. doi: [http://dx.doi.org/10.21930/rcta.vol18\\_num2\\_art:623](http://dx.doi.org/10.21930/rcta.vol18_num2_art:623)
- NAZIR, N.A. et al. (2011) Changes in fatty acid content and composition in silage maize during grain filling. In *Journal of the Science of Food and Agriculture*, vol. 91, no. 6, pp.1041–1049. doi:<http://dx.doi.org/10.1002/jsfa.4279>
- OLIVEIRA, M.A. et al. (2012) Fatty acids profile of milk from cows fed different maize silage levels and extruded soybeans. In *Revista Brasileira de Saúde e Produção Animal*, vol. 13, no. 1, pp. 192–203. doi: <http://dx.doi.org/10.1590/s1519-99402012000100017>
- SAS Institute (2008) Statistical Analysis System Institute, Version 9.2. SAS Institute, Cary, NC, USA.
- VAN Ranst, G. et al. (2009) Influence of herbage species, cultivar and cutting date on fatty acid composition of herbage and lipid metabolism during ensiling. In *Grass and Forage Science*, vol. 64, no. 2, pp. 196–207. doi:<http://dx.doi.org/10.1111/j.1365-2494.2009.00686.x>
- ZEMAN, L. et al. (2006) *Nutrition and feeding of livestock*. Praha: Profi Press. 360 p. (in Czech).