

# Effects of grass species on ruminal degradability of silages and prediction of dry matter effective degradability

F. JANČÍK<sup>1</sup>, V. KOUKOLOVÁ<sup>1</sup>, P. KUBELKOVÁ<sup>1</sup>, B. ČERMÁK<sup>2</sup>

<sup>1</sup>Institute of Animal Science, Prague-Uhřetěves, Czech Republic

<sup>2</sup>Faculty of Agriculture, University of South Bohemia in České Budějovice, České Budějovice, Czech Republic

**ABSTRACT:** Forty samples of grass silages, made from the five most widely used grass species in ruminant nutrition (*Dactylis glomerata* L., *Phleum pratense* L., *Lolium perenne* L., *Festuca arundinacea* L. and hybrid Felina) were tested in the present study. These grass species conserved by an ensiling process were compared among each other according to dry matter (DM) rumen degradability parameters ( $a$  = portion of DM solubilized at initiation of incubation,  $b$  = fraction of DM potentially degradable in the rumen,  $c$  = rate constant of disappearance of fraction  $b$  and  $ED_{DM}$  = effective degradability of DM, estimated for each ingredient assuming the rumen solid outflow rates of 0.02 ( $ED_{DM2}$ ), 0.05 ( $ED_{DM5}$ ) and 0.08 ( $ED_{DM8}$ )  $h^{-1}$ ). Based on the chemical composition of grass silages the regression equations for prediction of  $ED_{DM}$  were evaluated. The influence of the ensiling process on dry matter degradability parameters was also assessed. The best values of  $ED_{DM}$  were determined for *Lolium perenne* ( $ED_{DM2} = 753.2$ ,  $ED_{DM5} = 631.1$  and  $ED_{DM8} = 567.7$  g/kg DM). The best predictor was NDF ( $R^2$ -values of 0.757 ( $ED_{DM2}$ ), 0.863 ( $ED_{DM5}$ ) and 0.906 ( $ED_{DM8}$ )). Using two predictors the accuracy level increased. The combination of CF and NDF gave  $R^2$ -values 0.892, 0.920 and 0.929 for  $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$ , respectively. The regression equations based on the most important grass species harvested in different vegetation periods seem to be a useful tool for practical use. No significant ( $P < 0.05$ ) effect of the ensiling process in relation to dry matter rumen degradability parameters was proved.

**Keywords:** grass silages; grass species; dry matter; *in sacco*; rumen degradability

Grass silage is the most important form of conserved forage for the nutrition of ruminants in many regions of Europe (Dawson et al., 2002). The nutritive value of silages or hay is highly influenced by species and cultivars (Pozdíšek et al., 2003). Ruminal degradability is influenced by many factors, mainly by the stage of maturity, forage species and preservation method (Hoffman et al.,

1993; Komprda et al., 1996; Macháčová et al., 1998; Elizalde et al., 1999).

*Phleum pratense*, *Dactylis glomerata*, *Festuca arundinacea* and *Lolium perenne* are the most important grass species not only in the Czech Republic but also in the whole of Europe, Canada and USA (Hoffman et al., 1993; Hetta et al., 2004; Jančík et al., 2008). Grass hybrids (hybridization

Supported by the Ministry of Agriculture of the Czech Republic (Projects Nos. MZE 0002701403 and 0002701404) and Ministry of Education, Youth and Sports of the Czech Republic (Project No. MSM 6007665806).

of *Festuca* and *Lolium*) are useful and often used in Czech agriculture (Pozdíšek et al., 2003; Jančík et al., 2008).

Dry matter (DM) rumen degradability of roughages is a key value for the evaluation system of ruminant feeds. The rate and extent of rumen DM fermentation are very important determinants for the nutrients absorbed by the ruminants (Kamalak et al., 2005). *In sacco* (*in situ*) analyses are the most frequently used methods for determination of degradability parameters of DM, organic matter (OM), protein, fibre, minerals and other nutrients of feeds (Van Vuuren et al., 1991; Tománková and Kopečný, 1995; Čerešňáková et al., 2000, 2007; Homolka, 2000; Harazim et al., 2002; Třináctý et al., 2003; Homolka et al., 2002, 2007, 2008; Jančík et al., 2008).

However, these experiments are labour- and time-consuming and expensive for needs of fistulated animals. Therefore it is necessary to use/develop easier ways of determining degradability parameters. The simplest way of degradability determination is to use prediction equations based on a common chemical analysis of feeds (Nousiainen et al., 2003; Huhtanen et al., 2006; Jančík et al., 2008).

Relationships between degradability and chemical composition of forages were described in literature many times (Tamminga et al., 1991; Waters and Givens, 1992). For example according to Hoffman et al. (1993) and Von Keyserlingk et al. (1996) the increasing concentration of crude protein (CP) positively influences rumen degradability, on the contrary, the increasing amount of neutral-detergent fibre (NDF) has a negative influence. Based on information about the rumen degradability of feeds it is possible to predict the equations which are determined for forages growing in specific conditions. The relationships between chemical and even biological measurements to digestibility can be markedly different for the main grass species used for silage in different countries (Huhtanen et al., 2006).

