Update/validation of the DVE/OEB system

12-12-2019, Dorien Van Wesemael en Wouter Spek

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5. Overview first meta-analysis results (Dorien)

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1. Overview DVE/OEB 1991 and 2007 system

1. Overview DVE/OEB 1991 and 2007 system (1)

DVE = DVBE + DVME – DVMFE

OEB = MREN - MREE

1. Overview DVE/OEB 1991 and 2007 system (2)

DVE = DVBE + DVME – DVMFE

- "darmverteerbaar metabool fecaal eiwit"
- Endogenous losses

DVMFE
= 0,075 * ODS
= 0,075 * (DS-VOS-VRAS)

- Changes in 2007 system:
  - No differences

DVMFE
= 0,075 * ODS
= 0,075 * (DS-VOS-VRAS)

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1. Overview DVE/OEB 1991 and 2007 system (3)

DVE = DVBE + DVME – DVMFE

- "darmverteerbaar bestendig voedereiwit"

DVBE-91
= RE x 1,11 x %BRE x %DVBE

- Changes in 2007 system:
  - No correction factor

DVBE-07
= RE x %BRE x %DVBE

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1. Overview DVE/OEB 1991 and 2007 system (4)

DVE = DVBE + DVME – DVMFE

- "darmverteerbaar microbieel eiwit"

DVME
= 0,75 * 0,85 * MREE

- MREE = microbial protein based on available energy, fixed amount (150 g) per kg FOS

  MREE = 0,15*FOS

- Changes in 2007 system:
  - Calculation of MREE

DVME
= 0,75 * 0,85 * MREE

- Microbial growth depends on type of fermented substrate

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1. Overview DVE/OEB 1991 and 2007 system (5)

Fermented feed components

- Fermentation is the result of two factors:
  - Degradability of the nutrient (kd)
  - Intensity and duration of degradation, determined by the passage rate (kp)
- Feed components (CP, STA, NDF, …) are composed of different fractions:
  - U = rumen undegradable fraction
  - D = fraction potentially degradable in the rumen
  - W = washable fraction, particles < 40 µm
    - S = soluble fraction within W
    - (W-S) = small particles

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1. Overview DVE/OEB 1991 and 2007 system (6)

DVE = DVBE + DVME – DVMFE

- "darmverteerbaar microbieel eiwit"

MREE
= 0,15*FOS

- Changes in 2007 system:
  - Calculation of MREE

MREE
= 0,174*F_SSU + 0,166*$F_{(W-S)}$STA
+ 0,253*F_DSTA + 0,138*F_DNDF
+ 0,145*$F_{(W-S)}$RNSP + 0,168*F_DRNSP
+ 0,099*F_SCP + 0,082*$F_{(W-S)}$CP
+ 0,110*F_DCP + 0,087*F_SFP

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2. Experiment to measure microbial-N efficiency

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2. Experiment to measure microbial-N efficiency (1)

- Aim: to estimate the microbial N efficiency for rumen fermented starch and fibre and to determine the microbial N efficiency for rumen fermentation of maize silage relative to grass silage
- 4 diets:
  - Grass silage only
  - Grass silage + maize silage
  - Grass silage + soybean hulls
  - Grass silage + maize meal
- 4 x 4 Latin square design
- 12 animals (3 with a rumen fistula)

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2. Experiment to measure microbial-N efficiency (2)

	GS	GS+ MS	GS + SBH	GS + MM
Planned DMI (kg/d)				
grass silage A	15.5	5.5	12.0	12.0
Maize silage		9.3		
Maize meal				7.3
soya bean hulls			8.0	0.0
Urea		0.090		0.050
Megalac	0.300		0.320	
Premix	0.075	0.075	0.075	0.075
Total	15.9	15.0	20.4	19.4
Planned intake rumen fermentable nutrients (g/d)				
Starch	**0**	**2706**	**48**	**3327**
CP	2056	1397	2017	1969
Sugar	957	393	840	852
OM	**7797**	**7798**	**10116**	**10113**
NSP	**4783**	**3331**	**7211**	**3966**
VEM intake (/d)	13789	13784	19012	19006
Nutrient concentrations (g/kg DM) unless otherwise mentioned				
VEM (/kg DS)	869	921	932	979
DVE	78	62	79	91
OEB	53	10	22	11
CP	197	133	163	163
RUP	65	39	63	62

