Indian Journal of Animal Sciences **83** (12): 1347–1350, December 2013/Short communication

Quantitative prediction of indigestible cell wall fraction of tropical forages used in livestock feeding

SONALI PRUSTY[1], S S KUNDU[2], AJAY KUMAR[3], A P RUHIL[4] and CHANDER DATT[5]

National Dairy Research Institute, Karnal Haryana 132 001 India

Received: 28 February 2013; Accepted: 15 August 2013

Key words: ADF, ADIN, Indigestible cell wall carbohydrate, Lignin, NDF

Cell wall carbohydrate (CWC) fraction of forages is only partially utilized by ruminants. Assessing the utilization of CWC is important to understand the feeding value quantitatively and for preparing a balanced ration. Lignin bound nitrogen is often considered as the indigestible part of crude protein fraction and lignin bound carbohydrates as the indicator of indigestible CWC. This proportion of CWC which is bound with lignin and actually ultimately indigestible is not properly defined and described adequately. Under the Cornell net carbohydrate (CHO) and protein system (CNCPS) the indigestible CHO fraction has been denoted as fraction C, as % of CHO and adopted as 2.4 times of the lignin content (Sniffen *et al.* 1992). The tropical climate affects the forages and their growth differently and renders them more indigestible than their counterpart in temperate region. The reported lignin content of the tropical forages (Bakshi *et al*. 2005, Chaurasia *et al*. 2006, Das *et al*. 2008, Srinivas *et al*. 2008, Kamble *et al*. 2011) differs from that of temperate forages (Sniffen *et al*. 1992). Present study was, therefore, planned to work out suitable empirical equations to predict indigestible CWC (iNDF) quantitatively in tropical forages.

The samples of forages including cereal fodders, viz. maize (*Zea mays*), pearl millet (*Pennisetum typhoides*), sorghum (*Sorghum bicolar*), oats (*Avena sativa*), fenugreek (*Trigonella foenum-griecum)*, cowpea (*Vigna unguiculata)*, berseem (*Trifolium alexandrinum*) and clusterbean fodder (*Cyamopsis tetragonoloba)*, dry roughages, viz. paddy straw (*Oryza sativa*), wheat straw (*Triticum aestivum*), sugarcane tops (*Saccharum officinarum)*, sorghum stovers, and range grasses viz. guinea (*Panicum maximum)*, sehima (*Sehima nervosum)*, heteropogon (*Heteropogon* spp.), crysopogon (*Crysopogon fulvus)*, buffel (*Cenchrus ciliaris)* and bermuda (*Cynodon dactylon)* grass were collected. Samples were dried in hot air oven at 70°C for days till a constant weight was attained and ground to pass through 1 mm sieve using electrically operated Willey mill. The fodder samples were analyzed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) exclusive of residual ash. Lignin was estimated by hydrolysis of acid detergent residue in 72% (w/w) H_2SO_4 for 3h (Van Soest *et al.* 1991). ADIN was estimated by analyzing the CP content of the residual ADF (Licitra *et al.* 1996). Approximately 2.5 g of fodder sample was put into nylon bags (40–50µ porosity) in triplicates each, and tied to an iron chain and then suspended in the rumen of fistulated animals for incubation. Blank samples were run to correct rumen contamination errors. The bags were removed after 96 h of incubation and washed thoroughly under slowly running tap water until clear water came out of the bags. The bags were dried in hot air oven at 80°C for 16 to 20 h to a constant weight. The residual DM was taken and analyzed for NDF (AOAC 2005). The ultimate iNDF that is ‘C’ fraction was statistically regressed upon the estimated cell wall fractions using (SAS) by step-wise multiple regression method.

The feeds were incubated for 96 h after which the disappearance rate could not be measured due to non-significant variations in the disappearance. In CNCPS, the undegradable CWC was denoted as ‘C’, which could be assessed by multiplying factor 2.4 to the lignin content of the feed. This factor was based on 60 to 90 days methane fermentation of various waste materials (Chandler *et al.* 1980). Van Soest *et al.* (2005) established the same factor to determine the fraction C in forages. The similar method was followed in the present experiment as that of Van Soest *et al.* (2005) to validate defined relation. On correlating the ultimate iNDF with 2.4 times the lignin value, the relation was found to be significantly different from unity. There was significant variation ($P < 0.05$) between both the values and the coefficient of variation was 36.35%. It has been shown in Fig. 1, wherein, the bisection points were scattered on

Present address: [1]Ph. D. scholar (World.sonalindri@gmail.com), [2]Principal Scientist and Head (sskundu.kln@gmail.com), [5]Senior Scientist, DCN Division (chandatt@gmail.com). [3]Government Poultry Farm, Sundervani, Rajouri, Jammu and Kashmir (drsudan86@gmail.com). [4]Senior Scientist and Controller (Online Examinations), ASRB, Krishi Anusandhan Bhavan-I, Pusa, New Delhi (apruhil@gmail.com).

