Original Paper

Calculating the meadow hay energy value based solely on the *NDF*

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In our study was compare the accuracy of prediction of the energy value NEL of meadow hay. Predictive equations calculated from the results of our monitoring is *NEL* = 12.9085 - 0.1276*x*, where *x* = the *NDF*. Values of prediction equation which we calculated is comparable with the values indicated by the other authors. The great advantage of our prediction equation is the unpretentiousness of its calculation. Own calculation of NEL requires more analytically determined values. The number of analysis needed to calculate predictive equations and the time needed for all analysis is in our determination in the prediction of *NEL*, big advantage. It is further enhanced by lower finance costs.

Keywords: meadow hay, prediction of the energy, *NEL*, *NDF*

1. Introduction

Cow is a ruminant. Therefore, it is important to know the physiology nutrition of ruminant, where the rumen microorganisms play the main role in the digestion and exploitation of nutrients. This microorganisms converting the nutrient of feeds into valuable nutrients – microbial protein and volatile fatty acids – the basic source of energy for ruminant. Resource for VFA are polysaccharides in feed ration and it is fiber.

Given the fact that fiber is very variable conglomerate of various digestible substances, with different energy potential, our work has been directed to confirm or refute the hypothesis of whether knowledge about individual fractions of fiber their digestibility in feed, will help to refine the prediction of the energy value ruminant and thus make more effective use of feed rations.

In order to achieve maximal production of the cows must receive a large amount of quality feed. High-quality ration is recognized by the fact that animals taste, is well digested and contains properly balanced all the necessary nutrients, especially protein and energy. Feeding quality forage reduces feed costs, which often represent 45–60% of the total cost of milk production (Ishler et al., 1996; Mudřík et al., 2006). Also supports high milk production, increases dry matter intake, contributes to better health, economy and longer the productive life of the cow.

Roughage in the dry state contain 50–80% carbohydrates (Weiss, 2010; Pond et al., 2005; Mika et al., 1997) and their representation in rations for dairy cows is around 60–80% (NRC, 2001; Harris, 1993; Ishler and Varga, 2007; Mudřík et al., 2006 Nocek and Russel, 1988). They are the main source of energy for the rumen microorganisms and affect the composition of the milk, as precursors for lactose, fat and protein in milk (Ishler and Varga, 2007).

Carbohydrates can be divided to structural and non-structural (NRC, 2001; Harris, 1993). Structural carbohydrates consist of elements that can be found in the cell wall (Ishler and Varga, 2007) and ensure the normal function of rumen, stimulate chewing, salivation, contribute to the buffering capacity of the rumen and are involved in regulating the intake of forage (Mika et al., 1997, Mudřík et al., 2006). Nonstructural carbohydrates are placed inside the plant cells and are generally more digestible than structural carbohydrates (Ishler and Varga, 2007). Nonstructural carbohydrates are fermentable rumen microorganisms (nearly 100%) and thei are substantial source of quick energy for ruminants. Structural carbohydrates being cellulose, hemicellulose, lignin, pectin and beta glucans. To nonstructural carbohydrates include also starches, sugars and fructans, in silage organic acids. Structural carbohydrates are generally referred to as fibre. The fiber determines as a whole, but are determined also the factions, namely, acid detergent fiber (*ADF*) and neutral detergent fiber (*NDF*) fiber (Mudřík et al., 2006, Ishler and Varga, 2007). *NDF* method is the best method of separating structural and nonstructural carbohydrates (NRC, 2001). Dietary fiber is not nutritionally, chemically

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or physically uniform material (Van Soest et al. 1991). Traditionally, this term means the complex nutrients in the feed is relatively resistant to digestion, which are slowly and only partially digestible for ruminants (Mudřík et al., 2006). It consists primarily of cellulose, hemicelluloses and lignin. When one realizes the function of fiber, or its individual components then we can come to the fact that fiber and its components has will not only influence the feed intake and digestibility of organic matter, or individual nutrients, but will mainly affect the energy value of the received feed. For ruminant's it is value *NEL* or *NEV*.

The goal of our study was to demonstrate the possibility of using *NDF* and *ADF* for predicting the energy value (*NEL*) used in feeds for dairy cows.

2. Material and methods

In the Czech Republic in 1991 was changed the energy evaluation of feeds. Starchy unit will be replaced by the more objective value and it is *NEL*. Today value of *NEL* it is predicted by the formula according to Vencl (Sommer et al., 1994).

$$NEL = ME \times (0.463 + 0.24) \times (ME/BE)$$

BE being calculated according to the formula *BE* = 0.00588. *CP* + 0.01918. *OM* and value of *ME* according to the formula $ME = 0.00137\times CP + 0.01504 \times SOH$.

