Calculation of rumen degradation characteristics of residual non-starch polysaccharides of feedstuffs

J. De Boever, J.W. Spek

Public
Report 1474

WAGENINGEN
UNIVERSITY & RESEARCH

Calculation of rumen degradation characteristics of residual non-starch polysaccharides of feedstuffs

J. De Boever[1], J.W. Spek[2]

1 Instituut voor Landbouw-, Visserij- en Voedingsonderzoek (ILVO), Scheldeweg 68, 9090 Melle, Belgium

2 Wageningen Livestock Research, PO BOX 338, 6700 AH Wageningen, the Netherlands

This research was carried out by Wageningen Livestock Research, Instituut voor Landbouw-, Visserij en Voedingsonderzoek and the foundation CVB and subsidised by the Dutch Ministry of Agriculture, Nature and Food Quality, within the framework of the PPS project “Voeding op Maat” (LWV20.189)

Wageningen Livestock Research
Wageningen, maart 2024

Report 1474

De Boever, J., J.W. Spek, 2024. *Calculation of rumen degradation characteristics of the residual non-starch polysaccharides.* Wageningen Livestock Research, Public Report 1474.

Samenvatting
Het DVE/OEB-2007 eiwitevaluatiesysteem voor herkauwers vereist het schatten van gefermenteerde residuele niet-zetmeelpolysacchariden (RNSP) in de pens om microbiële eiwitsynthese en de beschikbaarheid van dit microbiële eiwit in de dunne darm te bepalen. RNSP, bestaande uit verschillende niet-NDF-polysacchariden, wordt berekend, niet direct gemeten, waardoor fouten uit andere fracties zich opstapelen. Het passend maken van RNSP-fermentatiedata is uitdagend vanwege inconsistente afbraakpatronen. In tegenstelling tot RNSP, nemen NSP- en NDF-afbraak over het algemeen gestaag toe in de tijd, wat helpt bij het fitten van afbraak van NSP en NDF in de pens. Analyse van pensincubatiedata van verschillende voedermiddelen laat zien dat er voor de onderzochte voedermiddelen een substantiële variatie aanwezig is in RNSP-fermentatie voor de verschillende incubatieperioden. In deze studie wordt voorgesteld om fermentatie van RNSP in de pens te berekenen als het verschil tussen de hoeveelheid pensgefermenteerd NSP en NDF. Verder wordt voorgesteld om voor pensafbreekbaar RNSP dezelfde microbiële eiwitsynthese efficiëntie toe te kennen als voor pensafbreekbaar zetmeel gezien hun vergelijkbare fermentatiekenmerken.

Summary
The DVE/OEB-2007 protein evaluation system for ruminants requires estimating fermented residual non-starch polysaccharides (RNSP) in the rumen to determine microbial protein synthesis and the availability of this microbial protein in the small intestine. RNSP, comprising various non-NDF polysaccharides, is calculated, not measured directly, accumulating errors from other fractions. Fitting of RNSP fermentation data is challenging due to inconsistent degradation patterns. Unlike RNSP, NSP and NDF degradation generally increase steadily over time, aiding curve fitting. Analysis of rumen incubation data of various feedstuffs shows a substantial variation in RNSP fermentation across incubation periods. It is proposed to calculate rumen fermentable RNSP as the difference between rumen fermentable NSP and NDF and applying microbial protein efficiency for starch fermentation to RNSP, given their similar fermentation characteristics.

This report can be downloaded for free at https://doi.org/10.18174/653888 or at www.wur.nl/livestock-research (under Wageningen Livestock Research publications).

Public Wageningen Livestock Research Report 1474

Table of contents

Foreword

The present study 'Calculation of rumen degradation characteristics of residual non-starch polysaccharides of feedstuffs in the updated DVE/OEB evaluation system' was conducted by a collaboration of Wageningen Livestock Research (WLR), the Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) and the foundation CVB as part of the Public Private Partnership "Voeding op Maat" with the aim to reduce nitrogen emission in production animals through improved nutrition. This project was funded by the foundation CVB and the Dutch Ministry of Agriculture, Nature and Food Quality. The authors thank the members of the Ad hoc committee and the technical committee of CVB for their support.

