Acta fytotechn zootechn, 19, 2016(2): 54–58
http://www.acta.fapz.uniag.sk

**Original Paper**

# The quality of farm-scale alfalfa silages

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Article Details: Received: 2016-11-03 | Accepted: 2016-01-29 | Available online: 2016-05-31

dx.doi.org/10.15414/afz.2016.19.02.54–58

The aim of the work was to determined the nutritive and fermentation quality of farm-scale alfalfa silages from West part of Slovakia, analyzed in 2014 in the laboratory of the Department of Animal Nutrition, SUA in Nitra. In alfalfa silages, was found the average dry matter content 372.66 g $kg^{-1}$, while 30% of samples had lower dry matter content than 350 g $kg^{-1}$. Only 15% of samples had higher content of crude protein than 200 g. Content of ADF lower than 300 g $kg^{-1}$ of DM in any sample was not found. In alfalfa silages was higher content of NDF than 37.5% in 70% of alfalfa silages. The lactic acid content was higher than 10 g of the original matter in all samples except one, ranged from 0.73 to 14.67% on a dry matter basis. Average content of acetic acid was 29.82 g $kg^{-1}$ of DM. Undesirable butyric acid was found in 35% of samples with average content 8.44 g $kg^{-1}$ of DM, with maximal content 108.25 g $kg^{-1}$ of DM. The difference in PDIN production efficiency of silages after comparison of the best and the worst silage was 1.01 kg of milk (4% fat corrected milk).

**Keywords:** alfalfa, silage, nutritive value, fermentation, quality

## 1 Introduction

Animal productivity depends on the nutrient composition of the ration presented to the animal as well as on the quality of feed ingredients (Ward, 2008; Steinshamn, 2010). Dairy cows should be fed the highest quality ensiled forages and grains possible for maximum milk production since fermented feeds can exceed 50% of the total dry-matter ration. Silage quality is important to dairy profitability and is why monitoring silage quality is an important part of the nutritional program (Seglar, 2003). Lactic acid should be the primary acid in good silages. This acid is stronger than other acids in silage (acetic, propionic and butyric) and thus usually responsible for most of the drop in silage pH. Lactic acid should be at least 65 to 70% of the total silage acids in good silage (Kung, 2010). Excessive amounts of acetic, propionic, or butyric acids as well as ethanol indicate a poorer quality fermentation process resulting from other microbes that are not exclusive lactic acid-producing bacteria (Van Saun, 2008). The effect of high concentrations of acetic acid (>4–6% of dry matter) in silages fed to animals is unclear at this time. Some studies found that dry matter intake was depressed due to high acetic acid silage when fed to ruminants (Huhtanen et al., 2002). However, the depressed intake due to high acetic acid in the diet has not been consistent (Schmidt et al., 2014). If is intake problems due to silages with excessively high acetic acid (>5–6% of dry matter), the amount of that silage should be reduced in the total mixed ration (Baumont, 1996; Kung, 2010; Daniel et al., 2013). A high concentration of butyric acid (>0.5% of dry matter) indicates that the silage has undergone clostridial fermentation, which is one of the poorest fermentations. Silages high in butyric acid are usually low in nutritive value and have higher acidodetergent fiber and neutraldetergent fiber levels because many of the soluble nutrients have been degraded. Such silages may also be high in concentrations of soluble proteins and may contain small protein compounds called amines that have sometimes shown to adversely affect animal performance. High butyric acid has sometimes induced ketosis in lactating cows and because the energy value of silage is low, intake and production can suffer (Shaver, 2013; Gerlach et al., 2014). High concentrations of ammonia (>12 to 15% of crude protein) are a result of excessive protein breakdown in the silo caused by a slow drop in pH or clostridial action. High amounts of ammonia (by itself) in silage should not have negative effects on animal performance if the total dietary nitrogen fractions are in balance. If the high ammonia contributes to an excess of ruminally-degraded protein (RDP), this could have negative consequences on milk

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and reproductive performances. Blood or milk urea nitrogen can be used as an indicator of excess RDP. Usually, silage with high concentrations of ammonia coupled with butyric acid may also have significant concentrations of other undesirable end products, such as amines, that may reduce animal performance (Kung and Shaver, 2001). Products from protein and amino acid degradation ($NH_3$-N, butyric acid) are negative correlated to dry matter intake (Gerlach et al., 2014).

