Equation changes since NorFor 2011 (EAAP No.130)

2014-12-23, 2016-09-15, 2016-10-15; 2017-03-09; 2017-12-28 ($iNDF_{504}$); 2019-09-16; 2019-09-17; 2020-01-27; 2020-05; 2020-10-11; 2021-10-12; 2022-01-21

Content

Chapter 3 Animal input and characteristics

Table 3.1 New input data for cows in NorFor

Input data	unit
Body condition score at calving, BCS_calv	BCS
Body condition score at drying off, BCS_end	BCS

Table 3.5. Default values for BW_birth, BW_mat for heifers, bulls and steers (kg), and kg_BCS for cows

Breed	BW_birth heifer	BW_birth bull	BW_mat heifer	BW_mat bulls	BW_mat steers	kg_BCS for cows
Early maturing dairy breeds						
Danish HO	40	41	640	950	750	60
Danish Red	40	41	660	950	750	60
Icelandic breed	33	33	470	800	700	45
Jersey	28	30	440	650	550	30
Norwegian Red	39	41	600	950	750	60
Swedish HO	39	41	640	950	750	60
Swedish Red	39	41	620	950	750	60
Crossbred of two large dairy breeds	39	40	630	950	750	60
Crossbred of Jersey and a large dairy reed	34	35	540	800	650	45
Early maturing beef breeds						
AA	36	38	650	950	750	60
BSH, Beef short horn	38	40	650	1100	900	60
BSW, Brown Swiss	38	40	650	1000	800	60
DEX	21	24	300	450	400	30
GAL	34	35	500	850	750	50
GVH, Gelbvieh	38	40	700	1100	900	60
HRF	40	42	700	950	750	60
HIG	29	30	500	700	600	50
PIN, Pinzgauer	38	41	750	1150	900	60
TIR	39	42	650	950	750	60
Late maturing beef breeds						
BB	44	47	750	1200	1050	70
BLO	44	47	800	1200	1050	70
CHA	46	49	800	1200	1050	70
CHI	50	55	850	1200	1050	70
LIM	41	43	700	1200	1050	60
PIE	41	43	600	1200	1050	60
SAL	39	41	750	1200	1050	70
SIM	44	46	750	1200	1050	70
WAG, Wagyu	34	36	700	1100	900	60
Early x Late maturing breeds						
Crossbred	42	44	750	1050	950	60

Chapter 4 Feed fraction characteristics

Eq 4.5 kdRestCHO=60

Where kdRestCHO is the degradation rate of the rest carbohydrate fraction (eq 4.1) (%/h). the degradatuion rate is generally set to 60%/h, with exception for some feedstuffs, e.g. dried beet pulp (both molassed and unmolassed), molasses, propylene glycol, propionic acid, glycerol where the rate is set to 150%/h.

NEW eq.4.8

$$IV = (\mathrm{C18\_1} \cdot 89.8 + \mathrm{C18\_2} \cdot 2 \cdot 89{,}8 + \mathrm{C18\_3} \cdot 3 \cdot 89.8 + \mathrm{C20\_5} \cdot 5 \cdot 81.7 + \mathrm{C22\_6} \cdot 6 \cdot 75)/100$$

Where IV is the iodine value of the feed stuffs fatty acids (g/100g FA), C18_1, C18_2, C18_3, C20_5 and C22_6 are the concentration of the fatty acids oleic acid, linoleic acid, linolenic acid EPA and DHA (g/100g FA).