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2. Experiment to measure microbial-N efficiency (3)

- 18 days of adaptation per period
- 3 measurement days per period
- Measurements during measurement period:
  - DMI
  - Milk production + sampling
  - Total collection of faeces + sampling
  - Total collection of urine + sampling
  - In situ incubation of grass silage, maize silage, maize meal and soybean hulls (0, 4, 8, 24, 72 and 336 h)

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2. Experiment to measure microbial-N efficiency (4)

- Analysis:
  - Feedstuffs: DM, Ash, CP, NDF, Starch, Sugar
  - Milk: fat, protein, lactose, urea
  - Faeces: DM, Ash, NDF, Starch
  - Urine: N, purine derivatives (allantoin, uric acid)
  - Incubation residues: DM, Ash, CP, NDF, Starch
  - Rumen fluid: ammonia, pH

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2. Experiment to measure microbial-N efficiency (5)

- Calculations
  - Rumen in situ degradation rates of DM, OM, CP, Starch and NDF; W and U fractions for the various feedstuffs
  - Amount of rumen fermented OM, CP, NDF, Starch, Sugar and rest fraction based on:
    - In situ degradation results
    - Predicted passage rates of nutrients
  - Amount of metabolizable bacterial protein
    - Predicted from amount of purine derivatives excreted in urine

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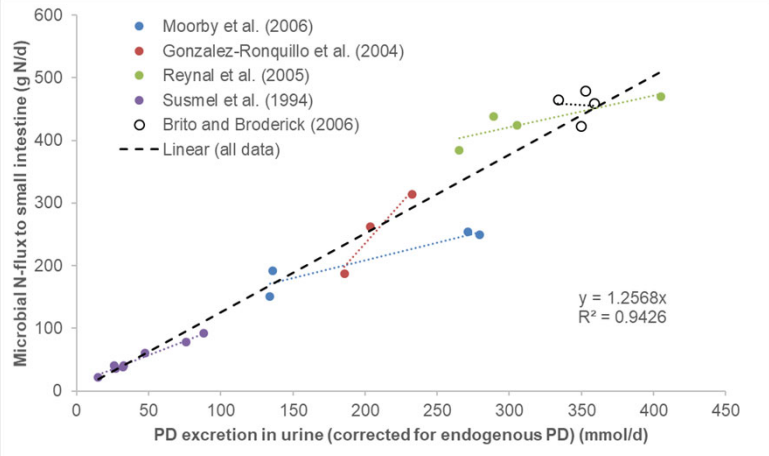
2. Experiment to measure microbial-N efficiency (6)



Slope becomes 0.760 when accounting for random experiment effect

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2. Experiment to measure microbial-N efficiency (7)

Acknowledgements

- Innovation program funds Dairy Campus
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3. Meta-analysis (database with digestion trials)

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3. Meta-analysis (database with digestion trials) (1)

- 84 studies with dairy cattle
- 384 diets (3442 feedstuffs)

		Rumen digestibility				
	Studies	Diets	NDF	Starch	CP	OM
Asia	1	4			4	4
EU	35	174	67	51	69	77
NA	48	206	184	129	151	158
Total	84	384	251	180	224	239

		Faecal digestibility				
	Studies	Diets	NDF	Starch	CP	OM
Asia	1	4				
EU	35	174	153	65	147	168
NA	48	206	171	107	157	157
Total	84	384	324	172	304	325

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3. Meta-analysis (database with digestion trials) (2)

- 240 observations for microbial protein
  - 76 (EU); 160 (NA); 4 (Other countries)

			CP		NDF		Starch	
	Studies	Diets	Average	Stdev.	Average	Stdev.	Average	Stdev.
Asia	1	4	160					
EU	35	174	171	29.1	395	54	163	163
NA	48	206	174	17.8	319	54	274	274
Total	84	384	172	23.6	355	66	225	225