The authors:
Johan de Boever and Wouter Spek

Summary

In the DVE/OEB-2007 protein evaluation system for ruminants, the estimation of the amount of residual non-starch polysaccharides (RNSP) fermented in the rumen (FRNSP) is required for determining the amount of microbial protein formed by rumen fermentation of RNSP and the contribution of this microbial protein to the amount of microbial protein being available to the cow in the small intestine. However, the RNSP-fraction is a heterogeneous collection of non-starch polysaccharides (NSP), which do not belong to NDF, such as pectins, arabans, xylans and beta-glucans. This fraction is not determined, but calculated by difference, so cumulating all analysis errors of the other feed fractions. For most feedstuffs, the fitting of FRNSP is problematic as the calculated degradability at the various incubation periods is highly variable and seldom continuously increases with longer rumen incubation time in an exponential way. This makes it difficult to fit an exponential degradation curve and a degradation rate which is required in order to calculate FRNSP. In contrast with RNSP, the rumen degradation of NSP and NDF in most cases increases continuously with longer rumen incubation time and the fitted exponential degradation curve has mostly a high determination coefficient. In this study results from rumen incubation results of feedstuffs obtained by ILVO in the period of 1992 up to 2023 are shown in order to demonstrate the high variation in observed rumen fermented RNSP values of various feedstuffs at various incubation periods. Because of this high variation in rumen fermentation, it is proposed to calculate FRNSP as the difference between FNSP and FNDF. Furthermore, because fermentation characteristics of RNSP match more closely with fermentation characteristics of starch than of NDF, it is proposed to use for FRNSP the same microbial protein efficiency as used for rumen fermentable starch.

1 Introduction

One of the major differences between the DVE/OEB evaluation system of 1991 (Tamminga et al., 1994) and that of 2007 (Van Duinkerken et al., 2011) is how the content of rumen fermentable organic matter (FOM) is calculated and how the yield of rumen microbial protein (MPY) per kg FOM is estimated. In the 1991 system, FOM is calculated by difference starting from the total (faecal) digestible organic matter (OM; g/kg DM), from which the contents of rumen by-pass protein and starch, of crude fat and half of the silage fermentation products (FP; g/kg DM) are subtracted. Further it is assumed that 150 g microbial protein is produced per kg FOM. In the 2007 system, FOM is calculated by summing up the different rumen fermented feed fractions of sugars, protein, starch, NDF, residual non-starch polysaccharides (RNSP; expressed in g/kg DM) and half of the FP. Further, the MPY depends on the type of feed substrate and its fractional passage rate (Kp; %/h) and the type of rumen microbes (liquid vs. particle associated bacteria).

The RNSP-fraction is a heterogeneous collection of non-starch polysaccharides (NSP's), which do not belong to NDF, such as pectins, arabans, xylans and beta-glucans. In some feedstuffs, organic acids (e.g. oxalic acid in sugar beets) may also contribute to RNSP. This fraction is not determined, but calculated by difference, so cumulating all analysis errors of the other feed fractions.

The formula is as follows (all fractions in g/kg DM):

$$RNSP = OM - (CP + starch + sugars + GOS + CFAT + NDF + 0.92\ LA + 0.5 \times VFA)$$

Where OM = organic matter (g/kg DM), CP = crude protein (g/kg DM), GOS = gluco-oligosaccharides (g/kg DM), CFAT = crude fat (g/kg DM), NDF = neutral detergent fibre (g/kg DM), LA = lactic acid (g/kg DM) and VFA = volatile fatty acids mainly consisting of acetic acid, propionic acid and butyric acid (all expressed in g/kg DM).

In this equation CP does not include ammonia (NH_3) and GOS are fragments (soluble in 0.4 M ethanol) of incomplete starch degradation, present in some high-moisture by-products. It is assumed that 0.08 of LA, 0.50 of VFA and 1.00 of alcohols and NH_3 evaporate during the oven drying process of the samples.