Chapter 5 Feed Analyses and Digestion Methods

5.1.1 Dry Matter in roughage

Eq. 5.7 this value on DM should the laboratory send to the NorFor Feed Analysis System (FAS)

5.2.2 Rumen degradation of starch

Eq. 5.25

$$kdST = (\mathrm{r\_kpc} \times rSTD)/(1000 - rSTD)$$

Where kdST is the degradation rate for starch (%/h), r_kpc is the ruminal passage rate for starch described in equation 13.4 and 13.5 (for DMI_{std} of 20 kg, 6,087 and 4,479 %/h respectively) and rSTD is the ruminal digestibility (g/kg starch). But if starch content is less than 60 g per kg DM and there is no scientifically rSTD then set kdST to 25% per hour

It is stated that soluble starch is zero and all starch is potentially degradable

Eq.5.26 pdST=1000, sST=0

5.2.3 Indigestible NDF

Eq 5.27 a

For individual concentrate feedstuffs the iNDF is still measured as the NDF residue in an *in situ* nylon bag after 288 h (as described in NorFor, 2011)

$$iNDF = 〖NDF〗\_288/\mathrm{NDF} \times 1000$$

Eq 5.27b

If the roughage sample includes more than 50% legume plants then the iNDF is calculated as

$$iNDF = (940 - 10.6 \times \mathrm{OMD} - 0.517 \times \mathrm{Ash})/\mathrm{NDF} \times 1000$$

Eq 5.27c

If the roughage sample includes less than 50% legume plants then the iNDF is calculated as

$iNDF = (506 - 5.60 \times \mathrm{OMD} - 0.159 \times \mathrm{Ash})/\mathrm{NDF} \times 1000$

Where OMD is the organic matter digestibility in vivo (%) described in eq 5.12 to 5.18. Ash is the ash content (g/kg DM) and NDF is the NDF content (g/kg DM)

There is an exception when the calculation leads to less than 20 g iNDF per kg DM, then the feedstuff gets the value:

Eq 5.27d

$iNDF = 1000 \times 20/\mathrm{NDF}$

$iNDF_{288} = 1000 - \left((1000 - \mathrm{iNDF}_{504}) \times 0.997 - 15.5\right)$

according to Krämer et al (2012)

5.2.4 Indigestible starch

Eq. 5.29 iST=1000-STD

Where iST is the indigestible starch (g/kg ST), STD is the total tract starch digestibility (g/kg ST)

References

Krämer et al, 2012. Anim Feed Sci Tech 177:40-51

Chapter 6 Feed calculations in NorFor

In the calculation of kdNDF

Eq. 6.3

Where …; OMD is organic matter digestibility expressed as g/g; …

Eq 6.7

$pdNDFcorr = 1000 - iNDF$

Where iNDF is the indigestible NDF (g/kg NDF) described in eq 5.27 b, c and d

Eq 6.10

$$FV = \frac{0.86 - OMD \cdot 0.005}{0.94 + 0.56 \cdot exp^{-0.000029 \cdot \left(\frac{NDF}{10}\right)^{2.9}}} \cdot corr$$

(Clarifying Euler’s constant e to exp)

Where …; corr is a correction factor explained in eq 6.11.

Eq 6.11

$$corr = \left(1 - \left(\frac{-0.000531 \cdot \left((TAF)^2 - 6400\right)}{100} + \frac{-4.765 \cdot (ln(NH_3N) - ln(50))}{100}\right)\right)$$

Where corr is a correction factor when fill value (equation 6.10) is corrected for silage fermentation products. TAF is the content of total fermentation acids in the ensiled feed, g/kg DM, Equation 4.6 ; and NH_3N of ammonia N in the ensiled feeds, g/kg N. When TAF is lower than 80 g/kg DM the value 80 should be used. When NH_3N is lower than 50 g/kg N the value 50 should be used. The factor corr is equal to 1 when both TAF is less than 80 g/kg DM and NH_3N is less than 50 g/kg N.

Chapter 7 Digestion and metabolism in the gastroinestinal tract

7.1 Rumen

A linear passage rate for roughage NDF was developed by Åkerlind *and* Nielsen (2019) based on 290 feeding trials.

Eq. 7.5 $r\_kpNDFr = 0.7792 + 0.09296 * NDF\_BW$

Where r_kpNDFr is the fractional passage rate of pdNDF in roghage particles, %/h : NDF_BW is the NDF intake per kg current body weight, g/kg.