Table 1. Indigestible NDF (iNDF) after 96h of incubation, fiber and fiber bound nitrogen fractions of the roughage samples

Fodders	iNDF (% of total CHO)	NDF (%DM)	ADF (%DM)	Lignin (%DM)	NDF+ ADIN	ADIN (%DM)
Non-legume fodder						
Maize	23.97	68.65	35.45	4.5	70.18	1.53
Pearl millet	28.89	55.17	34.76	5.85	56.74	1.57
Sorghum	29.83	61.63	38.07	5.85	63.32	1.69
Oats	10.25	45.7	30.85	2.28	48.49	2.79
Legume fodders						
Fenugreek	13.82	29.12	28.6	9.18	29.89	0.77
Cowpea	17.48	46.34	30.64	8.29	46.56	0.22
Berseem	8.69	41.71	30.23	4.32	42.65	0.94
Clusterbean	6.59	31.56	28.45	3.50	31.70	0.14
Dry roughages						
Paddy straw	32.85	64.99	53.42	6.55	66.39	1.40
Wheat straw	40.72	77.92	52.82	8.73	78.83	0.91
Sugarcane tops	39.40	71.74	44.54	7.25	72.86	1.12
Sorghum stover	46.20	69.16	50.84	10.43	71.23	2.07
Range grasses						
Guinea	26.28	64.27	38.14	6.54	65.92	1.65
Sehima	32.06	71.22	52.11	6.24	72.01	0.79
Heteropogon spp.	37.71	73.79	51.48	7.48	74.55	0.76
Crysopogon	36.70	69.23	46.25	9.88	70.12	0.89
Bermuda	24.25	61.5	33.75	5.23	63.87	2.37
Buffel	45.82	68.98	54.26	12.00	71.05	2.07

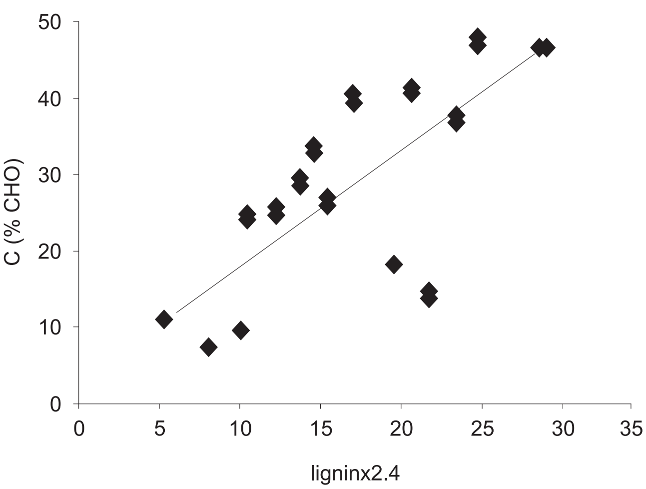

Fig. 1. Undegradable CHO (fraction C) versus 2.4 times lignin of all forages

plotting the C fraction obtained by 96 h *in sacco* digestion against its derived value. Corroborating reports on deviation in the linear equation was also reported earlier (Traxler *et al.* 1998). They suggested the linear equation used by the CNCPS was due to mean bias and, suggested log models, 4.37× (lignin/NDF) (.84) to estimate the undegradable fiber fraction from lignin determined by permanganate method. In NRC (2001), the 48 h NDF digestibility was predicted from the NDF lignin and neutral detergent insoluble nitrogen (NDIN) content of forages. But to obtain ultimate CP digestibility ADIN seems to be a better predictor since it escapes as such from the gastro intestinal tract. Upon regression of the C fraction with the NDF, ADF, lignin and ADIN, the following prediction equations were developed.