## Material and methods

### *2.1 Analysis*

The quality of farm-scale alfalfa silages from West part of Slovakia in 2014 (*n* = 20) was determined on the Department of animal nutrition, Faculty of agrobiology and food resources, Slovak university of agriculture in Nitra, Slovakia. Alfalfa silages were evaluated on the base of nutritional value, the result of fermentation process and silage quality according to Škultéty (1999). For analysis of organic (crude protein, crude fiber, fat) and inorganic nutrients (ash) were 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). determined was the content of dry matter (DM) gravimetrically by drying of sample to constant weight by temperature 103 ±2 °C (predrying by t 60 °C). Content of nitrogen free extract (NFE) and organic matter (OM) were calculated (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 with the use of a muffle furnace by 550 °C, crude fiber: gravimetrically as the residue remaining after extraction in acid and alcalic reagent, acid detergent fiber: gravimetrically as the residue remaining after extraction in acido detergent solution, neutral detergent fiber: gravimetrically as the residue remaining after extraction in neutral detergent solution. Energy (NEL, NEG) and protein values (PDIN and PDIE) were calculated by regression equations (Regulation of the Government of Slovak Republic no. 439/2006, appendix no.7, part G Nutritive value of feeds). Production efficiency of silages was determined according to Pajtáš et al. (2009). Silage extracts were 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) was detected on analyzer EA 100 (Villa Labeco, SR) using the ionic electrophoresis method. Degree of proteolysis was calculated ($NH_3$-N / total N * 100). Active acidity was determined by electrometric method. Fermentation products were calculated by count of fermentable acids without alcohols.

### *2.2 Statistical Analysis*

Results were statistical analyzed in statistic program SAS Enterprise Guide 5.1. (SAS Institute, Inc).

## 3 Results and discussion

According to Doležal et al. (2012) is the optimal content of dry matter 350–400 g kg$^{-1}$ for alfalfa silage. The average content of dry matter 372.66 g kg$^{-1}$ in farm-scale alfalfa silages from West part of Slovakia was detected. We found that 30% of the samples had a dry matter content of less than 350 g kg$^{-1}$. Nutritive value of alfalfa silages closely related to the phenological stage at harvest (Charmley, 2001). Optimal phenological stage for the production of alfalfa silage is butonization (Bíro et al., 2014). High quality alfalfa silage has min. 200 g crude protein in one kg of dry matter. Crude protein content and their fractions depends mainly on the maturity of the crop at harvest, climatic conditions and fertilizer application (Jendrišáková, 2010). Only 15% of samples had higher content of crude protein than 200 g. Alfalfa silages are characterized by having a low fat content. detected the average content of fat 28.19 g kg$^{-1}$ of DM. Content of crude fiber under 270 g kg$^{-1}$ of DM is by one of parameters for classification of silage in 1st qualitative class (Škultéty, 1999). This condition was reached in only 30% of samples. The average of legume silage ash values is 10.9% with many samples over 15% (Ward, 2008). In 10% of samples was detected higher content of ash than 150 g kg$^{-1}$ of DM. The average content of nitrogen free extract in alfalfa silages was determined 393.01 g kg$^{-1}$ of DM. Petrikovič et al. (2000) reported average content of NFE in 366 samples of alfalfa silages 338 g kg$^{-1}$ of DM.