For evaluation objectivity of *NEL* values were our values compared with formulas used in the world for calculating *NEL*. According to Linn and Martin (1999) were used for the calculation of *NEL* in meadow hay these formulas (indicated it as Pensyl):

$$NEL\ (Mcal/lb) = (TDN \times 0.01114) - 0.054$$

TDN value was calculated according to the formula % *TDN* = 88.9% - (0.779 . % *ADF*). The values Mcal and lb were converted to MJ and kg according NRC (2001). According Undersander et al. (1993), we also used the equation is used to compare the accuracy of our predictive calculations for meadow hay (indicated it as New York):

$$NEL\ (Mcal/lb)^* = 1.0876 - (0.0127 \times ADF)$$

Also here were the values *Mcal* and *lb* converted to MJ and kg according NRC (2001).

The same author mentions one more prediction equation for *NEL* meadow hay (as Midwest):

$$NEL\ (Mcal/lb)^* = 1.085 - (0.0150 \times ADF)$$

Also here were the values *Mcal* and *lb* converted according NRC (2001).

All feed analysis were made using the methods that are listed in the annexes to the Law on animal feed.

3. Results and discussion

The results of our observations allow us to devise an equation for predicting the *NEL* $NEL = 12.9085 - 0.1276x$, where x = the *NDF*.

File analyzed of feeds was represented by 59 samples of meadow hay, which were obtained from the harvest years 2012, 2013 and 2014 in the whole Czech Republic. In the tested samples were detected (deducting ash from dry matter) concentration of organic matter at a level of 925±0.32 g kg^{-1} DM, which is in very good agreement with the value (914 g kg^{-1} DM), listed in the catalog of feed (Zeman et al., 1995). The results agree well with the values of DM presented in NRC (2006). Also other results of the values which we tested in meadow hay are in a good agreement with the results of the two cited standards. Consensus of identified results is clearly visible in the table 1. We were most interested in the results of *NDF*.

If we compare a time necessary for prediction *NEL* then it is very clearly to see the difference. The determine of any nutritional value of the feed, it is always in the 100% dry matter. It is for all prediction methods the same. For calculations *NEL* by cited authors, it is necessary to perform a quantity of analyzes. Our forecast calls for only one analysis and it is the *NDF*. This analysis is done on a special device Ankom. The period of her analysis is *x* hours. For comparison, we outline the time and financial costs of any necessary analysis for predict the *NEL*.

Calculation of the prediction equation *NEL* is possible to calculate from *NDF* or *ADF* or *DNDF* or *DADF*. Financial costs and time required for the necessary analysis led us to predict *NEL* on the basis of determining the *NDF*. Specifically time determination *NDFD* was the longest (123 hours), slightly shorter (122.5 hours) was a method based on *ADFD*. The reason for such delays, these methods is the fact that it is necessary to the first know

Table 1 Comparison of nutritional values by authors in g kg^{-1}

Values/ autors	DM	CP	E. extr	CF	*NDF*	*ADF*	Ash	OM
NRC, 2006	923	106	26		642	395	86	837
Zeman, 1995	914	101	21	333			70	844
Our analysis	925	94	16	300	615	363	76	849

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Table 1 Time and financial demands analytical methods necessary to predict energy values (MJ NEL) feed

Pointer	Methods based on analyzes and their time and financial demands				
	DMD, OMD	*NDF*	***ADF***	*NDF**D***	***ADFD***
Time of analyses in h	104.5	13.25	13	123	122.5
Price for 1 sample €	3.50	2.50	2.20	8.50	7.90
Seriality determination (bags/samples)	100/50	24/12	24/12	24/12	24/12

the initial content of fiber fractions in samples (13.25 hours *NDF*, *ADF* 13 hours).

Furthermore, samples are subjected to enzymatic digestion without burning in a muffle furnace (104.5 - 8 = 96.5 hours), and after this analysis for samples again assayed fiber fractions (*NDF* 13.5 hours; *ADF* 13 hours). Given that the determination of the digestibility of fiber fractions need several analyzes will also be expressed higher financial costs of these measurements (*NDFD* = 8.50 €; *ADFD* = 7.90 €). Less demanding is a widespread method in the our country, based on the organic matter digestibility. Time-consuming analyzes can be calculated to be 104.5 hours at a price of one specimen, cca 3,50 EU. As the least demanding in terms of time and economy, methods were evaluated based on the contents of *NDF* and *ADF*. Specifically, analysis of the samples *NDF* requires about 13.5 hours, and the price of one piece does not exceed 2.50 € Complete analysis *ADF* is approximately similar (13 hours), and the price of determination 1 sample is about 2.20 €.

4. Conclusions

In our experiments, we studied the relationship of the individual fractions of polysaccharides to the energy value of pet food with the intent to mark the parameter the most affecting the accuracy of prediction of the content of net energy of lactation in meadow hay, taking into account the accuracy, speed and cost per assay.