The objectives of this experiment were to compare the most widely used grass species conserved by an ensiling process according to dry matter rumen degradability parameters and to evaluate the regression equations for prediction of effective dry matter rumen degradability ( $ED_{DM}$ ) of grass silages based on the chemical composition of estimated samples. Following these results the effect of the ensiling process on dry matter degradability parameters was estimated.

## MATERIAL AND METHODS

### Samples

Forty samples of grass silages were evaluated in the present study. Five grass species (*Dactylis glomerata* L. – Dana variety, *Phleum pratense* L. – Sobol variety, *Lolium perenne* L. – Jaspis variety, *Festuca arundinacea* L. – Prolate variety and Felina hybrid), the most widely used in ruminant nutrition, were grown as a monoculture at the Větrov Breeding Station, Tábor region, Czech Republic (49° 31' 2.04" N lat, 14° 28' 4.9" E long; 620 m altitude). Individual grass species were ensiled from primary growth at two dates in 2004 and 2005. Grass forage was wilted on a table drier with cool air ventilation. After wilting up to 300–400 g/kg dry matter, grass was cut to 1–1.5 cm long pieces and ensiled without any additives into hermetic glass vessels (3 litre capacity). The vessels were stored in a dark and cold room for 10 and 20 weeks. After the opening of vessels, silage samples were oven-dried at 50°C for 48 h and milled to pass through a 1 mm screen. Grass forage was also dried, milled and analyzed as silage samples.

### Chemical analysis

All samples were analyzed for DM, CP, ash, crude fat, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). DM was determined after drying at 105°C for 12 hours, and ash content was determined after combustion at 550°C for 4.5 hours (Regulation No. 497/2004, 2004). Crude fat was extracted for 6 h with petroleum ether, whereas the automated Kjeldahl method was used to determine nitrogen (N) (AOAC, 2005). CP was calculated as  $N \times 6.25$ . NDF was determined according to the methods of Van Soest et al. (1991) and ADF and ADL were detected according to AOAC Official Method 973.18 (AOAC, 2005) using an ANKOM 220 Fibre Analyzer (ANKOM Technology Corporation, NY, USA). Fresh silage samples were analyzed for fermentation quality, i.e. pH, concentration of lactic, acetic and butyric acid (IONOSEP 3001 analyzer) according to Kvasnička (2000).

### *In sacco* analysis

Ruminal DM disappearances were estimated for all silage samples and also for grass forage by an

*in sacco* technique. Tested samples were incubated three times in the rumen of two Holstein steers fitted with rumen cannulas. Animals had *ad lib* access to meadow hay and were fed 1 kg of barley meal per day. Samples were weighed (1.5 g; 1 mm screen sieve) into nylon bags with pore size 42 µm (internal dimensions 50 × 120 mm) (Uhelon 130 T, Silk and Progress Moravská Chrastová). The bags with the samples were attached to a cylindrical carrier (Třináctý et al., 1996) and incubated in the rumen for 6, 12, 24, 48, 72 and 96 hours. Upon removal, bags were hand washed in cold water for 30 min. Zero time disappearances were obtained by washing unincubated bags. After that all nylon bags were dried in a forced-air oven at 50°C for 48 h.

Degradation of DM and effective degradability of dry matter ( $ED_{DM}$ ) were calculated using the equations of Ørskov and McDonald (1979):

$$\text{Deg}_{(t)} = a + b \times (1 - \exp^{-ct})$$

$$ED_{DM} = a + b \times (c/(c + k))$$

where:

Deg = disappearance rate at time t

*a* = intercept representing the portion of DM solubilized at initiation of incubation (time 0)