**Table 1** Content of nutrients in farm-scale alfalfa silages

| 2014 | DM | CP | Fat | CF | Ash | NFE | OM |
|---|---|---|---|---|---|---|---|
| | g kg$^{-1}$ | g kg$^{-1}$ of DM | | | | | |
| $\bar{x}$ | 372.66 | 174.44 | 28.19 | 291.83 | 116.74 | 393.01 | 883.14 |
| s.d. | 73.23 | 26.52 | 5.54 | 43.2 | 29.91 | 43.02 | 31.35 |
| $x_{min}$ | 225.4 | 126.2 | 22.1 | 220.6 | 81.8 | 299.9 | 785.7 |
| $x_{max}$ | 458.7 | 219.8 | 38.6 | 402.5 | 214.3 | 470.1 | 918.2 |

s.d. – standard deviation, DM – dry matter, CP – crude protein, CF – crude fiber, NFE – nitrogen free extract, OM – organic matter

**Table 2** Content of ADF, NDF and net energy and PDI in farm-scale alfalfa silages

| 2014 | ADF | NDF | NEL | NEG | PDIN | PDIE |
|---|---|---|---|---|---|---|
| | g kg$^{-1}$ of DM | MJ kg$^{-1}$ of DM | g kg$^{-1}$ of DM | | | |
| $\bar{x}$ | 364.39 | 418.41 | 4.83 | 4.5 | 107.51 | 64.41 |
| s.d. | 42.82 | 46.57 | 0.18 | 0.17 | 14.42 | 4.96 |
| $x_{min}$ | 316.10 | 359.8 | 4.31 | 4.00 | 83.0 | 53.9 |
| $x_{max}$ | 485.80 | 502.6 | 5.02 | 4.68 | 133.6 | 71.6 |

s.d. – standard deviation, DM – dry matter, ADF – acidodetergent fiber, neutraldetergent fiber, NEL – net energy for lactation, NEV – net energy for gain, PDIN, PDIE – protein digestible in intestine

Seglar (2003) recommend the optimal content of ADF less than 300 g kg$^{-1}$ of DM in alfalfa silages. Content of ADF lower than 300 g kg$^{-1}$ of DM in any sample was not found. According to Mitrík (2010) is target level of NDF in alfalfa silage ≤37.5%. In collection of samples analyzed in 2014 was the higher content of NDF than 37.5% in 70% of alfalfa silages, which indicate the harvest of alfalfa in later phenological stages. The average value of NEL in silages analyzed in 2014 was determined 4.83 MJ kg$^{-1}$ of DM. Vyskočil et al. (2008) reported average value of NEL in alfalfa silages even 5.47 MJ kg$^{-1}$ of DM. The maximal value of NEL only 5.02 MJ kg$^{-1}$ of DM was found. Alfalfa silage is source of crude protein and protein digestible in intestine in the feed rations (Tabacco et al., 2002; 2006). In the present study was average content of PDIN 107.51 g kg$^{-1}$ of DM and PDIE 64.41 g kg$^{-1}$ of DM. Petrikovič et al. (2000) reported average value of PDIN 116 g kg$^{-1}$ of DM and PDIE 71 g kg$^{-1}$ of DM in 366 samples of alfalfa silages. After comparison of PDIN production efficiency was found difference between minimal and maximal production efficiency of silages 1.01 kg of milk (min. 1.66 kg vs. 2.67 kg of 4% fat corrected milk).