	% Grass silage		% Maize silage		% Legumes		% Roughage	
	Gemiddeld	Stdev.	Gemiddeld	Stdev.	Gemiddeld	Stdev.	Gemiddeld	Stdev.
Asia	0		0		0		30	
EU	29	28.4	7	20.2	3	12.5	65	17.8
NA	2	9.1	16	15.2	26	17.2	48	12.0
Total	14	24.4	12	18.1	15	19.0	56	17.3

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4. Validation/update of the DVE/OEB system

4 A. Estimating Kp rates of nutrients (1)

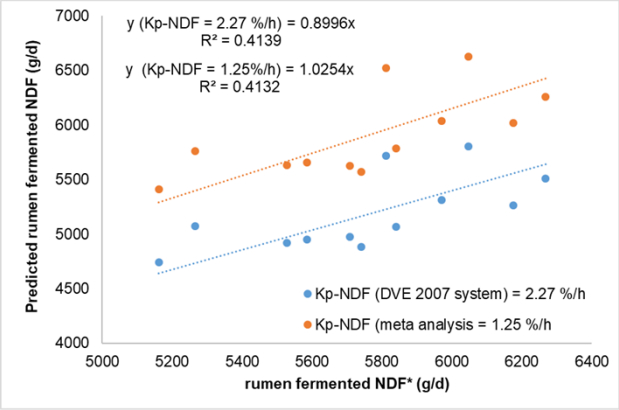
Rumen fermented nutrient = Nutrient × Kd/(Kd + Kp)

Goal: accurate prediction of amount of fermented nutrients in the rumen:

- By using CVB Table Matrix values of in situ degradation characteristics of feedstuffs (W, U, D, and Kd values)
- By adjusting Kp values of nutrients
  - Based on level of feed intake
  - Type of nutrient (NDF versus other nutrients)
  - Type of feedstuffs (concentrates vs roughages)

4 A. Estimating Kp rates of nutrients (2)

Example data study of Valk et al. (2000) on fresh grass



*rumen fermented NDF calculated as 0.92*total tract digestible NDF

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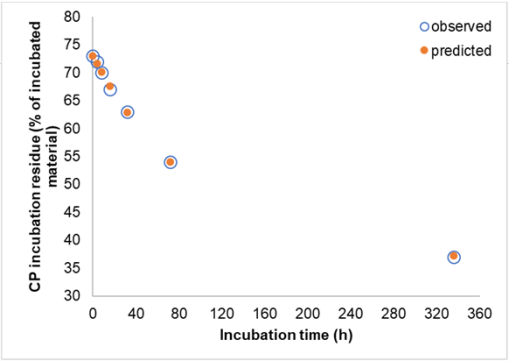
4 B. Correcting in situ CP residue values for microbial contamination (1)

- U-CP = 36%
- W-CP = 27%
- D-CP = (100 – U – W)
- Kd-CP = 0.01/h



- CP-res (%) = U-CP + D-CP×exp(-Kd*incubation time (h))
- %RUP = U-CP + D-CP ×(Kp/(Kp+Kd)) + 0.05×W-CP