NDF content in the meadow hay was very variable, moving from 487 to 727 g kg^{-1} DM. Content *ADF* moved in a narrower range (from 294 to 425 g kg^{-1} DM). CF content varied from 228 to 350 g kg^{-1} DM at an average of 300±0.52 g kg^{-1} DM. This values was highly variable depending on the content (*NFC* 59–135 g kg^{-1} DM).

The energy value of the food is very closely related to the availability of nutrients the body of animals. Therefore we used, the method of *in vitro* determination of the digestibility of monitored nutrients (dry matter, organic matter, *NDF* and *ADF*). Data obtained for feed are successively presented arithmetic mean error of the mean (x±s x) and the limit values (min., max.) Which indicate which part of the nutrients can be utilized as an energy source.

In the case of meadow hay was recorded *DMD* at 52.30±1.89% (from 27.1 to 69.4%), *OMD*: 44.9±2.07% (from 18.8 to 63.4%), *NDFD*: 33.66±1.48% (from 22.09 to 53.92%), *ADFD*: 26.73±1.86% (from 10.94 to 52.43%).

Using statistical methods were sought linkage between content, respectively. digestibility of individual fractions of fiber content and net energy of lactation feed (*NEL*). Trough a correlation analysis was clearly established that *NEL* content in feeds is significantly ($P \leq 0.05$) has a very strong negative relation with the content and positive relation to digestibility of individual fractions of structural carbohydrates. To find the most suitable parameters for the design equations to predict *NEL*, a comparison was made of the correlation coefficients.

They reached values: meadow hay:

NDF (r = -0.81), *ADF* (r = - 0.69) *NDFD* (r = 0.54), *ADFD* (r = 0.56)

Based on our experimental observations we can design an equation to predict *NEL*:

$$NEL = 12.9085 - 0.1276x$$

where:
x = the *NDF*

5. References

HARRIS B. JR. (1993) *Nonstructural and structural carbohydrates in dairy cattle rations.* [Online] University of Florida, IFAS Extension. Available at http://ufdc.ufl.edu/UF00008566/00001/1j. [Accessed: 2015-06-10].

ISHLER V., HEINRICHS J. and VARGA G. (1996) *From feed to milk: Understanding rumen fiction*. [Online] Penn State College of Agricultural Sciences. Available at: http://extension.psu.edu/animals/dairy/nutrition/nutrition-and-feeding/rumen-function/from-feed-to-milk-understanding-rumen-function. [Accessed: 2015-06-10].

ISHLER, V. and VARGA, G. (2007) Carbohydrate nutrition for lactating dairy cattle: Information and tools to assist in managing dairy nutrition, including resources on forages, pasture, heifers, and calves. [Online] Penn State College of Agricultural Sciences. Available at: http://www.das.psu.edu/research-extension/dairy/nutrition/pdf/chonutrition.pdf. [Accessed: 2015-06-10].

LINN J. G. and MARTIN N. P. (1999) Forage Quality Test and Interpretations. In: Mendenhall, K. (ed.) 2009. The organic dairy handbook: a comprehensive guide for the transition and beyond. Cobleskill, NY: Northeast Organic Farming

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Association of New York. Available at: http://www.nofany.org/organic-farming/technical-assistance/organic-dairy. [Accessed: 2015-07-12].

MÍKA V. et al. (1998) *Forage quality*. Praha: UZPI (in Czech).

MUDŘÍK, Z. et al. (2006) *Foundations of modern cattle nutrition*. Prague: CZU (in Czech).

NRC (2001) *Nutrient requirements of dairy cattle: Nutrient requirements of domestic animals.* 7th revised edition. Washington: National Reserach Council.

NOCEK, J. E. and RUSSELL, J. B. (1988) Protein and Energy as an Integrated System. Relationship of Ruminal Protein and Carbohydrate Availability to Microbial Synthesis and Milk Production. In *J. Dairy Sci.,* vol. 71, pp. 2070–2107.
DOI: http://dx.doi.org/10.3168/jds.S0022-0302(88)79782-9

POND, W. G. et al. (2005) *Basic animal nutrition and feeding.* 5th edition. New York: Wiley.

SOMMER, A. et al. (1994) *Nutrient requirements and nutritive value tables for ruminants.* Pohořelice: VÚVZ (in Czech).

UNDERSANDER, D. et al. (1993) *Forage analyses procedures.* Madison: National Forage Testing Association.

VAN SOEST, P. J., ROBERTSON, J.B. and LEWIS, B.A. (1991) Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. In *J. Dairy Sci,* vol. 74: 35 pp. 83–3597.
DOI: http://dx.doi.org/10.3168/jds.S0022-0302(91)78551-2

VENCL, B. et al. (1991) *The new evaluation systems for cattle feeds.* Praha: AZV ČSFR (in Czech).

WEISS, P. H. (2010) Refining the net energy systém WCDS. In *Advances in Dairy Technology*, vol. 22, pp. 191–202.

ZEMAN, L. et al. (1995). *Catalog of feeds (tables of feeds nutritional values).* Pohořelice: VUVZ (in Czech).

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