Session: 29 – "Ruminant nutrition. Free communications"
Abstract number: 2579
E-mail address: jancik.filip@vuzv.cz

Prediction of indigestible neutral detergent fiber of grasses

F. Jančík[1,2], P. Homolka[1], B. Čermák[2]

[1]Institute of Animal Science, Prague – Uhříněves, Czech Republic
[2]Faculty of agriculture, University of South Bohemia in České Budějovice, Czech Republic

Abstract:
In this study, four grass species (*Dactylis glomerata* L., *Phleum pratense* L., *Lolium perenne* L., *Festuca arundinacea* L. and Hybrid Felina (*Lolium multiflorum* L. *x Festuca arundinacea* L.)), commonly used in roughages for ruminants, were harvested at different maturities of primary growth (n = 60), and evaluated for dry matter (DM), crude protein (CP), ash, crude fat, neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and indigestible neutral detergent fibre (INDF) contents. INDF content was determined by *in sacco* rumen degradation of grasses for 12 days in non-lactating cows. ADL content presented a reliable ($R^2 = 0.78$; residual mean square error of 17.65 g/kg DM; $P < 0.0001$) parameter to predict INDF contents. Over a six week period maturing increased ($P < 0.0001$) INDF contents in all observed grasses. It was confirmed by this study that the INDF contents of grasses, which markedly increased during maturing, could effectively be predicted from ADL contents. This research was supported by the Ministry of Agriculture (grant MZE 0002701403) and the Ministry of Education of Czech Republic (grant MSM 6007665806).

Key words: grass; indigestible neutral detergent fibre; *in sacco* method

INTRODUCTION

Due to variability of NDF to rumen degradation and the influence thereof on animal performance, knowledge about digestibility of NDF in forage is critical for effective ruminant feeding (Oba and Allen, 1999).

Indigestible NDF (INDF) contents, that needs long *in sacco* incubation periods (Fonseca et al., 1998), presents an important indicator of quality of grass cell wall carbohydrates, and can be a good predictor of *in vivo* digestibility of roughages (Nousiainen et al., 2003). Forage digestibility in ruminants is constrained by the extent of cell wall (NDF) digestion (Van Soest, 1994). INDF is the most important factor affecting total diet organic matter digestibility (Nousiainen et al., 2004). A part of the forage cell wall, i.e. INDF, is unavailable to microbial digestion in ruminants, even if total tract residence time of fibre could be extended to infinite time (Huhtanen et al., 2006). INDF represents actually nondigestible part of NDF.

Methods for determination of INDF are time consuming and expensive. Prediction equations, based on basic parameters of chemical analysis, are cheaper and faster for institutions without availability of experimental animals.

Incomplete degradation of cell walls is a major factor limiting the value of forages and straws to animals (Ahmad and Wilman, 2001). Grenet and Besle (1991) and Nagadi et al. (2000) postulated that the cell wall carbohydrates that are little degraded in the rumen for high extent of lignification. Lignin is generally accepted as the primary component responsible for limiting the digestion of forages (Traxler et al., 1998).

OBJECTIVES

The aim of the present study was to determine indigestible neutral detergent fibre (INDF) contents of grasses by the *in sacco* nylon bag technique and prediction of INDF contents from chemical composition.

MATERIAL AND METHODS

Four of the most widely used grass species in ruminant nutrition, *Dactylis glomerata* L. – variety Dana, *Phleum pratense* L. – variety Sobol, *Lolium perenne* L. – variety Jaspis, *Festuca arundinacea* L. – variety Prolate and hybrid Felina (hybridization of *Lolium multiflorum* L. *and Festuca arundinacea* L.) were grown as a monoculture at the Breeding station Větrov, Tábor region, Czech Republic (49° 31' 2.04" N lat, 14° 28' 4.9" E long; 620 m altitude). Grasses were harvested from primary growth at six dates (May13th until Jun 17th) in 2004 and 2005. Maturity stages were from stem elongation to anthesis. After drying (at 50 °C for 48 h), grass samples were milled through a 1 mm sieve for chemical analysis and in sacco incubation.

Samples were analyzed for DM, crude protein (CP), ash, crude fat, NDF, acid detergent fibre (ADF) and acid detergent lignin (ADL).

INDF content was determined after a 288 h rumen incubation period (Rinne et al., 1997) of grass samples in nylon bags with two non-lactating cows fitted with rumen cannulas. Animals had *ad lib* access to meadow hay and were fed 1 kg of barley meal per day. A small pore size of 17 µm was used for nylon bags to minimize particle inflow and outflow, but still ensuring sufficient microbial activities inside the bags (Huhtanen et al., 1998). Each sample was weighed in amount of 3 g into nylon bags and incubated in 3 repetitions in each cow. After incubation bags were rinsed by hand with cold water for 30 min and dried at 50 °C for 48 h.