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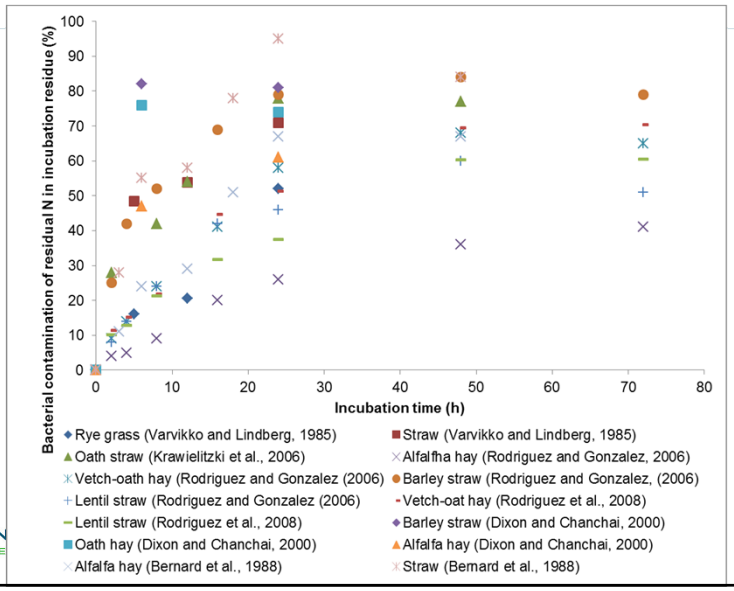
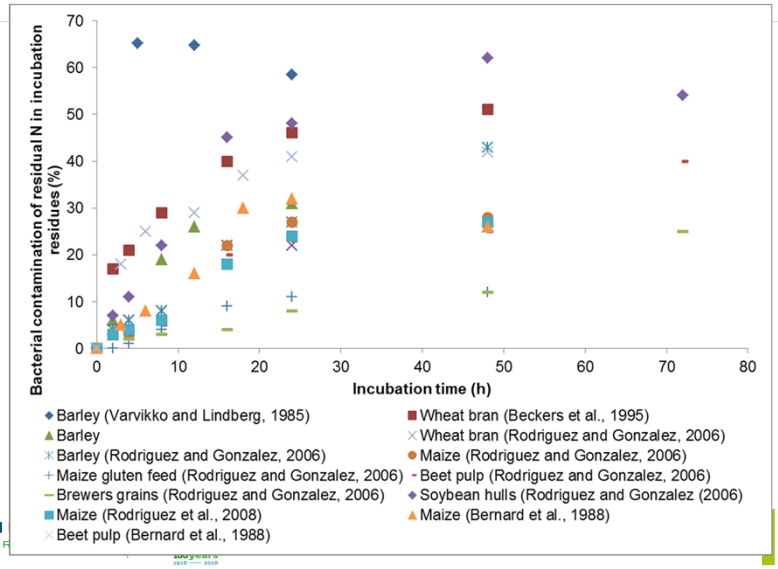
4 B. Correcting in situ CP residue values for microbial contamination (2)



4 B. Correcting in situ CP residue values for microbial contamination (3)



4 B. Correcting in situ CP residue values for microbial contamination (4)

Model:

- Bacterial N cont. (%) = a*NDF (g/kg DM) + b*CP (g/kg DM) + c*(1-exp(-d*incubation time)) + random experiment effect

Model parameter	**Concentrate Feedstuffs**	**Roughage Feedstuffs**
a	0.0275	0.0208
b	-0.1012	-0.0954
c	36.1	67.0
d	0.0681	0.0994
Observations	85	85
R^2	0.72	0.82

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4 B. Correcting in situ CP residue values for microbial contamination (5)

- Effect of correction for bacterial protein on rumen in situ degradation characteristics of CP in **grass** silages (n=101)

	uncorrected			corrected		
	D-CP (%)	Kd-CP (/h)	U-CP* (%)	D-CP (%)	Kd-CP (/h)	U-CP (%)
Average	30	0.064	22	44	0.106	8
Stdev	10.6	0.0286	6.6	9.9	0.0292	2.2
Min	3	0.009	9	20	0.053	4
Max	55	0.153	42	73	0.182	14

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4 B. Correcting in situ CP residue values for microbial contamination (6)

- Effect of correction for bacterial protein on rumen in situ degradation characteristics of CP in **maize** silages (n=100)

	uncorrected			corrected		
	D-CP (%)	Kd-CP (/h)	U-CP (%)	D-CP (%)	Kd-CP (/h)	U-CP (%)
Average	19	0.020	28	35	0.068	9
Stdev	9.8	0.0117	5.3	8.3	0.0116	1.5
Min	3	0.003	14	19	0.029	5
Max	54	0.059	42	66	0.103	12

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4 C. Estimation of microbial-N efficiencies of rumen fermentable nutrients

- Prediction of rumen fermented fractions of OM, CP (accounting for endogenous rumen protein flow), NDF, Starch, Sugar and RNSP fraction
- Estimation of microbial nitrogen efficiency of rumen fermentation of Starch and NDF (results experiment)
- Meta analysis: regressing measured/predicted rumen fermented fractions against measured rumen microbial protein yields