In the Dutch protocol for *in situ* rumen incubations is stated that the rumen degradation characteristics of NDF need only be determined if the ratio RNSP/NDF ≥ 0.5 and NDF > 100 g/kg DM. The latter conditions are valid for the following feedstuffs: citrus pulp, yeast, groundnut meal, carob meal, maize solubles, maize feed meal, millet, protapec, beet pulp, soya beans, soybean meal, wheat milling products. In all other cases it is assumed that the degradation characteristics of NDF and RNSP are identical and may be calculated from the disappearance of NSP (= NDF + RNSP). Further it is assumed (CVB, 2007) that:

$W_{NDF} = 0$ $\quad\quad$ $W_{RNSP} = W_{NSP}$

$D_{NDF} = NDF/NSP \times D_{NSP}$ $\quad\quad$ $D_{RNSP} = RNSP/NSP \times D_{NSP}$

$U_{NDF} = NDF/NSP \times U_{NSP}$ $\quad\quad$ $U_{RNSP} = RNSP/NSP \times U_{NSP}$

$Kd\text{-}D_{NDF} = Kd\text{-}D_{RNSP} = Kd\text{-}D_{NSP}$

Where W = the washable percentage of NDF (W_{NDF}; %), NSP (W_{NSP}; %) and RNSP (W_{RNSP}; %). Where U = the rumen undegradable percentage of NDF (U_{NDF}; %), NSP (U_{NSP}; %) and RNSP (U_{RNSP}; %). Where D = the potentially rumen degradable percentage (calculated as 100 – W – U) of NDF (U_{NDF}; %), NSP (U_{NSP}; %) and RNSP (U_{RNSP}; %). Where Kd-D = the rumen degradation rate of D (%/h) of NDF (Kd-D_{NDF}; %/h), NSP (Kd-D_{NSP}; %) and RNSP (Kd-D_{RNSP}; %).
To calculate the degradation characteristics of RNSP, the RNSP content needs also be calculated for the rumen incubation residues. Thereby, one needs to correct for the rumen degradation behavior of fats assuming that W = 35%, U = 0% and Kd-D = 15 %/h.

However, contrary to what is written in the Dutch protocol (CVB, 2007), an alternative procedure has been used to calculate values for RNSP and NDF rumen degradation characteristics. This procedure is as follows, taking soybean hulls as an example. In this example soybean hulls contain 773 g NSP per kg DM, 621 g NDF per kg DM and 153 g RNSP per kg DM. W_{NSP} = 6.80%, U_{NSP} = 2.97%, D_{NSP} = 90.23% and Kd-D_{NSP} = 3.20 %/h. In this case the following calculations/assumptions were made:

W_{NDF} = 0%
$U_{NDF} = U_{NSP} \times 100 / (100 - W_{NSP}) = 2.97 \times 100 / (100 - 6.80) = 3.2\%$
$D_{NDF} = 100 - W_{NDF} - U_{NDF} = 100 - 0 - 3.2\% = 96.8\%$
$W_{RNSP} = NSP / RNSP \times W_{NSP} = 773 / 153 * 6.80 = 34.4\%$
$U_{RNSP} = U_{NSP} \times (100 - W_{RNSP}) / (100 - W_{NSP}) = 2.97 \times (100 - 34.4) / (100 - 6.80) = 2.10\%$
$D_{RNSP} = 100 - W_{RNSP} - U_{RNSP} = 100 - 34.4 - 2.10 = 63.5\%$
Kd-D_{RNSP} = Kd-D_{NDF} = Kd-D_{NSP} = 3.20%/h

The main assumption made in both the CVB protocol (CVB, 2007) and the alternative procedure used in reality as described above is that W_{NDF} is zero and that W_{NSP} can be for 100% attributed to RNSP. However, the alternative procedure correctly carries out this assumption whereas this is not the case for the procedure described in CVB (2007). Furthermore, the alternative procedure offers an alternative calculation method to convert U_{NSP} to U_{RNSP} and U_{NDF} in which a higher proportion of U_{NSP} is ascribed to U_{NDF} than to U_{RNSP}.