Linear, multiple, and stepwise multiple regression analysis were used to develop prediction equations for INDF content using nutrient concentrations in grasses (Statistica 6, 2001). The MIXED procedure of SAS (SAS, 2002-2003) was used for comparison of differences among INDF contents as influenced by harvest dates and grasses.

RESULTS AND DISCUSSION

The chemical composition and INDF content of observed grasses are presented in Table 1.

Table 2 shows the regression equations describing the relationships between INDF and the chemical composition of grasses. According to R^2-values and the residual mean square errors ADL presented the best single predictor of INDF content, and CF the worst. Traxler et al. (1998) predicted INDF from ADL contents with R^2-values of 0.63, 0.69, 0.66 and 0.79 for C_3 grasses, C_4 grasses, legumes, and combined forages, respectively. According to a multiple regression including ADL and CP contents INDF could be predicted with a R^2-value of almost 0.85, whereas stepwise multiple regression included NDF contents in the above equation to increase the R^2-value to 0.87. In accordance to the present study Nousiainen et al. (2003) and Huhtanen et al. (2006) found ADL as the best single predictor of *in vivo* organic matter digestibility for grass silages (R^2 = 0.62), and for a set of forage samples (grasses, legumes and whole crops) (R^2 = 0,43), respectively.

Increasing INDF contents as harvest time progressed was observed in all grass species. This indicates an increase in cell wall fractions with harvest dates, as was also found by Cone et al. (1999). The highest accumulation of INDF was detected for *Dactylis glomerata* and lowest for *Lolium perenne*, however it was statistically significant ($P < 0.0001$) in all grasses (Table 3). Pozdíšek et al. (2003) described higher digestibility of NDF for *Festuca arundinacea* compared to hybrid Hykor. In the present study ADL increased from 15 to 38, 16 to 32, 14 to 26, 19 to 29 and 10 to 31 g/kg DM with harvest dates for *Dactylis glomerata*, *Phleum pratense*, *Lolium perenne*, *Festuca arundinacea* and hybrid Felina, respectively.

According to Beck et al. (2007) NDF contents of grasses increased from 587 to 722 g/kg DM, ADF contents from 334 to 433 g/kg DM in one month. Maturity of grass caused a decreased degradability and digestibility, both in magnitude and rate (Dawson et al., 2002). For example Rinne et al. (2002) described that INDF content of grass silage made from grasses harvested from June 13 to July 4 increased from 48 to 124 g/kg DM. Harrison et al. (2003) presented evidence that harvesting of grass and maize at younger stages improved NDF digestibility. In contrast, in the present study the contents of CP decreased from 188 to 98, 176 to 83, 182 to 100, 201 to 95 and 154 to 68 g/kg DM with harvest dates for *Dactylis glomerata*, *Phleum pratense*, *Lolium perenne*, *Festuca arundinacea* and hybrid Felina, respectively. Hoffman et al. (1993) found a similar decrease in CP content during maturing of grasses. Differences among grass species in changes of INDF content during harvest dates are described in Table 3. There were no differences between *Phleum pratense* and *Festuca arundinacea* and between *Festuca arundinacea* and hybrid Felina. Other differences among grasses were statistically significant ($P < 0.05$). Also Harrison et al. (2003) described significant differences in NDF digestibility among perennial ryegrass cultivars.

Table 1. Chemical composition and INDF content of grasses (n = 60)

	Mean	S. D.	Minimum	Maximum
Dry matter (g/kg)	234.9	44.3	159.1	341.5
Chemical composition (g/kg DM)				
CP	130.3	37.9	64.5	211.3
Ash	76.6	14.5	49.0	105.3
Fat	23.5	8.0	5.4	42.6
CF	281.2	49.7	166.5	373.8
NDF	544.5	75.1	337.0	691.2
ADF	301.9	48.7	183.0	382.8
ADL	22.7	8.0	8.2	42.2
INDF (g/kg DM)	68.9	37.6	18.0	175.7

CP = crude protein; CF = crude fibre; NDF = neutral detergent fibre; ADF = acid detergent fibre; ADL = acid detrgent lignin; INDF = indigestible neutral detergent fibre; S.D. = standart deviation.

Table 2. Prediction of indigestible neutral detergent fibre (y) of grasses from chemical components

Equation	RMSE[1]	R^2	Probability
Simple linear regression			
y = 164.2 - 7.308 CP	25.60	0.544	<0.0001
y = - 83.16 + 5.408 CF	26.48	0.512	<0.0001
y = - 139.8 + 3.834 NDF	24.39	0.586	<0.0001
y = - 124.3 + 6.399 ADF	21.20	0.687	<0.0001
y = - 25.17 + 41.36 ADL	17.65	0.783	<0.0001
Multiple regression			
y = - 86.98 + 1.542 NDF + 31.63 ADL	15.55	0.835	<0.0001
y = - 77.30 + 2.692 ADF + 28.55 ADL	15.78	0.830	<0.0001
y = - 65.84 + 2.088 CF + 33.43 ADL	15.73	0.831	<0.0001
y = 36.28 + 32.36 ADL - 3.144 CP	14.97	0.847	<0.0001
Stepwise multiple regression			
y = - 21.15 + 27 ADL - 2.524 CP + 1.13 NDF	13.80	0.872	<0.0001

