PLS "NIR - CRUDE FIBER" MODEL FOR FORAGES FROM HILL PERMANENT GRASSLAND

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Abstract

The main objective of this study was to obtain a NIR calibration model for prediction the crude fiber content of forages harvested in June 2009 from hill permanent grassland (Grădinari, Caraş-Severin District). The experimental field was organized in ten experimental trials fertilized organic, mineral, and organo-mineral. The soil was Calcic Luvisol and the annual average temperature around 10.4°C. The floristic composition of forages from this period was determined gravimetrically. From *Poaceae* were present *Festuca rupicola* and *Calamagrostis epigejos*. *Fabaceae* family was represented by *Trifolium repens* and *Lathyrus pratensis*. From other botanical family: *Rosa canina*, *Filipendula vulgaris*, *Galium verum* and *Inula britanica*.

Like main input data for calibration model was used the results for this qualitative parameter by chemical method and the reflectance values from NIR spectra for all analysed samples. Partial last square (PLS) regression was used to obtain the "NIR - Total Fiber" model, implemented in Panorama program (version 3, LabCognition, 2009). The statistical parameters (R^2=0.7355; RMSEC=3.2764) and the differences between references and predicted values situated in range 0.0631 and 13.1948% suggest a medium quality of calibration model, but it is promising to use it to predict the crude fiber contents of forages from grassland in this period of year using higher number of samples for calibration.

Key words: crude fiber, NIR, forages, grassland

Crude fiber represents an important parameter for forages quality (Crăiniceanu et al., 2006). The term crude fiber define the component of plant forages insoluble in water and which are not digestible by mammalian enzyme systems (Moore&Hatfield, 1994), formed by cellulose, hemicelluloses, pectic substances and lignin.

Cellulose represents a microfibrillar component of cell wall of forage plants. It is formed of β-glucose linked 1-4, with a polymerization degree of between 2000 – 6000 in primary cell walls, and more than 10000 in secondary walls (Waldron et al, 2003). Hemicelluloses are hetero-polysaccharides witch contain arabinans, mannnans, xylans, and galactans (Gârban, 1999) and are fond in primary and secondary cell wall (Waldron et al, 2003). Hemicelluloses have a higher nutritive value than cellulose because are more digestively (Drînceanu, 1994). Pectic substances represent a non-homogeny poly-saccharine group, witch contain pectic acid, galactans, arabinans and sometime xylans (Gârban, 1999). Lignin is a complex chemical compound linked both to hemicelluloses and to different plant polysaccharides, conferring mechanical strength to the cell wall (Şumălan, 2006).

Some animals, particularly ruminants, have the capacity to digest and use crude fiber like a source of nutrients, with the help of symbiotic micro-organisms that live in their guts (Georgescu et al, 2007; Van Soest, 1994). Drînceanu (1994) affirm that for ruminants the cellulose content must be between 23-25% in feed ratio. Volatile fatty acids resulted after microbial crude fiber degradation represents the main source of energy for these animals (65-75% from energy available for organism). For swine and poultry crude fiber is a restrictive factor, the recommended level being between 3 – 8% in feed ratio (Drînceanu, 1994).

The chemical method used to determine the crude fiber content of forages from grassland are limited by money, reagents acquisition, a long time for sample analyses, necessity of qualified personal capable to obtain the good results. NIR Spectroscopy can be used like an alternative method for these classical determinations because is a non-destructive and a very quickly qualitative and quantitative analysis method (Wilson, 1994). NIR Spectroscopy not requires the usage of reagents, being a friendly method for environment (Foley et al, 1998).

The necessity to study NIRS method applications in our country to characterize the crude fiber quantity of forages from grassland

refers to calibrate this method for the plants species existed in different pedo-geographically zones from Romania.

The main objective of this study was to obtain a NIR calibration model for predict the crude fiber content of forages from hill grassland (Grădinari; Caras-Severin County). For this, the harvested forages samples were analyzed for crude fiber content using both the chemical and NIR Spectroscopy methods. Then it was made the validation of obtained NIR model using samples from the same grassland and harvested in the same period of the year (June 2009).