Furthermore, It should be noted that the differentiation between NDF and RNSP instead of considering the total fraction of NSP unnecessarily complicates the calculation of DVE for feedstuffs containing relatively little RNSP (RNSP/NDF < 0.5). In fact, the distinction between rumen fermented NDF (FNDF) and rumen fermented RNSP (FRNSP) instead of rumen fermented NSP (FNSP) doesn't matter for the calculation of FOM. Indeed, according to the formulae to calculate FNDF, FRNSP and FNSP (see below), the content of FNSP equals the sum of FNDF and FRNSP as similar degradation rates and passage rates are used for both W_{NSP} and W_{RNSP} (W_{NDF} = 0 and therefore not relevant), and as similar degradation and passage rates are assumed for both D_{NSP}, D_{RNSP} and D_{NDF}:

FNDF (%) = $D_{NDF} \times [\text{Kd-}D_{NDF}/(\text{Kd-}D_{NDF} + \text{Kp-}D_{NDF})]$
FRNSP (%) = $W_{RNSP} \times [\text{Kd-}W_{RNSP}/(\text{Kd-}W_{RNSP} +8)] + D_{RNSP} \times [\text{Kd-}D_{RNSP}/(\text{Kd-}D_{RNSP} + \text{Kp-}D_{RNSP})]$
FNSP (%) = $W_{NSP} \times [\text{Kd-}W_{NSP}/(\text{Kd-}W_{NSP} + 8)] + D_{NSP} \times [\text{Kd-}D_{NSP}/(\text{Kd-}D_{NSP} + \text{Kp-}D_{NSP})]$
with
Kd-W_{RNSP} = Kd-W_{NSP} = 2.5 × Kd-$D_{(R)NSP}$
Kd-D_{RNSP} = Kd-D_{NDF} = Kd-D_{NSP}
Kp-W_{RNSP} = Kp-W_{NSP} = 8%/h
Kp-D_{RNSP} (forages) = Kp-D_{NSP} = Kp-D_{NDF} = 1.39 + 0.1775 × Kd-D_{NDF}
Kp-D_{RNSP} (concentrates) = Kp-D_{NSP} = Kp-D_{NDF} = 1.855 + 0.1775 × Kd-D_{NDF}

Where Kp-W_{NSP}, Kp-W_{RNSP}, Kp-D_{NSP}, Kp-D_{RNSP}, are rumen passage rates (%/h) of, respectively, W_{NSP}, W_{RNSP}, D_{NSP}, and D_{RNSP}.

For most feedstuffs, the fitting of FRNSP data is problematic as for most feedstuffs the calculated degradability at the various incubation periods is highly variable and seldom continuously increases with longer rumen incubation time in an exponential way. Particularly when RNSP < 50 g/kg DM, degradability values are often completely out of the possible range. This makes it difficult to fit an exponential degradation curve and to obtain a Kd-D_{RNSP} value.

The goal of this short study is to:

1. show the high variability of rumen degradability of RNSP at various rumen incubation times and the absence of a clear continuous increase in rumen degradability at increasing incubation time.
2. propose a new approach to calculate FRNSP as FNSP – FNDF.

2 Results and Discussion

To show the difficulty of fitting RNSP-degradation data we looked at the ILVO rumen incubation data from common feedstuffs, collected from 1992 up to 2023. In Table 1 the RNSP content of common roughages and concentrates is presented as well as the calculated rumen degradability at rumen incubation times of 0, 8/12, 24, 48, 72 and 336 h. Negative degradability values were set at 0%, whereas degradability values > 100% were cut off at 100%.

Table 1 *RNSP content of common feedstuffs and rumen degradability (Deg.; %) at various incubation times; mean ± SD; (min – max).*