*b* = fraction of DM potentially degradable in the rumen

*c* = rate constant of disappearance of fraction *b*

*t* = time of incubation

*k* = outflow rate of the rumen

Table 1. Chemical composition and fermentation quality of tested samples

|                               | Mean   | Minimum | Maximum | SD     |
|-------------------------------|--------|---------|---------|--------|
| <b>Grass silages (n = 40)</b> |        |         |         |        |
| Ash (g/kg DM)                 | 84.46  | 64.62   | 119.40  | 13.450 |
| Fat (g/kg DM)                 | 33.68  | 19.96   | 51.70   | 8.029  |
| CP (g/kg DM)                  | 146.10 | 93.71   | 214.10  | 33.990 |
| CF (g/kg DM)                  | 308.20 | 210.70  | 431.40  | 58.100 |
| ADF (g/kg DM)                 | 339.10 | 252.80  | 421.90  | 44.100 |
| NDF (g/kg DM)                 | 547.60 | 396.60  | 676.70  | 69.600 |
| ADL (g/kg DM)                 | 26.58  | 10.34   | 45.85   | 8.548  |
| pH                            | 4.87   | 4.04    | 5.68    | 0.470  |
| Lactic acid (g/kg DM)         | 21.68  | 3.78    | 64.41   | 12.880 |
| Acetic acid (g/kg DM)         | 7.52   | 3.00    | 18.30   | 4.110  |
| Butyric acid (g/kg DM)        | 2.49   | 0.00    | 11.37   | 3.250  |
| Proteolysis (%)               | 7.69   | 3.26    | 13.87   | 2.780  |
| <b>Grass forages (n = 20)</b> |        |         |         |        |
| Ash (g/kg DM)                 | 76.83  | 54.35   | 105.30  | 13.880 |
| Fat (g/kg DM)                 | 23.87  | 13.73   | 36.08   | 6.201  |
| CP (g/kg DM)                  | 133.40 | 74.27   | 187.10  | 34.300 |
| CF (g/kg DM)                  | 277.40 | 194.00  | 327.40  | 36.770 |
| ADF (g/kg DM)                 | 299.00 | 214.70  | 365.00  | 42.270 |
| NDF (g/kg DM)                 | 539.90 | 417.30  | 610.10  | 58.600 |
| ADL (g/kg DM)                 | 22.22  | 10.93   | 41.04   | 8.130  |

SD = standard deviation; CP = crude protein; CF = crude fibre; NDF = neutral detergent fibre; ADF = acid detergent fibre; ADL = acid detergent lignin

$ED_{DM}$  was estimated for each ingredient assuming the rumen solid outflow rates of 0.02 ( $ED_{DM2}$ ), 0.05 ( $ED_{DM5}$ ) and 0.08 ( $ED_{DM8}$ )  $h^{-1}$ , which are representative of low, medium and high feeding amounts (Petit and Tremblay, 1992).

### Statistical analysis

Data for  $a$ ,  $b$  and  $c$  values and for  $ED_{DM}$  were evaluated by the general linear models procedure (SAS, 2002–2003) as a completely randomized design with steer as the replicate. Treatment sums of squares were partitioned to provide contrasts and compare grasses with each other. Prediction equations for  $ED_{DM}$  based on chemical composition were calculated using simple linear and multiple regressions (SAS, 2002–2003). The influence of ensiling on chemical composition and parameters of DM degradability was evaluated by one-way ANOVA.

## RESULTS AND DISCUSSION

The chemical composition and fermentation quality of tested grass silages and grass forages are

described in Table 1. Presented values of chemical composition are comparable with results of other authors (Huhtanen et al., 2002; Koukolová et al., 2004; Nousiainen et al., 2004). For example Blümmel et al. (1999) reported ADL contents ranging from 13 to 38 g/kg DM in silages made from *Lolium perenne*. Table 2 shows the values of parameters describing dry matter rumen degradability ( $a$ ,  $b$ ,  $c$ ) and  $ED_{DM}$  calculated for various rumen solid outflow rates (0.02, 0.05 and 0.08  $h^{-1}$ ). The degradability parameters of grass silages tested by Petit and Tremblay (1992) varied from 180 to 530 g/kg DM ( $a$ ), 350 to 670 g/kg DM ( $b$ ), 0.022 to 0.056  $h^{-1}$  ( $c$ ), 580 to 710 g/kg DM ( $ED_{DM2}$ ), 450 to 630 g/kg DM ( $ED_{DM5}$ ) and 400 to 600 g/kg DM ( $ED_{DM8}$ ). Coblenz et al. (1998) found similar ranges of degradability parameters, which ranged from 180 to 260, 460 to 540 g/kg DM and 0.031 to 0.056  $h^{-1}$  for parameters  $a$ ,  $b$  and  $c$ , respectively. Tables 1 and 2 show the high variability of chemical composition and degradability parameters of the observed grass silages. Elizalde et al. (1999) and Rymer and Givens (2002) reported the mean values of grass  $ED_{DM}$  ( $k = 0.026$  and  $0.06$   $h^{-1}$ ) 470 and 560 g/kg DM, respectively. Averages of  $a$  (250 g/kg DM),  $b$  (550 g/kg DM) and  $c$  (0.053  $h^{-1}$ ) were published by Gosselink et al. (2004).