Eq. 7.33b $r\_mRestCHO = r\_mCP \cdot 270\ /512$

Where r_mCP and r_mRestCHO are the microbial crude protein and microbial rest fraction in the rumen where CP and restCHO represent 512 and 270 gram per kg microbial organic matter respectively

7.2 Small intestine

Eq 7.40.

$$sid\_ST = \left(\sum_i (DMI_i \cdot ST_i) - rd\_ST - \sum_i \left(DMI_i \cdot ST_i \cdot \frac{iST_i}{1000}\right)\right) \cdot \left(0.0052 \cdot \frac{100 \cdot rd\_ST}{\sum_i (DMI_i \cdot ST_i)} + 0.2864\right)$$

Where DMI_i is the dry matter intake of the i'th=1… feedstuff (kg /day), ST_i is the starch content (g/kg DM), rd_ST is the rumen degraded starch (g/day) described in eq 7.14 an iST_i is the indigestible fraction of starch (g/kg ST).

7.3 Large intestine

Eq 7.49

$$lid\_ST = \left(\sum_i (DMI_i \cdot ST_i) - rd\_ST - \sum_i \left(DMI_i \cdot ST_i \cdot \frac{iST_i}{1000}\right)\right) \cdot \left(-0.0052 \cdot \frac{100 \cdot rd\_ST}{\sum_i (DMI_i \cdot ST_i)} + 0.7136\right)$$

Where DMI_i is the dry matter intake of the i'th=1… feedstuff, kg/day; ST_i is the starch content, g/kg DM; rd_ST is the rumen degraded starch, g/day, described in eq 7.14 and iST_i is the indigestible fraction of starch, g/kg ST.

A fixed value of 100 g/kg degraded carbohydrates is used for the efficiency of microbial protein synthesis in the large intestine (Dierick *et al.*, 1990)

Eq 7.50 $li\_mCP = (lid_{NDF} + lid_{ST} + r\_mST \cdot 0.1 + \mathrm{r}\_mRestCHO \cdot 0.75) \cdot 0.10$

Where li_mCP is the microbial protein synthesis in the large intestine, g/d; lid_NDF is the degraded NDF in the large intestine, g/d, eq 7.48; lid_ST is the degradation of starch in the large intestine, g/d, eq7.49, r_mST is the microbial synthesised starch in the rumen, g/d, eq 7.33; the factor 0.1 is related to 10% of the rumen synthesised starch is degraded in the large intestine eq7.33; r_mRestCHO is the microbial synthesised rest fraction i.e. cell walls, g/d, eq7.33b; the factor 0.75 is related to the proportion of the cell walls is digested in the large intestine; the factor 0.10 is the efficiency of microbial protein synthesis in the large intestine

Eq 7.51a $li\_mOM = li\_mCP \cdot 1000/512$

Eq 7.51b $li\_mCFat = li\_mCP \cdot 167/512$

Eq 7.51c $li\_mST = li\_mCP \cdot 51/512$

Eq 7.51d $li\_mRestCHO = li\_mCP \cdot 270/512$

Where li_mOM, li_mCP, li_mCFat, li_mST, li_mRestCHO are the microbial organic matter, microbial crude protein, microbial crude fat, microbial starch and microbial rest fraction in the large intestine where CP, CFat, ST and restCHO represent 512, 167, 51 and 270 gram per kg OM respectively

Eq. 7.52 $td\_CP = \sum_i(DMI_i \cdot CP_i) - (\sum_i(DMI_i \cdot CP_i) - rd\_CP - sid\_CP + r\_mCP + r\_outOM \cdot 0.03 \cdot 3 \cdot 0.4 + si\_outOM \cdot 0.009 + li\_mCP)$