Equation 1: Forage (n=36): C_f = - 20.0163 + 1.8498 lignin + 0.5775NDF, (R^2=85.91)

Equation 2: Grass (n=12): C_g = -85.8844 + 1.8805 Lignin – 3.5146NDF + 4.9493 (NDF+ADIN), (R^2=99.86)

Equation 3: Legume fodder (n=8): C_l = –67.5640 + 1.3779 Lignin + 2.4108ADF, (R^2=94.13)

In the equations y represented fraction C (% CHO). The high R^2 value indicated how well the predictor and the C fractions vary together. In the present study, lignin and NDF of forages were better predictors (R^2= 85.91) of the forage C fraction. Smith *et al.* (1972) found that cell wall indigestibility was highly correlated with lignin. In grasses lignin, NDF and ADIN were better predictor of the C fraction (R^2= 99.86) whereas in legume fodders fraction C value could be predicted from ADF and lignin (R^2= 94.13). Though the R^2 values were so high but the variables in the prediction equations were significant at the 0.15 level only, probably due to less numbers of replicates. In equation 1, NDF as a predictor was significant below 1% level to predict the C fraction of forages. In equation 3, ADF was significant below 5% level to predict the C fraction in legumes. However, contradictory to present finding, ADF is reported to be poor predictor of NDF degradability in temperate legumes (Undersander 2007). This difference might be due to consideration of the retention time of NDF in the rumen in

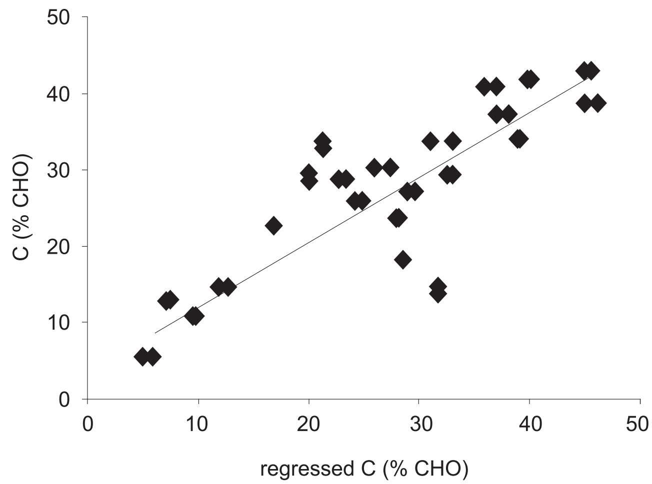

Fig. 2. Regressed and estimated indigestible NDF of all forages

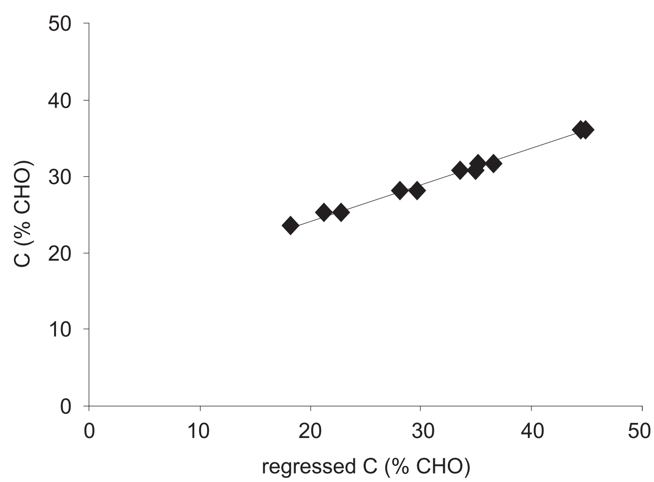

Fig. 3. Regressed value and estimated indigestible NDF of grasses

previous studies whereas in the present study ultimate iNDF was considered. Among legume, non-legume fodders, dry roughages and grasses, the variation to predict the C value was low compared to all the forages together. When the regressed 'C' value for forages (Fig. 2) and grasses (Fig. 3) was plotted against its estimated value, there was clustering of the bisection points around the linear trend line in the graph.

A large portion of energy in ruminant diet is provided by the CHO fraction and in forages significant portion of CHO is contributed by the cell wall fractions. So, given empirical equations could be useful to predict the quality of forages, for higher C fraction reduces the feed value of the forages to cater energy requirements. Factor 2.4 in the current study gave higher coefficient of variation and found to be a over-simplification to obtain the 'C' fraction of tropical forages, since there is higher cross bonding and lignifications of tropical forages compared to temperate ones. The equations developed in the present study may be used to predict the C fraction efficiently for tropical forages. But due to lower significance of the variables in the developed prediction equations, validation of the equations with more number of samples needs to be done. There was significant ($P < 0.01$) relationship between NDF and iNDF of forages. So, NDF along with lignin may be useful to develop prediction equations for 'C' fraction in case of tropical forages.