Table 2. Dry matter degradability of tested samples

|  | Mean  | Minimum | Maximum | SD    |
|--|-------|---------|---------|-------|
| <b>Grass silages (<math>n = 40</math>)</b> |       |         |         |       |
| $a$ (g/kg DM)                              | 320.5 | 197.4   | 490.0   | 70.30 |
| $b$ (g/kg DM)                              | 574.9 | 455.0   | 684.7   | 61.28 |
| $c$ ( $h^{-1}$ )                           | 0.040 | 0.030   | 0.056   | 0.008 |
| $ED_{DM2}$ (g/kg DM)                       | 699.3 | 588.1   | 801.5   | 58.21 |
| $ED_{DM5}$ (g/kg DM)                       | 572.3 | 463.4   | 693.1   | 64.76 |
| $ED_{DM8}$ (g/kg DM)                       | 509.3 | 393.5   | 642.5   | 66.26 |
| <b>Grass forages (<math>n = 20</math>)</b> |       |         |         |       |
| $a$ (g/kg DM)                              | 299.2 | 241.0   | 416.3   | 56.42 |
| $b$ (g/kg DM)                              | 569.6 | 486.2   | 666.6   | 51.02 |
| $c$ ( $h^{-1}$ )                           | 0.037 | 0.027   | 0.056   | 0.009 |
| $ED_{DM2}$ (g/kg DM)                       | 665.4 | 583.3   | 810.6   | 72.51 |
| $ED_{DM5}$ (g/kg DM)                       | 539.2 | 459.9   | 698.4   | 76.58 |
| $ED_{DM8}$ (g/kg DM)                       | 478.1 | 406.0   | 636.0   | 74.89 |

SD = standard deviation;  $a$  = portion of DM solubilized at initiation of incubation (time 0);  $b$  = fraction of DM potentially degradable in the rumen;  $c$  = rate constant of disappearance of fraction  $b$ ;  $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$  = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08  $h^{-1}$

Table 3. Comparison of species according to the parameters of rumen dry matter (DM) degradability of grass silages

| Grass species              | $a^1$               | $b^1$                | $c^2$                | $ED_{DM2}^1$        | $ED_{DM5}^1$         | $ED_{DM8}^1$        |
|----------------------------|---------------------|----------------------|----------------------|---------------------|----------------------|---------------------|
| <i>Dactylis glomerata</i>  | 316.2 <sup>ab</sup> | 553.6 <sup>a</sup>   | 0.0416 <sup>a</sup>  | 687.4 <sup>a</sup>  | 565.8 <sup>ab</sup>  | 504.4 <sup>ab</sup> |
| <i>Phleum pratense</i>     | 245.9 <sup>ac</sup> | 652.4 <sup>abc</sup> | 0.0375 <sup>b</sup>  | 669.0 <sup>b</sup>  | 523.9 <sup>ac</sup>  | 453.1 <sup>ac</sup> |
| <i>Lolium perenne</i>      | 365.4 <sup>ad</sup> | 561.5 <sup>b</sup>   | 0.0451 <sup>bc</sup> | 753.2 <sup>ab</sup> | 631.1 <sup>acd</sup> | 567.7 <sup>ad</sup> |
| <i>Festuca arundinacea</i> | 369.3 <sup>bc</sup> | 524.7 <sup>c</sup>   | 0.0390 <sup>c</sup>  | 711.9 <sup>bc</sup> | 596.0 <sup>cd</sup>  | 538.9 <sup>bc</sup> |
| Felina hybrid              | 290.0 <sup>cd</sup> | 579.5 <sup>c</sup>   | 0.0344 <sup>ac</sup> | 655.3 <sup>ac</sup> | 525.5 <sup>bd</sup>  | 463.9 <sup>bd</sup> |

<sup>1</sup>g/kg DM; <sup>2</sup>h<sup>-1</sup>a,b,c,d within a column means with the same superscript letters are different ( $P < 0.05$ )

$a$  = portion of DM solubilized at initiation of incubation (time 0);  $b$  = fraction of DM potentially degradable in the rumen;  $c$  = rate constant of disappearance of fraction  $b$ ;  $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$  = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08 h<sup>-1</sup>

Averages of dry matter degradability parameters of grass silages determined for each grass species are presented in Table 3. The highest value of parameter  $a$  was determined for *Festuca arundinacea* and the lowest for *Phleum pratense*, parameter  $b$  was in opposite trend. Adding up the parameters  $a$  and  $b$ , *Lolium perenne* was the best (926.9 g/kg DM), followed by *Phleum pratense* (898.3 g/kg DM), *Festuca arundinacea* (894 g/kg DM), *Dactylis glomerata* (869.8 g/kg DM) and Felina hybrid (869.5 g/kg DM). The rate of degradation (parameter  $c$ ) was the highest for *Lolium perenne* and the lowest for

Felina hybrid. Values of effective degradabilities were the highest for *Lolium perenne* and the lowest for hybrid Felina and *Phleum pratense*. These DM degradability results indicate *Lolium perenne* as the best grass species. Higher digestibility of *Lolium perenne* in comparison with *Festuca arundinacea* was detected also by Wilman and Ahmad (1999). Pozdíšek et al. (2003) reported higher digestibility for *Festuca arundinacea* in comparison with hybrid Hykor. Hoffman et al. (1993) compared  $ED_{DM}$  of different grass species, the highest values were found for *Lolium perenne*, lower for *Dactylis glom-*