Where td_CP is the apparent total tract digestion of crude protein, g/d; DMI_i is the dry matter intake of the i=1…n'th feedstuff, kg/d; CP_i is the crude protein content in the i=1…n'th feedstuff, g/kg DM; rd_CP is the rumen degraded crude protein, g/d, eq 7.8; sid_CP is the small intestine digested crude protein, g/d, eq 7.37; r_mCP is the rumen microbial synthesised crude protein eq 7.30; r_outOM is the flow of oerganic matter from rumen into the small intestine, g,/d, eq 7.36; si_outOM is the flow of organic matter from the small intestine into the large intestine, g/d, eq 7.47; the factors 0.03, 3 and 0.4 is the are explained in eq 7.47

In equation 7-52, 9 g protein per kg OM flowing into the large intestine is used as an estimate of endogenous protein excretion in the large intestine (Marini et al., 2008)

Eq. 7.54 $td\_CPcorr = \sum_i(DMI_i \cdot CPcorr_i) - (\sum_i(DMI_i \cdot CP_i) - rd\_CP - sid\_CP + r\_mCP + r\_outOM \cdot 0.03 \cdot 3 \cdot 0.4 + si\_outOM \cdot 0.009 + li\_mCP)$

Equation 7.54 is similar to equation 7.52 except that ammonia- and urea-corrected CP ($CPcorr_i$, eq 4.4) is used for input.

References

Dierick, N.A., I.J. Vervaeke, J.A. Decuypere & H.K. Henderickx, 1990. Bacterial protein synthesis in relation to organic matter digestion in the hindgut of growing pigs; contribution of hindgut fermentation to total energy supply and growth performance. Journal of Animal Physiology and Animal Nutrition 63:220-235.

Marini, J.C., D.G. Fox & M.R. Murphy, 2008. Nitrogen transactions along the gastrointestinal tract of cattle: A meta-analytical approach. Journal of Animal Science 86:660-679.

Åkerlind, M. & N.I. Nielsen, 2019. Evaluation of NorFor's prediction of neutral detergent fibre digestibility in dairy cows. Proceedings of the 10th Nordic Feed Science Conference June 11-12 2019, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Chapter 9 Animal requirements and recommendations

9.1 Energy

9.1.4 Growth

Eq 9.4 is valid for both 1st and 2nd calvers

Eq 9.9

$$gain\_fat = \left(\left(\frac{1000 \cdot Fat\_mass}{EBW}\right) \cdot \left(\frac{(factor\_2 + 2 \cdot factor\_3 \cdot ln(EBW)) \cdot factor\_4}{Factor\_4^{1,78}}\right)\right) \cdot \left(\frac{EBWG}{1000}\right)^{1.78}$$

Where… EBWG is the daily empty body weight gain, g/day…

9.1.5 Mobilisation and deposition for lactating cows

Eq 9.17

$$NEL\_dep = BW\_change\_mobdep \cdot 31.0$$

If change_BCS >0 then $NEL\_dep = change\_BCS \cdot kg\_BCS \cdot 31.0$

Where BW_change_mobdep is the body weight change during mid and late lactation depending on deposition (kg/day)

Eq 9.18

$$NEL\_mob = -1 \cdot BW\_change\_mobdep \cdot 24.8$$

If change_BCS <0 then $NEL\_mob = change\_BCS \cdot kg\_BCS \cdot 24.8$

Where BW_change_mobdep is the body weight change during early lactation depending on mobilisation (kg/day) described in NEW eq 9.19**d**

Eq 9.19 and figure 9.3 in the book should be excluded

Table 9.6, Eq 9.19 (about NEL_variable) and figure 9.3 are deleted

NEW eq 9.19 a

$$BW\_mob = a \cdot \left(1 + 2 \cdot \frac{BCS\_calv - 3.5}{3.5}\right)$$

New eq 9.19 b

$$b = 0.04{+}0.05 \cdot BW\_m\text{ob-}0.305 \cdot (\text{BCS\_calv-BCS\_end}) \cdot 2$$