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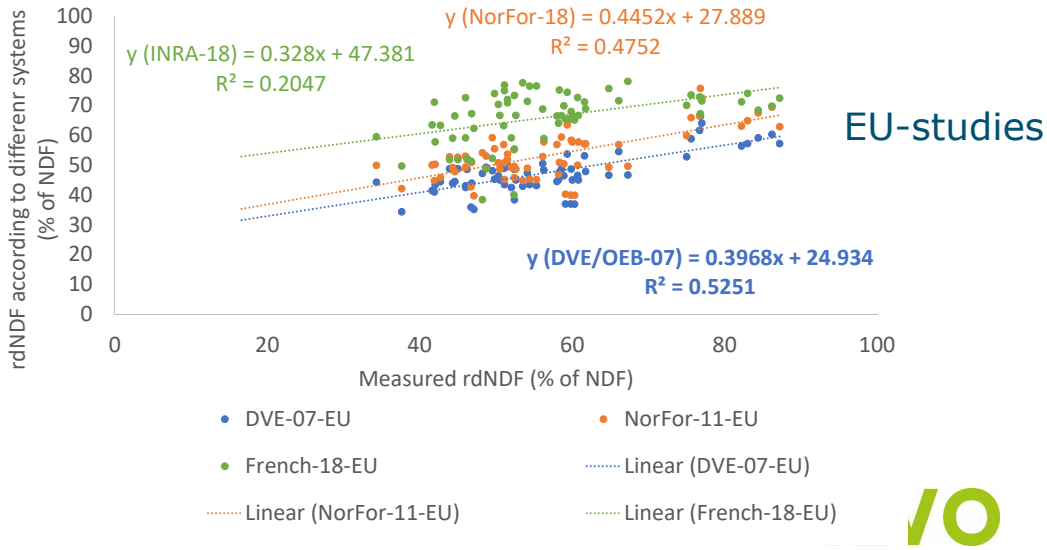
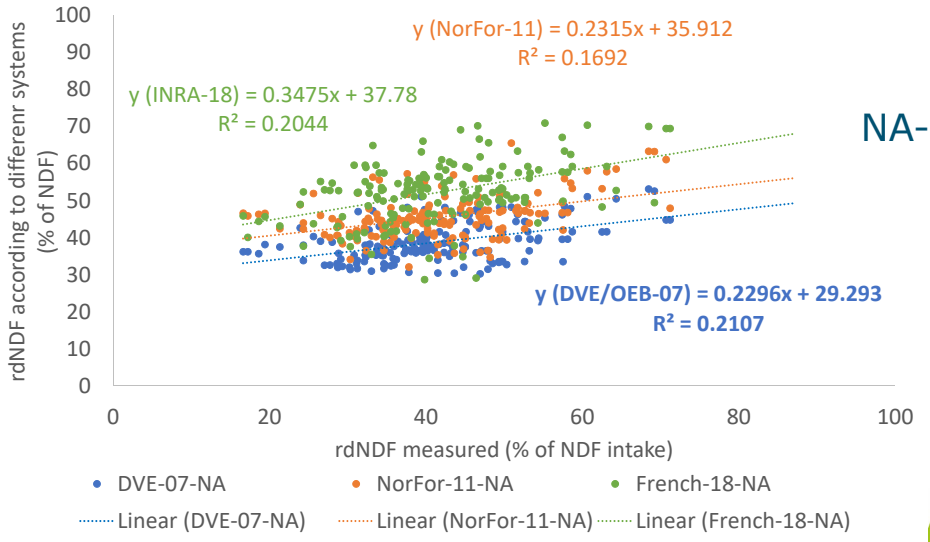
5. Overview first meta-analysis results

5. Overview first meta-analysis results (1) - NDF



EU-studies

5. Overview first meta-analysis results (2) - NDF



NA-studies

5. Overview first meta-analysis results (3) - NDF

rdNDF according to DVE/OEB 2007 system

- rdNDF (%DM) = D-NDF * [kd-NDF / (kd-NDF + kp-NDF)]
- kp-NDF-concentrate (%/h) = 1.855 + 0.1775 x kd-NDF
- kp-NDF-roughage (%/h) = 1.390 + 0.1775 x kd-NDF