[1] residual mean square error

Table 3. Evaluation of INDF contents of grasses depending on harvest date

Grass	Estimate[1]	S.E.	Probability
Dactylis glomerata	23.61[ab]	0.999	<0.0001
Phleum pratense	15.26[a]	0.427	<0.0001
Lolium perenne	11.46[ac]	0.466	<0.0001
Festuca arundinacea	16.34[bc]	1.200	<0.0001
Hybrid Felina	19.74[a]	0.624	<0.0001

[1] estimate values describe the increase of INDF content (g/kg DM) with increasing order of harvesting

[a,b,c]Within a column, means with same superscript letters differ ($P < 0.05$).

CONCLUSION

It was confirmed by this study that the INDF contents of grasses could effectively be predicted from ADL contents. INDF contents were markedly increased during maturing of grasses, which have practical implications for the time of harvesting.

ACKNOWLEDGEMENTS

This research was supported by the Ministry of Agriculture (grant MZE 0002701403) and the Ministry of Education of Czech Republic (grant MSM 6007665806).

REFERENCES

Ahmad N., Wilman D. (2001): The degradation of the cell walls of lucerne, Italian ryegrass and wheat straw when fed to cattle, sheep and rabbits. J. Agri. Sci., 137, 337-349.

Beck, P. A., Hutchison, S., Gunter, S. A., Losi, T. C., Stewart, C. B., Capps, P. K., Phillips, J. M. (2007): Chemical composition and in situ dry matter and fiber disappearance of sorghum x Sudangrass hybrids. J. Anim. Sci. 85, 545-555.

Cone J. W., Van Gelder A. H., Soliman I. A., De Visser H., Van Vuuren A. M. (1999): Different techniques to study rumen fermentation characteristics of maturing grass and grass silage. J. Dairy Sci., 82, 957-966.

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 Forage Sci. 57, 255-267.

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. Anim. Feed Sci. Tech. ,72, 205-219.

Grenet E., Besle J. M. (1991): Microbes and fibre degradation. In: Jouany J. P., Rumen microbial metabolism and ruminant digestion, Institut national de la recherche agronomique, Paris, pp. 107-129.

Harrison J., Huhtanen P., Collins M. (2003): Perennial Grasses. In: Silage science and technology. Agron. Monogr., 42, 665-747.

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 forages. J. Dairy Sci., 76, 2632-2643.

Huhtanen P., Vanhatalo A. and Varvikko T. (1998): Enzyme activities of rumen particles and feed samples incubated *in situ* with differing types of cloth. Br. J. Nutr., 79, 161-168.

Huhtanen, P., Nousiainen, J., Rinne, M. (2006): Recent developments in forage evaluation with special reference to practical applications. Agric. Food Sci., 15, 293-323.

Nagadi S., Herrero M., Jessop N. S. (2000): The effect of fermentable nitrogen availability on *in vitro* gas production and degradability of NDF. Anim. Feed Sci. Tech., 87, 241-251.

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. Anim. Feed Sci. Tech., 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. Anim. Feed Sci. Tech., 115, 295-311.

Oba M., Allen M. S. (1999): Evaluation of the importance of the digestibility of neutral detergent fiber from forage: effects on dry matter intake and milk yield of dairy cows. J. Dairy Sci., 82, 589-596.

Pozdíšek, J., Loučka, R., Machačová, E. (2003): Digestibility and nutrition value of grass silages. Czech J. Anim. Sci. 48, 359-364.

Rinne M., Huhtanen P., Jaakkola S. (1997): Grass maturity effects on cattle fed silage-based diets. 2. Cell wall digestibility, digestion and passage kinetics. Anim. Feed Sci. Tech., 67, 19-35.

Rinne M., Huhtanen P. and Jaakkola S. (2002): Digestive processes of dairy cows fed silages harvested at four stages of grass maturity. J. Anim. Sci., 80, 1986-1998.

SAS (2002-2003): SAS System for Windows, Release 9.1 (TS1M3), SAS Inst., Inc., Cary, NC, USA

Statistica (2001): Data analysis software system, version 6, StatSoft, Inc., OK.

Traxler M. J., Fox D. G., Van Soest P. J., Pell A. N., Lascano C. E., Lanna D. P. D., Moore J. E., Lana R. P., Vélez M., Flores A. (1998): Predicting forage indigestible NDF from lignin concentration. J. Anim. Sci., 76, 1469-1480.

Van Soest P. J. (1994): Nutritional Ecology of The Ruminant. Cornell University. ISBN 0-8014-2772-X, 476 p.