SUMMARY

A cell wall fraction in forages remains indigested even after longer enteric retention time. This ultimate indigestible portion is referred to as fraction 'C' as per Cornell net carbohydrate and protein system (CNCPS). Fraction 'C' is not only indigestible, but also limits intake of fibrous tropical forages, thereby increasing its relevance during analysis, to assign their feeding value. Under CNCPS the C value is computed by multiplying factor 2.4 to the lignin content of forages is a over simplification because in tropical climate the value of lignin and subsequently other components of forages differ greatly due to higher lignifications and cross bonding in forages compared to that of temperate region. Hence, the objective of the present study was to derive alternative equation for the prediction of the C fraction in tropical forages. Cell wall components (NDF, ADF, ADIN and lignin) of 18 selected forages were determined. Ground forage samples were incubated for 96 h *in sacco* in the rumen to quantify the C fraction. The following regression equations were obtained. For all forages, $C_f = -20.0163 + 1.8498$ lignin + 0.5775NDF, ($R^2 = 85.91$); grasses, $C_g = -85.8844 + 1.8805$ lignin – 3.5146NDF + 4.9493 (NDF+ADIN), ($R^2 = 99.86$) and legumes, $C_l = -67.5640 + 1.3779$ lignin + 2.4108ADF, ($R^2 = 94.13$).

REFERENCES

AOAC. 2005. *Official Method of Analysis*. 18th edn. Association of Official Analytical Chemists. Chapter 9. Pp. 20–22, Virginia, USA.

Bakshi M P S, Singh M P, Wadhwa M and Singh B. 2005. Evaluation of forest grasses as livestock feed. *Livestock Research for Rural Development* **17**. http://www.lrrd.org/lrrd17/11/baks17127.htm.

Chandler J A, Jewell W J, Gossett J M, Van Soest P J, and Robertson J B. 1980. Predicting methane fermentation biodegradability. *Biotechnology and Bioengineering Symposium No. 10.* Pp. 93–107.

Chaurasia M, Kundu S S, Singh S and Mishra A K. 2006. Cornell net carbohydrate and protein system for nutritional evaluation of tree leaves, shrubs and grasses. *Indian Journal of Animal Sciences* **76**: 81–87.

Das M M, Pailan G H and Kundu S S. 2007. Chemical composition and carbohydrate fractions of some locally available forage and concentrate feeds of Bundelkhand. *Indian Journal of Animal Sciences* **77**: 1173–77.

Datt C, Datta M and Singh N P. 2008. Assessment of fodder quality of leaves of multipurpose trees in subtropical humid climate of India. *Journal of Forestry Research* **19**: 209–14.

Kamble A B, Puniya M, Kundu S S, Shelke S K and Mohini M. 2011. Evaluation of forages in terms of carbohydrate, nitrogen fractions and methane production. *Indian Journal of Animal Nutrition* **28**: 231–38.

Licitra G, Harnandez T M and Van Soest P J. 1996. Standardizations of procedures for nitrogen fractionation of ruminant feeds. *Animal Feed Science and Technology* **57**: 347–58.

Smith L W, Goering H K and Gordon C H. 1972. Relationships of forage compositions with rates of cell wall digestion and indigestibility of cell walls. *Journal of Dairy Science* **55**: 1140–47.

Sniffen C J, O'Connor J D, Van Soest P J, Fox D G and Russel J B. 1992. A net carbohydrate and protein system for evaluating cattle diets. 2. Carbohydrate and protein availability. *Journal of Animal Science* **70**: 3562–77.

Srinivas B, Swain N and Singh N P. 2008. Disassociate bound protein in tree leaves by trypsin hydrolysis and its effect on feed utilization, microbial protein and weight gain in sheep – an experimental study. *Livestock Research for Rural Development* **20**. http://www.lrrd.org/lrrd20/12/srin20190.htm

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, Velez M and Flores A. 1998. Predicting forage indigestible NDF from lignin concentration. *Journal of Animal Science* **76**: 1469–80.

Undersander D. 2007. New developments in forage testing. *Idaho Alfalfa and Forage Conference*. Pp. 26–27.

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. *Journal of Dairy Science* **74**: 3583–97.

Van Soest P J, Van Amburgh M E, Robertson J B and Knaus W F. 2005. Validation of the 2.4 times lignin factor for ultimateextent of NDF digestion, and curve peeling rate of fermentation curves into pools. *Proceedings of the Cornell Nutrition Conference for Feed Manufacturers*. Pp. 139–49. East Syracuse, NY. Cornell University, Ithaca, New York.