Kd-NDF and D-NDF: specific for individual feedstuffs

Kp-NDF: needs to be adjusted

5. Overview first meta-analysis results (4) - NDF

Kp-formulas in other systems

- NorFor-2011 (Volden and Larsen 2011)
  - Kp-NDF$_{concentrate}$ (%/h) = (2.504 + 0.1375 x (DMI (kg/d) x 1000) /BW (kg) – 0.02 x concentrate ratio (% of DM) x 0.43
  - Kp-NDF$_{roughage}$ (%/h) = 0.480 + 1.5106 / (1+(((DMI (kg/d) x NDF intake (g/kg DMI))/(BW (kg) x 7.484))^-3.198)

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5. Overview first meta-analysis results (5) - NDF

Kp-formulas in other systems

- Frans Systali systeem (2016)
  - Kp-ruwvoer (%/uur) = 2.02 + 0.88 * DSO (% van LG) - 3.13 * concentrate ratio^2 (ratio)
  - Kp-krachtvoer (%/uur) = 2.53 + 1.22 * DSO (% van LG) - 2.61 * concentrate ratio^2 (ratio)

- DMI and concentrate or roughage ratio are included!

  ↔ DVE/OEB systems

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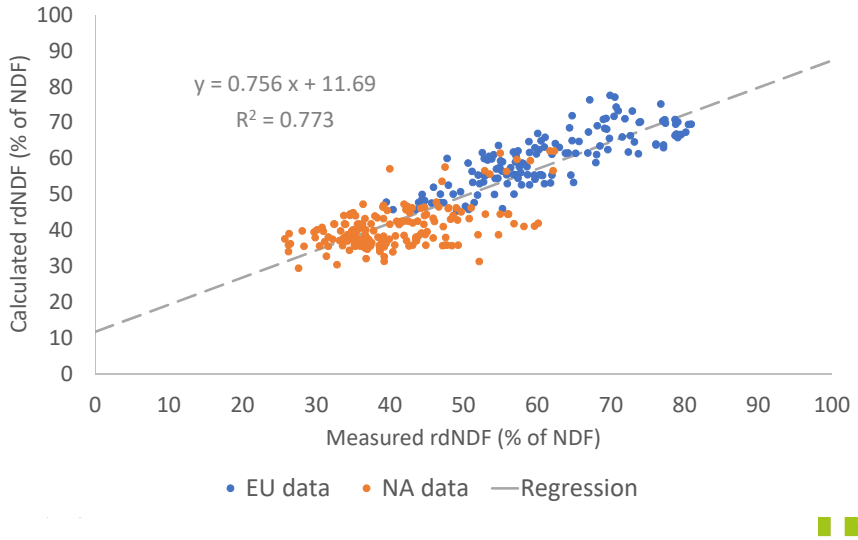
5. Overview first meta-analysis results (6) - NDF

Models based on all data

Kp-NDF-roughage
= 1,20 + 1,86*leguminous – 0,84*hay/straw

Kp-NDF-concentrate
= 3,10

5. Overview first meta-analysis results (7) - NDF



5. Overview first meta-analysis results (8) - STA

rdSTA according to DVE/OEB 2007 system

rdSTA (%DM) = D-STA * [Kd-D-STA / (Kd-D-STA + Kp-D-STA)]
+ W-STA * [Kd-W-STA / (Kd-W-STA + Kp-W-STA)]

Kp-D-STA-concentrate (%/h) = 6 = Kp-D-STA-roughage (%/h)
Kp-W-STA (%/h) = 8
Kd-W-STA = 2 x Kd-D-STA + 37,5

Kp: fractional passage rate
Kd: fractional degradation rate
D-STA: potentially degradable fraction of starch
W-STA: washable fraction of starch
(rd = rumen degraded)

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5. Overview first meta-analysis results (9) - STA