Table 4. Prediction of effective dry matter degradability ( $ED_{DM}$ ; g/kg DM) using multiple regression ( $n = 40$ )

|   | RMSE  | $R^2$ | $P$      |
|---|-------|-------|----------|
| <b>Equation <math>ED_{DM2}</math></b>               |       |       |          |
| $y = 1083 + 0.464 \text{ CF} - 0.962 \text{ NDF}$   | 19.66 | 0.892 | < 0.0001 |
| $y = 1073 - 1.861 \text{ ADL} - 0.593 \text{ NDF}$  | 26.34 | 0.806 | < 0.0001 |
| <b>Equation <math>ED_{DM5}</math></b>               |       |       |          |
| $y = 1035 + 0.337 \text{ CF} - 1.035 \text{ NDF}$   | 18.75 | 0.920 | < 0.0001 |
| $y = 1028 - 1.329 \text{ ADL} - 0.768 \text{ NDF}$  | 22.74 | 0.883 | < 0.0001 |
| <b>Equation <math>ED_{DM8}</math></b>               |       |       |          |
| $y = 998.3 + 0.220 \text{ CF} - 1.017 \text{ NDF}$  | 18.13 | 0.929 | 0.0012   |
| $y = 992.0 - 0.832 \text{ NDF} - 1.012 \text{ ADL}$ | 19.64 | 0.917 | < 0.0001 |

RMSE = root mean square error;  $R^2$  = determination coefficient;  $P$  = probability;  $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$  = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08 h<sup>-1</sup>; CF = crude fibre; NDF = neutral detergent fibre; ADL = acid detergent lignin

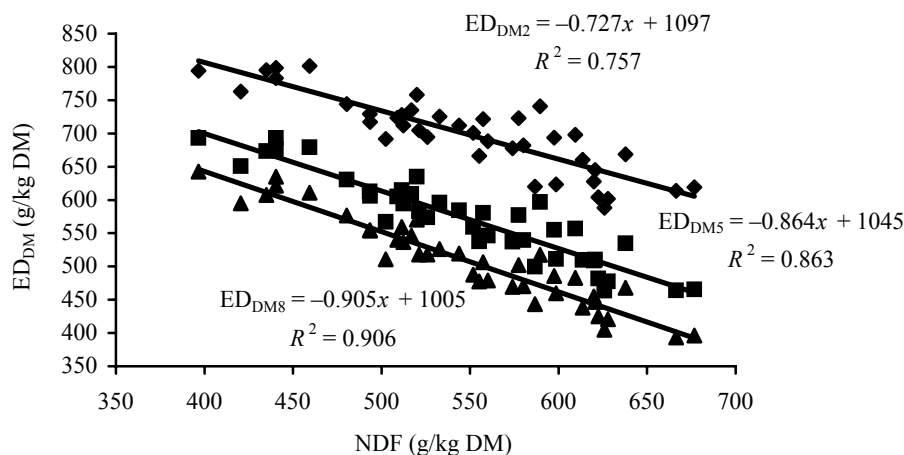


Figure 1. Prediction of DM effective degradabilities by NDF ( $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$  = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08  $h^{-1}$ )

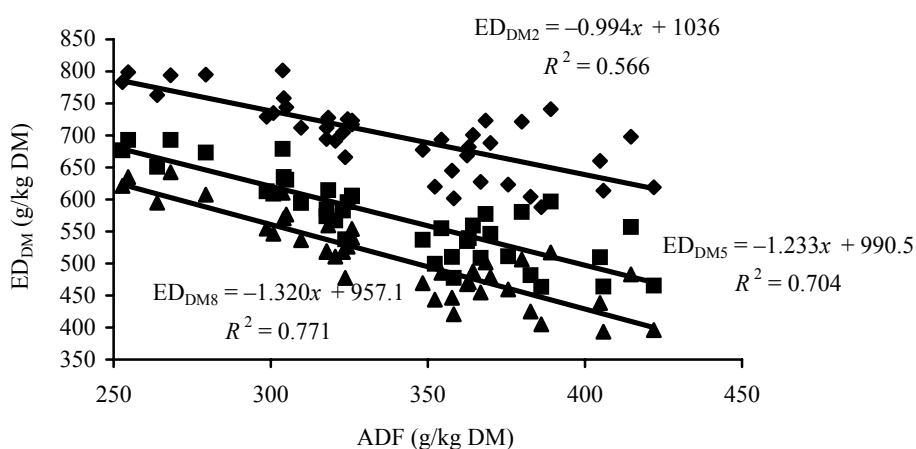


Figure 2. Prediction of DM effective degradabilities by ADF ( $ED_{DM2}$ ,  $ED_{DM5}$  and  $ED_{DM8}$  = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08  $h^{-1}$ )

*erata* and the lowest for *Phleum pratense*. Gosseling et al. (2004) found out a faster degradation rate for *Lolium perenne* compared to *Dactylis glomerata*.