MATERIAL AND METHOD

PLS (Partial Last Square) regression, implemented in Panorama software (Variant 3, LabCognition, 2009) was selected to obtain the NIR calibration model using the chemical data for crude fiber content by JAOAC 962.09/1990 method (when the samples are sequentially refluxed in dilute base followed by dilute acid) and the values of reflectance from 150 NIR spectra scanned with V670 Spectrophotometer instrument by Abble-Jasco. The scan was made in the range 800-2500 nm. For all the grounded dried samples the determinations were made in triplicate.

The analysed forages were harvested in June 2009 from hill permanent grassland (Grădinari, Caraş-Severin District), organized in ten trials with different doses of fertilizers. For each variant were made five replications. It was used mineral (15:15:15 NPK complex, ammonium nitrate, superphosphat, potassium salt) and organic fertilizers (fermented sheep manure) over the period 2003-2008. The mineral fertilizers were applied yearly and fermented sheep manure at each two years.

The ten fertilized trials were organized in randomized plots, in multiple stage blocks with five replications: V1-unfertilized trial, V2-20 t/ha sheep manure, V3-40 t/ha sheep manure, V4-60t/ha sheep manure, V5-20 t/ha sheep manure + $50P_2O_5$(Kg/ha), V6-20 t/ha sheep manure + $50P_2O_5$ (Kg/ha) + 50 K_2O (Kg/ha), V7-20 t/ha sheep manure + 50 P_2O_5 (Kg/ha) + 50 K_2O (Kg/ha) + 50N(Kg/ha), V8-100 N (Kg/ha) + 50 P_2O_5 (Kg/ha) + 50 K_2O (Kg/ha), V9-150 N (Kg/ha) + $50P_2O_5$(Kg/ha) + 50 K_2O (Kg/ha), V10 - (100+100)N (Kg/ha) + 50 P_2O_5 (Kg/ha) + $50K_2O$(Kg/ha).

The floristic composition of forages from this period of year was determined gravimetrically. From *Poaceae* familly dominant was *Festuca rupicola* (varied between 16.00 – 52.00%), followed by *Calamagrostis epigejos* (5.00-13.00%). Fabaceae family was represented mainly by *Trifolium repens* (dominant) and *Lathyrus pratensis*. From other botanical family were present *Rosa canina* (7.00-18.00%), *Filipendula vulgaris* (3.00-9.00%), *Galium verum* (3.00-7.00%) and *Inula britanica* (5.00%).

The soil of permanent grassland was Calcic Luvisol and the annual average temperature in this region was around 10.4°C.

RESULTS AND DISCUSSIONS

To perform the NIR calibration model for prediction of crude fiber content of forages from permanent grassland were used whole spectral domain (800-2500 nm). Statistical parameters of obtained "NIR-CF" model are presented in *table1*.

Table 1

Statistical parameters for „NIR-CF" model with whole spectral domain

R^2	0.7355
RMSEC	3.2764
SD	4.3873
„NIR-CF" model - NIR-crude fiber model	

It can be observed that these statistical parameters (R^2 = 0.7355, RMSEC = 3.2764, SD = 4.3873) suggest a medium quality of "NIR-CF" model. This quality of NIR calibration is underlined very well both in the graphical presentation of prediction for crude fiber by „NIR-CF" model with whole spectral domain (Figure 1) and also by the differences between the chemical results and those predicted for control samples harvested in the same period of year and grassland and conditioned in the same maner with those used to performe the calibration (*table 2*).

The differences between Real and Predicted values were situated in range 0.0631 and 13.1948%, apreciativellly 28% from these being under 1%, 28% under 3%, and 23% under 5%. The differences values situated in range 10 – 13% represented 7.7%.

These results encourage the continuation of beginning studies. To perform optimum NIR prediction model is necessary in this case the selection of a high number of forages samples than 150, to characterize better the entire concentration values of this qualitative parameter of forages from permanent grassland.