Kp-W-STA
= 5,35 + 2,18 x DMI (%BW) – 3,71 x concentrate ratio

For EU-data:
Kp-D-STA-roughage = 2,06% h^{-1}
Kp-D-STA-concentrate = 4,37% h^{-1}
Kd-W-STA-roughage = 119% h^{-1}
Kd-W-STA-concentrate = 119 % h^{-1}

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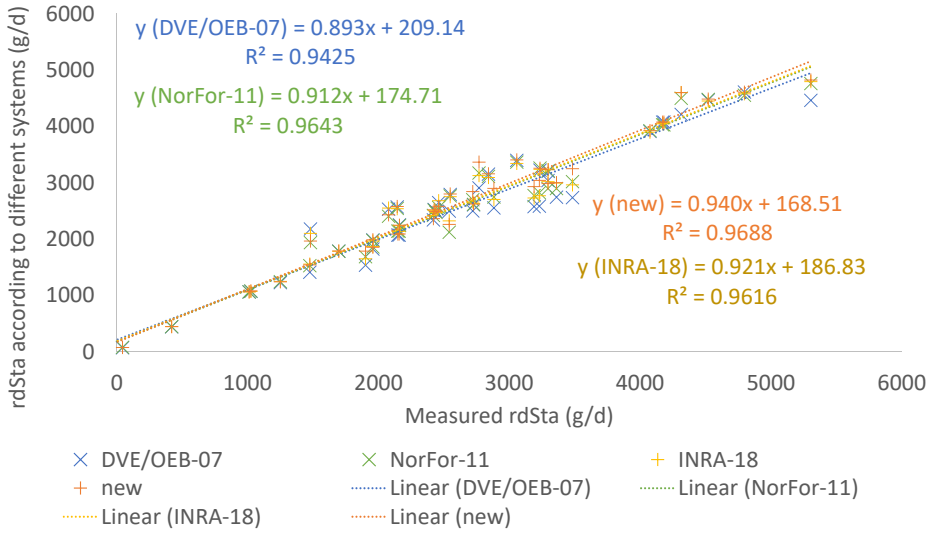
5. Overview first meta-analysis results (10) - STA



5. Overview first meta-analysis results (11) - STA

NA-studies

	Kp_D-starch of roughage formula			Kp_D-starch of concentrate formula				Kd_W-starch of roughage	Kd_W-starch of concentrate	Regression rdSta measured VS estimated		
Model number	Intercept	DMI (% BW)	Concentrate ratio	Intercept	DMI (% BW)	Concentrate ratio	Not ground starch	Intercept	Intercept	Slope	Intercept	R^2
DVE/OEB 2007	6			6				2 x Kd_D-starch +37.5	2 x Kd_D-starch +37.5	0.467	2190	0.359
19	-0.55			1.82				0.38	0.38	0.488	1696	0.454
20	0.001*			1.83				0.81	0.81	0.487	1701	0.453
21	-2.25			1.69				-3.53	2.02	0.520	1585	0.468
22	0.001*								76	0.492	1684	0.455
23	-6.74	1.79		3.03	-0.37			0.20	0.20	0.489	1692	0.455
24	0**	-0.12		1.46	0.11			0.52	0.52	0.485	1704	0.453
25	-5.59	0.94		2.35	-0.20			-3.80	2.29	0.522	1577	0.471
26	0**	-0.58		0.02	0.50			-3.06	2.25	0.506	1629	0.464
27	0**	-0.58			0.51			-3.06	2.26	0.506	1629	0.464
28	2.70		-8.97	6.12		-6.54		0.14	0.14	0.534	1522	0.488
29	0.24		-5.87	5.42		-5.57		-3.41	2.33	0.569	1400	0.504
30	4.52		-12.75	7.15		-3.50	-0.03	2.85	2.85	0.525	1566	0.522
31	1.98		-9.00	6.45		-3.03	-0.03	-1.27	5.10	0.550	1478	0.529

=> Strange models!

* 0.001 defined as the minimum value ** 0 defined as the minimum value

Thank you

Questions?

Wouter Spek (WUR)
Dorien Van Wesemael (ILVO)
http://www.cvbdiervoeding.nl/

Thanks to Anne-Laure Brizion for the meta-analysis work

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CVB voor waardevolle voederwaarden

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