Generally, in well-preserved silage, at least 65–70% of the total acid will be lactic acid or 4–7% lactic acid (% DM) (Ward, 2008). In 70% of samples more than 65% portion of lactic acid from the total acids was determined. Content of lactic acid higher than 10 g kg$^{-1}$ of original matter is one of parameters for classification of silage in 1$^{st}$ qualitative class (Škultéty, 1999). The lactic acid content was higher than 10 g of the original matter in all samples except one, ranged from 0.73 to 14.67% on a dry matter basis. Acceptable silages generally contain <3% acetic acid, <0.1% butyric acid, and <0.5% propionic acid (Ward, 2008). Average content of acetic acid was 29.82 g kg$^{-1}$ of dry matter in alfalfa silages. Undesirable butyric acid was found in 7 samples with average content 8.44 g kg$^{-1}$ of DM, with maximal content 108.25 g kg$^{-1}$ of DM. According to Škultéty (1999) quality alfalfa silage has lower content of butyric acid under 2.5 g kg$^{-1}$ of DM. The butyric acid content was higher than 2.5 g kg$^{-1}$ of DM in 6 samples. Well preserved alfalfa silage with DM content 201–300 g kg$^{-1}$ has to pH value less than 4.3, with DM 301–400 g kg$^{-1}$ has to pH value less than 4.5, while a silage with DM content 401–500 g kg$^{-1}$ has to pH value less than 4.7 (Škultéty, 1999). The value of pH fluctuated from 4.12 to 5.99 in analyzed alfalfa silages, while average pH 4.80 was in silages with DM 201–300 g kg$^{-1}$ (24% from total samples), average pH 4.63 was in silages with DM 301–400 g kg$^{-1}$ (35% from total samples) and 4.57 in silages with DM 401–500 g kg$^{-1}$ (41% from total samples). High ammonia indicates poor or extensive fermentation, indicating protein breakdown from proteolytic enzymatic activity contained within the crop. Several factors affect the level of proteolysis in the silo (Muck et al., 2003; Bíro et al., 2010). Values of degree of proteolysis are usually less than 15% in alfalfa and grass silages and less than 10% in corn silage and high moisture grains (Seglar, 2003). Degree of proteolysis

**Table 3** Fermentation parameters of farm-scale alfalfa silages

| 2014 | FA | LA | AA | BA | pH | DP | FP |
|---|---|---|---|---|---|---|---|
| | g kg$^{-1}$ of DM | value | % | g kg$^{-1}$ of DM | | | |
| $\bar{x}$ | 2.75 | 82.04 | 29.82 | 8.44 | 4.65 | 13.51 | 124.1 |
| s.d. | 2.13 | 33.38 | 16.94 | 25.9 | 0.45 | 15.44 | 33.76 |
| $x_{min}$ | ND | 7.32 | 6.11 | ND | 4.12 | 5.18 | 79.39 |
| $x_{max}$ | 6.24 | 146.66 | 75.0 | 108.25 | 5.99 | 69.73 | 185.7 |

s.d. – standard deviation, FA – formic acid, LA – lactic acid, AA – acetic acid, BA – butyric acid, DP – degree of proteolysis, FP – fermentation products without alcohols, ND – not detected lower than 8% is one of parameters for classification of silage in 1st qualitative class (Škultéty, 1999; Rajčáková and Mlynár, 2009). Higher degree of proteolysis than 8% in 45% of alfalfa silages was found.

## 4 Conclusions

In farm-scale alfalfa silages was found the average dry matter content 372.66 g kg$^{-1}$, while 30% of samples had lower dry matter content than 350 g kg$^{-1}$. Alfalfa silage is source of crude protein and protein digestible in intestine in the feed rations. Only 15% of samples had higher content of crude protein than 200 g. Content of ADF lower than 300 g kg$^{-1}$ of DM in any sample was not found. In alfalfa silages was higher content of NDF than 37.5% in 70% of alfalfa silages, which indicate the harvest of alfalfa in later phenological stages. The lactic acid content was higher than 10 g of the original matter in all samples except one, ranged from 0.73 to 14.67% on a dry matter basis. High levels of acetic (>30 g kg$^{-1}$ of dry matter) or butyric acid (>2.5 g kg$^{-1}$ of dry matter) are indicators of undesirable silage fermentation. Average content of acetic acid was 29.82 g kg$^{-1}$ of DM. Undesirable butyric acid was found in 35% of samples with average content 8.44 g kg$^{-1}$ of DM, with maximal content 108.25 g kg$^{-1}$ of DM. The difference in PDIN production efficiency of silages after comparison of the best and the worst silage was 1.01 kg of milk (4% fat corrected milk).

## Acknowledgments

This work was supported by Grant Agency of the Slovak Ministry of Education, Sport, Science and Research and Slovak Academy of Sciences (project VEGA no. 1/0723/15).

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