	RNSP **(g/kg DM)**	**Deg. 0h*** **(%)**	**Deg. 8/12h*** **(%)**	**Deg. 24h*** **(%)**	**Deg. 48h*** **(%)**	**Deg. 72h*** **(%)**	**Deg. 336h*** **(%)**
Grass silage (n=41)	106 ± 37 (46 – 198)	52 ± 28 (0 – 100) 5<0 1>100	51 ± 25 (1 – 88)	72 ± 14 (32 – 98)	82 ± 11 (61 – 100) 2>100	79 ± 12 (38 – 100) 1>100	76 ± 16 (30 – 99)
Grass clover silage (n=17)	138 ± 33 (99 – 223)	34 ± 13 (14 – 61)	51 ± 18 (25 – 100) 1>100	83 ± 11 (58 – 100) 1>100	84 ± 10 (64 – 100) 1>100	79 ± 15 (33 – 97)	88 ± 6 (77 – 100) 2>100
Fresh grass (n=10)	102 ± 43 (43 – 176)	71 ± 17 (33 – 100) 3>100	77 ± 6 (63 – 85)	87 ± 8 (75 – 100) 2>100	89 ± 9 (76 – 100) 2>100	Nd	84 ± 15 (53 – 99)
Grass hay (n=7)	58 ± 25 (37 – 101)	8 ± 12 (0 – 31) 4<0	57 ± 20 (36 – 90)	67 ± 13 (46 – 88)	75 ± 11 (60 – 95)	74 ± 10 (61 – 88)	73 ± 16 (50 – 100) 1>100
Maize silage (n=50)	85 ± 26 (28 – 132)	31 ± 30 (0 – 100) 14<0 1>100		55 ± 21 (0 – 100) 2<0 1>100	70 ± 14 (28 – 100)	72 ± 15 (16 – 96)	76 ± 17 (5 – 100) 2>100
Pressed beet pulp (n=11)	320 ± 46 (215 – 370)	4 ± 7	60 ± 23	94 ± 4	99 ± 1	99 ± 3	99 ± 3
Brewers grains (n=5)	-35 ± 20 (-69 - -16)						
Soybean meal (n=18)	171 ± 21 (130 – 204)	45 ± 9 (29 – 63)	93 ± 9 (77 – 100)	98 ± 2 (94 – 100)	99.7 ± 0.4 (99 – 100)	Nd	98 ± 2 (94 – 100)
Prot. soybean meal (n=18)	147 ± 55 (25 -208)	58 ± 24 (28 – 100)	85 ± 15 (65 – 100)	95 ± 7 (81 – 100)	97 ± 7 (78 – 100)	Nd	97 ± 5 (83 – 100)
Rapeseed meal (n=10)	113 ± 26 (62 – 147)	57 ± 20 (22 – 100)	79 ± 16 (61 – 100)	85 ± 17 (50 – 100)	88 ± 20 (39 – 100)	Nd	92 ± 14 (61 – 100)
Prot. rapeseed meal (n=13)	83 ± 38 (3 – 124)	56 ± 28 (27 – 100)	66 ± 25 (33 – 100)	87 ± 16 (57 – 100)	93 ± 10 (78 – 100)	Nd	97 ± 4 (88 – 100)
DDGS (n=21)	131 ± 23 (71 -178)	89 ± 25 (15 – 100) 16>100	90 ± 13 (60 – 100) 8>100	95 ± 6 (81 – 100) 5>100	98 ± 3 (87 – 100) 12>100	Nd	96 ± 2 (93 – 99)

*When the calculated degradability was negative, it was set at 0%, when degradability was > 100%, it was cut off at 100%.

Results in Table 1 show that W-RNSP fractions (=Deg. 0h) are high for most feedstuffs with a notable exception for pressed beet pulp (W_{RNSP} = 4%) and grass hay (W_{RNSP} = 8%). Furthermore, it appears that for roughages, degradation of RNSP mainly occurs up till 48 h after which hardly any degradation occurs, whereas for concentrate feedstuffs the bulk of RNSP is degraded during the first 24 h of incubation. The undegradable fraction after 14 d of incubation roughly amounts to 20% for roughages and 5% for concentrates. When the fractional degradation rate of RNSP is estimated based on the average RNSP degradation per feedstuff, this results in Kd-D_{RNSP} values of 5.4 %/h for grass silage, 7.8 %/h for grass clover silage, 10.1 %/h for fresh grass, 22.4 %/h for grass hay and 7.9 %/h for maize silage, 12.5%/h for pressed beet pulp, 21.4 %/h for soybean meal, 15.9 %/h for protected soybean meal, 14.1 %/h for rapeseed meal, 7.8% for protected rapeseed meal, and 5.4% for DDGS. For the roughages, grass hay excluded, a general mean Kd-D_{RNSP} of 8%/h and for concentrate feedstuffs a general mean Kd-D_{RNSP} value of 13%/h can be assumed.

In order to avoid the problems with fitting the degradation rate of the RNSP-fraction for feedstuffs with RNSP/NDF < 0.5, it is proposed to calculate the NSP-fraction of the feed as well as of the incubation residues and to derive the degradation characteristics of NSP.