In the present study simple linear (Figures 1 and 2) and multiple regressions (Table 4) were used for prediction of effective degradabilities of dry matter ( $ED_{DM2}$ ,  $ED_{DM5}$ ,  $ED_{DM8}$ ). NDF was found to be the best single predictor of  $ED_{DM}$  (Figure 1), where  $R^2$  (determination coefficient) was 0.757 for  $ED_{DM2}$ , 0.863 for  $ED_{DM5}$  and 0.906 for  $ED_{DM8}$ . Contrary to these findings, it was the worst predictor of CF content;  $R^2$  was 0.06 for  $ED_{DM2}$ , 0.14 for  $ED_{DM5}$  and 0.21 for  $ED_{DM8}$ . Similar results were reported by Fonseca et al. (1998). Yan and Agnew (2004) predicted  $ED_{DM5}$  by NDF and ADF with 0.66 and 0.43 ( $R^2$ ), respectively. Satisfactory regression equations based on ADF content only are in Figure 2. The ability to predict the equations ( $R^2$ ) was higher for results of multiple regressions (Table 4) than for simple linear regressions (Figures 1 and 2), which is in agreement with Nousiainen et al. (2003). The multiple regression using two predictors showed

the best  $ED_{DM}$  equation determination by the combination of CF and NDF. High determination of  $ED_{DM}$  equations was also found for NDF and ADL predictors.

There was not any difference ( $P < 0.05$ ) between the ensiling process versus chemical composition and dry matter degradability parameters ( $a$ ,  $b$ ,  $ED_{DM2}$ ,  $ED_{DM5}$ ,  $ED_{DM8}$ ). In general, higher values of CP and NDF values were found for ensiled samples compared to grass forage (Table 1). Figure 3 illustrates the relationship between the ensiling process and degradability parameters ( $a$ ,  $b$ ,  $ED_{DM2}$ ,  $ED_{DM5}$ ,  $ED_{DM8}$ ).  $ED_{DM}$  was the highest for silages stored for 20 weeks, then for silages stored for 10 weeks and the lowest for grass forage. A similar trend was also detected for parameter  $a$ ; parameters  $b$  and  $c$  showed just an opposite tendency. The values of parameter  $c$  were 0.037, 0.035 and 0.033  $h^{-1}$  for grass forage, silages stored for 10 weeks and silages stored for 20 weeks, respectively (not tabulated values). The lower degradation rate of DM measured for ensiled grasses compared to grass forage is in

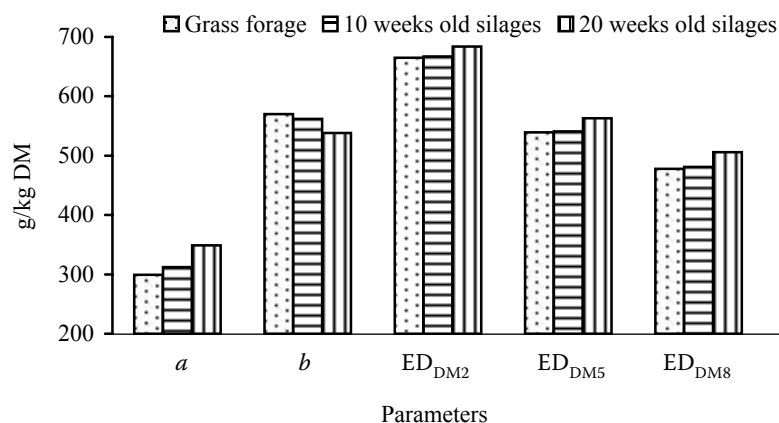


Figure 3. The influence of ensiling on degradability parameters (*a* = portion of DM solubilized at initiation of incubation (time 0); *b* = fraction of DM potentially degradable in the rumen; ED<sub>DM2</sub>, ED<sub>DM5</sub> and ED<sub>DM8</sub> = effective degradability of DM calculated for each ingredient assuming the rumen solid outflow rates of 0.02, 0.05 and 0.08 h<sup>-1</sup>)

agreement with Gosseling et al. (2004). Yahaya et al. (2001) determined, also without statistical significance, higher digestibility of DM for ensilaged grass than for grass forage.

## CONCLUSION

The best values of dry matter effective degradability (ED<sub>DM</sub>) were determined for *Lolium perenne*. The prediction equations of ED<sub>DM</sub> calculated on the basis of the chemical composition of grass silages suggested NDF as the best predictor. Using two predictors the accuracy level (*R*<sup>2</sup>) of prediction increased. Regression equations based on the most important grass species harvested in different vegetation periods seem to be a useful tool for practical use. The ensiling process did not have a statistically significant influence on the values of dry matter rumen degradability parameters.