Table 2

The results of crude fiber (%) prediction for the control samples forages (June 2009) by „NIR-CF" calibration model with whole spectral domain

Sample's name	Crude fiber (%)		
	Real (chemical method)	Predicted (NIR model)	Differences between Real - Predicted
101a	32.1000	36.7676	-4.6676
101b	43.9900	30.7952	13.1948
101c	18.8500	23.8517	-5.0017
101d	31.0600	27.6500	3.4100
102a	34.5700	36.9981	-2.4281
102b	24.8900	28.2247	-3.3347
102c	25.4600	24.7033	0.7567
102d	28.2500	29.0979	-0.8479
103a	36.4500	37.0095	-0.5595
103b	32.0800	32.6773	-0.5973
103c	21.0700	25.2712	-4.2012
103d	28.2200	28.5565	-0.3365
104a	38.8500	37.0497	1.8003
104b	32.9800	28.9572	4.0228
104c	20.7200	26.1794	-5.4594
104d	30.8200	26.2278	4.5922
105a	35.1700	36.3613	-1.1913
105b	20.7300	30.9529	-10.2229
105c	24.3300	25.2422	-0.9122
105d	32.0800	29.8422	2.2378
106a	33.0100	35.2060	-2.1960
106b	22.6000	26.4702	-3.8702
106c	24.7400	21.7402	2.9998
106d	31.0200	25.8390	5.1810
107a	36.4100	36.4731	-0.0631
107b	29.7800	30.4409	-0.6609
107c	20.0300	26.6518	-6.6218
107d	31.6200	29.8201	1.7999
108a	36.4400	36.2102	0.2298
108c	22.4200	24.9236	-2.5036
108d	29.5500	28.5828	0.9672
109a	33.7500	35.3963	-1.6463
109b	28.2200	27.2208	0.9992
109c	24.3700	25.8156	-1.4456
109d	36.0700	30.2473	5.8227
110a	40.7000	36.8461	3.8539
110b	39.1000	28.0055	11.0945
110c	25.3800	23.9805	1.3995
110d	36.2700	30.1481	6.1219

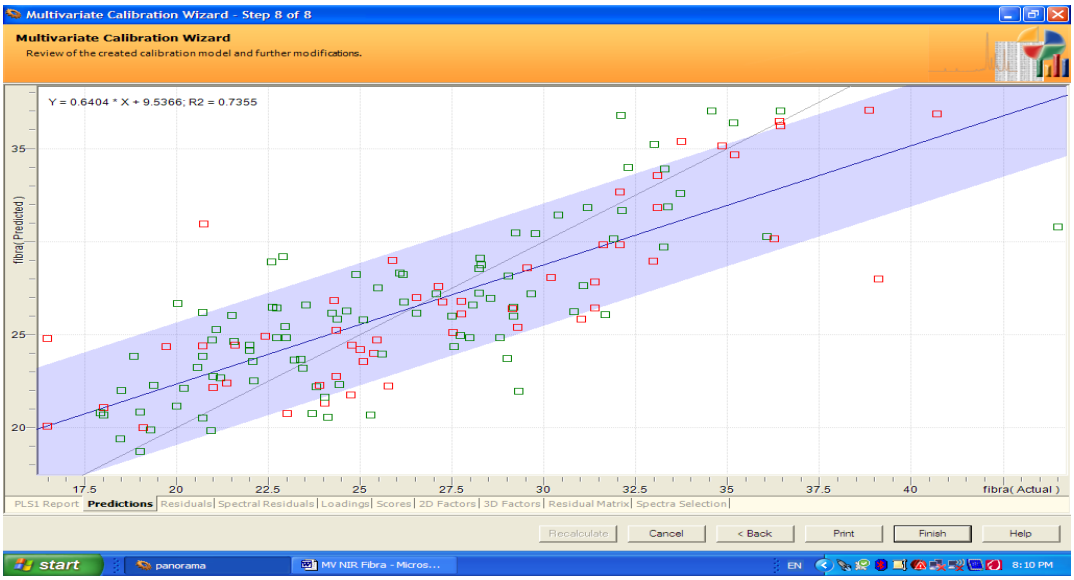

Figure 1 **Prediction of crude fiber by „NIR-CF" model with whole spectral domain**

CONCLUSIONS

The PLS regression model "NIR-CF" performed using the results of crude fiber of forages harvested in June 2009 by chemical method, and the reflectance values from whole NIR spectra had a medium quality. This model is promising to be used with success to determine routinely this parameter for the samples harvested in this period of year from the permanent grassland after the enrichment with a higher number of plants samples to characterize better the entire concentration values of crude fiber.

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