In contrast with RNSP, the degradation of NSP and NDF increases in most cases continuously with longer rumen incubation time and the fitted exponential degradation curve has mostly a very high determination coefficient.
In Table 2 the contents (mean ± SD) of NDF, NSP and RNSP as well as the ratio RNSP/NDF are presented for common feedstuffs, studied at ILVO. Further, the rumen degradation characteristics of NDF and NSP are given.

Table 2 *Content and rumen degradation characteristics (washable fraction (W), undegradable fraction (U), the potentially degradable fraction (D) and the rumen degradation rate of D (Kd-D)) of NDF, NSP and RNSP for common feedstuffs; mean ± SD.*

	Nutrient	Content (g/kg DM)	W (%)	D (%)	U (%)	Kd-D (%/h)	Fermented (g/kg DM)
Grass silage (n=42)	NDF	452 ± 60	0.0	84.4 ± 5.8	15.6 ± 5.8	3.73 ± 1.07	242 ± 34
	NSP	555 ± 59	10.5 ± 7.1	72.7 ± 7.8	16.7 ± 5.9	3.81 ± 0.99	289 ± 30
	RNSP*	103 ± 39	53.3 ± 29.2				47 ± 26
	RNSP/NDF	0.24±0.11					
Grass clover silage (n=17)	NDF	439 ± 69	0.0	76.1 ± 9.3	23.9 ± 9.3	4.33 ± 0.87	221 ± 42
	NSP	569 ± 53	8.2 ± 4.4	70.8 ± 7.8	21.0 ± 6.8	4.72 ± 1.06	299 ± 30
	RNSP*	131 ± 38	34.9 ± 13.9				78 ± 29
	RNSP/NDF	0.32±0.15					
Fresh grass (n=10)	NDF	513 ± 31	0.0	87.3 ± 3.0	12.7 ± 3.0	4.23 ± 0.71	296 ± 18
	NSP	615 ± 53	8.8 ± 7.3	78.3 ± 7.9	12.9 ± 2.8	4.52 ± 1.00	353 ± 38
	RNSP*	102 ± 43	61.0 ± 46.5				57 ± 42
	RNSP/NDF	0.20±0.08					
Grass hay (n=7)	NDF	593 ± 34	0.0	74.1 ± 9.7	25.9 ± 9.7	2.13 ± 0.67	237 ± 46
	NSP	652 ± 42	0.6 ± 0.9	73.7 ± 9.0	25.7 ± 9.1	2.35 ± 0.61	270 ± 39
	RNSP*	58 ± 25	7.9 ± 12.3				33 ± 15
	RNSP/NDF	0.10±0.04					
Maize silage (n=50)	NDF	378 ± 28	0.0	68.3 ± 6.3	31.7 ± 6.3	1.76 ± 0.50	129 ± 19
	NSP	463 ± 39	6.3 ± 6.4	64.0 ± 7.4	29.7 ± 5.7	1.88 ± 0.50	162 ± 20
	RNSP*	85 ± 28	30.5 ± 30.0				34 ± 16
	RNSP/NDF	0.22±0.07					
Pressed beet Pulp (n=11)	NDF	442 ± 75	0.0	93.4 ± 1.2	6.6 ± 1.2	6.07 ± 2.09	280 ± 58
	NSP	762 ± 32	1.4 ± 2.8	94.0 ± 3.2	4.6 ± 1.3	8.49 ± 2.51	762 ± 36
	RNSP*	320 ± 46	3.5 ± 7.0				483 ± 68
	RNSP/NDF	0.76±0.22					
Brewers grains (n=5)	NDF	551 ± 35	0.0	68.3 ± 6.3	31.7 ± 6.3	4.29 ± 1.62	309 ± 51
	NSP	516 ± 20	5.7 ± 4.2	63.6 ± 10.6	30.7 ± 6.6	2.56 ± 0.71	516 ± 20
	RNSP*	-35 ± 20					207 ± 62
	RNSP/NDF	-0.06±0.03					
Soybean meal (n=18)	NDF	134 ± 18	0.0	92.1 ± 3.3	7.9 ± 3.3	4.66 ± 1.42	71 ± 8
	NSP	305 ± 23	25.1 ± 5.9	71.5 ± 6.3	3.4 ± 1.5	8.67 ± 2.76	210 ± 21
	RNSP*	171 ± 21	45.0 ± 11.2				134 ± 18
	RNSP/NDF	1.31±0.26					
Prot. soybean meal (n=18)	NDF	130 ± 59	0.0	93.3 ± 5.8	6.7 ± 5.8	4.56 ± 4.37	80 ± 42
	NSP	277 ± 18	30.8 ± 8.6	65.9 ± 8.1	3.3 ± 1.8	5.33 ± 1.96	170 ± 21
	RNSP*	147 ± 50	58.0 ± 23.7				93 ± 41
	RNSP/NDF	1.40±0.67					
Rapeseed meal (n=10)	NDF	286 ± 30	0.0	60.8 ± 8.9	39.2 ± 8.9	5.52 ± 2.03	113 ± 22
	NSP	399 ± 22	18.2 ± 8.5	49.3 ± 9.7	32.5 ± 4.5	5.82 ± 1.34	182 ± 20
	RNSP*	113 ± 26	61.8 ± 24.2				68 ± 27
	RNSP/NDF	0.40±0.12					
Prot. rapeseed meal (n=13)	NDF	308 ± 44	0.0	60.2 ± 4.5	39.8 ± 4.5	3.87 ± 1.45	104 ± 26
	NSP	391 ± 15	14.9 ± 3.7	53.4 ± 5.1	31.7 ± 2.8	4.20 ± 1.70	156 ± 24
	RNSP*	83 ± 38	62.2 ± 27.7				57 ± 17
	RNSP/NDF	0.29±0.15					
DDGS (n=22)	NDF	320 ± 48	0.0	87.9 ± 6.4	12.1 ± 6.4	3.82 ± 0.82	169 ± 33
	NSP	444 ± 30	31.5 ± 13.5	58.2 ± 14.7	10.2 ± 4.0	3.43 ± 1.30	217 ± 19
	RNSP*	125 ± 36	87.7 ± 25.6				49 ± 35
	RNSP/NDF	0.41±0.14					
Grains (rolled/meal) (n=6)	NDF	173 ± 58	0.0	81.0 ± 4.1	19.0 ± 4.1	7.49 ± 3.99	95 ± 40
	NSP	150 ± 39	10.0 ± 8.4	67.0 ± 5.5	22.9 ± 8.1	3.18 ± 1.10	63 ± 22
	RNSP*	-23 ± 27					
	RNSP/NDF	-0.12±0.16					