## REFERENCES

- AOAC (2005): Official Methods of Analysis, AOAC International. 18<sup>th</sup> ed. Gaithersburg, USA.
- Blümmel M., Schroder A., Südekum K.-H., Becker K. (1999): Estimation ruminal microbial efficiencies in silage-fed cattle: comparison of an *in vitro* method with a combination of *in situ* and *in vivo* measurements. *Journal of Animal Physiology and Animal Nutrition*, 81, 57–67.
- Čerešňáková Z., Žitňan R., Sommer A., Kokardová M., Szakács M., Ševčík A., Chrenková M. (2000): Parameters of degradability of pasture herbage cell walls and organic matter. *Czech Journal of Animal Science*, 45, 139–144.
- Čerešňáková Z., Flak P., Poláčiková M., Chrenková M. (2007): *In sacco* macromineral release from selected forages. *Czech Journal of Animal Science*, 52, 175–182.
- Coblentz W.K., Fritz J.O., Fick W.H., Cochran R.C., Shirley J.E. (1998): *In situ* dry matter, nitrogen, and fiber degradation of alfalfa, red clover, and eastern gamagrass at four maturities. *Journal of Dairy Science*, 81, 150–161.
- Dawson L.E.R., Kirkland R.M., Ferris C.P., Steen R.W.J., Kilpatrick D.J., Gordon F.J. (2002): The effect of stage of perennial ryegrass maturity at harvesting, fermentation characteristics and concentrate supplementation, on the quality and intake of grass silage by beef cattle. *Grass and Forage Science*, 57, 255–267.
- Elizalde J.C., Merchen N.R., Faulkner D.B. (1999): *In situ* dry matter and crude protein degradation of fresh forages during the spring growth. *Journal of Dairy Science*, 82, 1978–1990.
- Fonseca A.J.M., Dias-da-Silva A.A., Ørskov E.R. (1998): *In sacco* degradation characteristics as predictors of digestibility and voluntary intake of roughages by mature ewes. *Animal Feed Science and Technology*, 72, 205–219.
- Gosselink J.M.J., Dulphy J.P., Tamminga S., Cone J.W. (2004): Comparison of the *in situ* technique and the gas production technique in mimicking rumen dry matter degradation. *Journal of Animal and Feed Sciences*, 13, 79–82.
- Harazim J., Třináctý J., Homolka P. (2002): Degradability and intestinal digestibility of crude protein and amino acids of extracted rapeseed meal. *Czech Journal of Animal Science*, 47, 50–56.
- Hetta M., Gustavsson A.-M., Cone J.W., Martinsson K. (2004): *In vitro* degradation characteristics of timothy and red clover at different harvest times. *Acta Agriculturae Scandinavica*, 54, 20–29.