*FRNSP (g/kg DM) = FNSP – FNDF.

Results in Table 2 show that for all roughages: grass silage, grass clover silage, fresh grass, grass hay and maize silage the RNSP/NDF is lower than 0.5. This is also the case for (treated) rapeseed meal and DDGS. The ratio is more than 0.5 for pressed beet pulp and (treated) soybean meal. For brewers grains and rolled/ground grains the RNSP is even slightly negative.

With the rumen degradation characteristics of NDF and NSP the contents of fermented NDF and NSP are calculated and the difference between FNSP and FNDF results in the content of FRNSP.

From the W_{NSP}-content the W_{RNSP}-fraction can be calculated, which for most feedstuffs is quite high, probably because also NDF is partly washable, but in the present calculations set to 0, thus artificially increasing W of the RNSP fraction.

For most feedstuffs the rumen degradation values U and Kd of NDF and NSP are very similar within feedstuff, except for pressed beet pulp and (treated) soybean meal. These feedstuffs contain a high amount of RNSP.

3 Conclusions and proposal

For feedstuffs with RNSP/NDF < 0.5 (most roughages and concentrate ingredients), the distinction between NDF and RNSP and the separate calculation of the rumen degradation characteristics of RNSP to calculate FOM and estimate microbial protein is complicated and sometimes impossible. Moreover, this extra work matters little for the calculation of DVE and OEB as rumen passage rates of RNSP and NSP cannot reliably be estimated using a meta-analysis approach of rumen digestion studies. The RNSP and NSP flows to the small intestine of cows are not measured and the number of studies in which RNSP and NSP flows can potentially be estimated using assumptions for bacterial organic matter, endogenous organic matter, and rumen passage of dietary fat are few. Additionally the errors of RNSP and NSP flows are likely very large making it impossible to reliably estimate microbial protein efficiencies for NSP and RNSP.

It is therefore suggested to make some general assumptions with respect to determining FRNSP and the microbial protein efficiency of FRNSP.

The following calculations and assumptions are suggested for feedstuffs for which only rumen NSP degradation characteristics have been determined (RNSP/NDF < 0.5):

1. Recalculate in situ U-NDF and U-NSP percentages in the same manner as has been done before in the DVE-2007 system such as described above in this report as follows:
    a. W_{NDF} (%) = 0
    b. U_{NDF} (%) = U_{NSP} (%) × 100 / (100 – W_{NSP} (%))
    c. D_{NDF} (%) = 100 – W_{NDF} (%) – U_{NDF} (%)
    d. W_{RNSP} (%) = NSP (g/kg DM)/ RNSP (g/kg DM) × $W\text{-}_{NSP}$ (%)
    e. U_{RNSP} (%) = U_{NSP} (%) × (100 – W_{RNSP} (%)) / (100 – W_{NSP} (%))
    f. D_{RNSP} (%) = 100 – W_{RNSP} (%) – U_{RNSP} (%)
    g. Kd-D_{RNSP} (%/h) = Kd-D_{NDF} (%/h)= Kd-D_{NSP} (%/h)
2. Kd-W_{RNSP} is equal to the Kd-W_{starch}
3. Kp-W_{RNSP} is equal to Kp of rumen fluid
4. Kp-D_{RNSP} is equal to Kp-D_{starch}.
5. the microbial protein efficiency of FRNSP is equal to the microbial efficiency estimated for fermented starch as, Kd and W values for RNSP are more similar to starch than to NDF.

The following calculations and assumptions are suggested for feedstuffs for which both NSP and NDF rumen degradation characteristics have been determined (RNSP/NDF > 0.5):

a. calculate the FRNSP fraction as the difference between FNSP and FNDF.
b. For the W_{NSP} fraction it is assumed that Kd-W_{NSP} is equal to the Kd-W_{starch} and Kp-W_{NSP} is equal to Kp of rumen fluid
c. the microbial protein efficiency of FRNSP is equal to the microbial efficiency estimated for rumen fermented starch as Kd and W values for RNSP are more similar to starch compared to NDF.

References

CVB 2003. Protocol for *in situ* rumen incubations: determination of degradation rate and washable fractions of protein starch, cell walls and organic residual fraction. In Dutch [Protocol voor *in situ* pensincubatie: bepaling van afbraaksnelheid en uitwasbare fracties van eiwit, zetmeel, celwanden en organische restfractie]. Centraal Veevoederbureau, Lelystad, The Netherlands.

CVB 2007. Protein evaluation system for ruminants: the DVE/OEB 2007 system. CVB-Documentation report nr. 53.

Tamminga S, Van Straalen WM, Subnel APJ, Meijer RGM, Steg A, Wever CJG, Blok MC 1994. The Dutch protein evaluation system: the DVE/OEB-system. Livestock Production Science 40, 139-155.

Van Duinkerken G., Blok M.C., Bannink A., Cone J.W., Dijkstra J., Van Vuuren A.M., Tamminga S. 2011. Update of the Dutch protein evaluation system for ruminants: the DVE/OEB_{2010} system. J. Agric. Sci. 149, 351-367.

To explore the potential of nature to improve the quality of life

Wageningen Livestock Research
P.O. Box 338
6700 AH Wageningen
The Netherlands
T +31 (0)317 48 39 53
E info.livestockresearch@wur.nl
www.wur.nl/livestock-research

Wageningen Livestock Research creates science based solutions for a sustainable and profitable livestock sector. Together with our clients, we integrate scientific knowledge and practical experience to develop livestock concepts for future generations.

Wageningen Livestock Research is part of Wageningen University & Research. Together we work on the mission: ‘To explore the potential of nature to improve the quality of life’. A staff of 6,500 and 10,000 students from over 100 countries are working worldwide in the domain of healthy food and living environment for governments and the business community-at-large. The strength of Wageningen University & Research lies in its ability to join the forces of specialised research institutes and the university. It also lies in the combined efforts of the various fields of natural and social sciences. This union of expertise leads to scientific breakthroughs that can quickly be put into practice and be incorporated into education. This is the Wageningen Approach.