- Hoffman P.C., Sievert S.J., Shaver R.D., Welch D.A., Combs D.K. (1993): *In situ* dry matter, protein, and fiber degradation of perennial forage. *Journal of Dairy Science*, 76, 2632–2643.
- Homolka P. (2000): Digestibility of nutrients, nitrogen degradability and intestinal digestibility of rumen undegraded protein of alkali-treated barley. *Czech Journal of Animal Science*, 45, 447–450.
- Homolka P., Tománková O., Břenek T. (2002): Prediction of crude protein degradability and intestinal digestibility of rumen undegraded protein of protein supplements in cattle. *Czech Journal of Animal Science*, 47, 119–123.
- Homolka P., Harazim J., Třináctý J. (2007): Nitrogen degradability and intestinal digestibility of rumen undegraded protein in rapeseed, rapeseed meal and extracted rapeseed meal. *Czech Journal of Animal Science*, 52, 378–386.
- Homolka P., Koukolová V., Němec Z., Mudřík Z., Hučko B., Sales J. (2008): Amino acid contents and intestinal digestibility of lucerne in ruminants as influenced by growth stage. *Czech Journal of Animal Science*, 53, 499–505.
- Huhtanen P., Khalili H., Nousiainen J.I., Rinne M., Jaakkola S., Heikkilä T., Nousiainen J. (2002): Prediction of the relative intake potential of grass silage by dairy cows. *Livestock Production Science*, 73, 111–130.
- Huhtanen P., Nousiainen J., Rinne M. (2006): Recent developments in forage evaluation with special reference to practical applications. *Agricultural and Food Science*, 15, 293–323.
- Jančík F., Homolka P., Čermák B., Lád F. (2008): Determination of indigestible neutral detergent fibre contents of grasses and its prediction from chemical composition. *Czech Journal of Animal Science*, 53, 128–135.
- Kamalak A., Canbolat O., Gurbuz Y., Ozay O. (2005): Comparison of *in vitro* gas production technique with *in situ* nylon bag technique to estimate dry matter degradation. *Czech Journal of Animal Science*, 50, 60–67.
- Komprda T., Homolka P., Harazim J. (1996): Influence of chemical, enzymatic and phytogenic ensiling preparations on digestibility, degradability and PDI and NEL content of lucerne and red clover. *Animal Feed Science and Technology*, 61, 325–334.
- Koukolová V., Weisbjerg M.R., Hvelplund T., Lund P., Čermák B. (2004): Prediction of NDF degradation characteristics of grass and grass/clover forages based on laboratory methods. *Journal of Animal and Feed Sciences*, 13, 691–708.
- Kvasnička F. (2000): Application of isotachopheresis in food analysis. *Electrophoresis*, 21, 2780–2787.
- Machačová E., Loučka R., Žalmanová V., Homolka P. (1998): Effect of probiotic enzymatic additive with glucose oxidase on palatability and digestibility of silages with low content of dry matter. *Czech Journal of Animal Science*, 43, 355–359.
- Nousiainen J., Rinne M., Hellämäki M., Huhtanen P. (2003): Prediction of the digestibility of the primary growth and regrowth grass silages from chemical composition, pepsin-cellulase solubility and indigestible cell wall content. *Animal Feed Science and Technology*, 110, 61–74.
- Nousiainen J., Ahvenjärvi S., Rinne M., Hellämäki M., Huhtanen P. (2004): Prediction of indigestible cell wall fraction of grass silage by near infrared reflectance spectroscopy. *Animal Feed Science and Technology*, 115, 295–311.
- Ørskov E.R., McDonald I. (1979): The estimation of protein degradability in the rumen from incubation measurements weighed according to rate of passage. *Journal of Agricultural Science*, 92, 499–503.
- Petit H.V., Tremblay G.F. (1992): *In situ* degradability of fresh grass and grass conserved under different harvesting methods. *Journal of Dairy Science*, 75, 774–781.
- Pozdíšek J., Loučka R., Macháčová E. (2003): Digestibility and nutrition value of grass silages. *Czech Journal of Animal Science*, 48, 359–364.
- Regulation No. 497/2004 (2004): Requirements of samples taking, methods for estimation of the feeds, supplements and premixes and way of samples storage. Collection of Law 2004. Czech Republic, part 172. (in Czech)
- Rymer C., Givens D.I. (2002): Relationships between patterns of rumen fermentation measured in sheep and *in situ* degradability and the *in vitro* gas production profile of the diet. *Animal Feed Science and Technology*, 101, 31–44.
- SAS (2002–2003): SAS System for Windows, Release 9.1 (TS1M3), SAS Inst., Inc., Cary, NC, USA.
- Tamminga S., Ketelaar R., van Vuuren A.M. (1991): Degradation of nitrogenous compounds in conserved forages in the rumen of dairy cows. *Grass and Forage Science*, 46, 427–435.
- Tománková O., Kopečný J. (1995): Prediction of feed protein degradation in the rumen with bromelain. *Animal Feed Science and Technology*, 53, 71–80.
- Třináctý J., Šimek M., Komprda T. (1996): The influence of a nylon bag carrier on alfalfa crude protein degradability. *Animal Feed Science and Technology*, 57, 129–137.
- Třináctý J., Homolka P., Zeman L., Richter M. (2003): Whole tract and post ruminal digestibility determined by *in situ* ruminal, intestinal mobile nylon bag and



- whole tract nylon capsule methods. *Animal Feed Science and Technology*, 106, 59–67.
- Van Soest P.J., Robertson J.B., Lewis B.A. (1991): Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74, 3583–3597.
- Van Vuuren A.M., Tamminga S., Ketelaar R.S. (1991): *In sacco* degradation of organic matter and crude protein of fresh grass (*Lolium perenne*) in the rumen of grazing dairy cows. *Journal of Agricultural Science*, 116, 429–436.
- Von Keyserlingk M.A.G., Swift M.L., Puchala R., Shelford J.A. (1996): Degradability characteristics of dry matter and crude protein of forages in ruminants. *Animal Feed Science and Technology*, 57, 291–311.
- Waters C.J., Givens D.I. (1992): Nitrogen degradability of fresh herbage: Effect of maturity and growth type, and prediction from chemical composition and by near infrared reflectance spectroscopy. *Animal Feed Science and Technology*, 38, 335–349.
- Wilman D., Ahmad N. (1999): *In vitro* digestibility, neutral detergent fibre, lignin and cell wall thickness in plants of three forage species. *Journal of Agricultural Science*, 133, 103–108.
- Yahaya M.S., Kimura A., Harai J., Nguyen H.V., Kawai M., Takahashi J., Matsuoka S. (2001): Effect of length of ensiling on silo degradation and digestibility of structural carbohydrates of lucerne and orchardgrass. *Animal Feed Science and Technology*, 92, 141–148.
- Yan T., Agnew R.E. (2004): Prediction of nutritive values in grass silages: II. Degradability of nitrogen and dry matter using digestibility, chemical composition, and fermentation data. *Journal of Animal Science*, 82, 1380–1391.

Received: 2008–08–29

Accepted after corrections: 2009–02–11

---

*Corresponding Author*

Ing. Filip Jančík, Ph.D., Institute of Animal Science, Přátelství 815, Prague-Uhřetěves, Czech Republic  
Tel. +420 267 009 620, e-mail: jancik.filip@vuzv.cz

---