NEW eq 9.19 c

$$c = \frac{b}{2.4207 \big/ -7.3955} + 0.151 \cdot \left(-\left(BCS\_calv - BCS\_end\right) \cdot 2 \cdot 2.55\right)$$

NEW eq 9.19 d

$$BW\_change\_mobdep = \begin{pmatrix} \text{BW\_mob} + \\ b \cdot \sqrt{\text{DIM}} \cdot \text{LN}(\text{DIM}) \\ + c \cdot (\text{LN}(\text{DIM}))^2 \end{pmatrix} - \begin{pmatrix} \text{BW\_mob} + \\ b \cdot \sqrt{(\text{DIM - 1})} \cdot \text{LN}(\text{DIM - 1}) \\ + \text{c} \cdot (\text{LN}(\text{DIM - 1}))^2 \end{pmatrix}$$

If DIM=1

$$BW\_change\_mobdep = \begin{pmatrix} \text{BW\_mob} + \\ b \cdot \sqrt{\text{DIM} + 2.1} \cdot \text{LN}(\text{DIM} + 2.1) \\ + c \cdot (\text{LN}(\text{DIM} + 2.1))^2 \end{pmatrix} - \begin{pmatrix} \text{BW\_mob} + \\ b \cdot \sqrt{(\text{DIM} + 2 - 1)} \cdot \text{LN}(\text{DIM} + 2 - 1) \\ + \text{c} \cdot (\text{LN}(\text{DIM} + 2 - 1))^2 \end{pmatrix}$$

NEW Eq 9.19d $BW\_dep = a \cdot \left(1 + 2 \cdot \frac{BCS\_end - 3.5}{3.5}\right)$

Where BW mob is the total body weight loss due to mobilisation in early lactation (kg), a is a factor taken from NEW table 9.6, BCS_calv is the body condition score at calving; BCS_end is the body condition score at drying off, BW_change_mobdep is the daily body weight change (kg/day), DIM is days in milk, BW_dep is the total body weight recovery due to deposition in mid and late lactation.

NEW Table 9.6. Factor **a** shows the mobilisation (kg) in BW change in early lactation (DIM 0 to approx. 70) provided BCS_calv is 3.5. Factor **a** also shows the deposition in mid and late lactation (DIM approx. 70 to 300) provided that BCS_end is 3.5

Breed	Lactation 1	Older
SLB; SDM; other	27	36
RDM, SRB, NRF	20	30
ISL	15	20
JER	20	27
AA, BB, BLO, BSH, BSW, CHA, CHI, DEX, GAL, GVH, HIG, HRF, LIM; PIE, PIN, SAL, SIM, TIR, WAG	a=kg_BCS*0.5*0.6*0.6	a=kg_BCS*0.5*0.6*0.6

If nothing else is stated assume that body condition score at calving (BCS_calv) is 3.5, body condition score at end of lactation (BCS_end) is 3.5 and the mobilisation in early lactation is approximately 0.5 BCS unit until lactation day 70. The equation is valid between DIM 1 to 300.

9.2 Protein

9.2.1 Maintenance

Eq 9.22 $AAT_N\_ma\text{int} = EUN + Scurf + MFP$

Where AAT_N_maint is the daily AAT_N requirement for maintenance, g/d; EUN is the endogenous urinary nitrogen, equation 9.22b; Scurf is skin cells and hair, equation 9.22c; MFP is metabolic fecal protein, equation 9.22d.

Eq 9.22b $EUN = \frac{2.75 \cdot BW\_cur^{0.5}}{0.67}$

Eq 9.22c $Scurf = \frac{0.2 \cdot BW\_cur^{0.6}}{0.67}$

Eq 9.22d $MFP = \frac{r\_outOM \cdot 0.03 \cdot 0.5 \cdot 3 \cdot 0.4}{0.67} + si\_outOM \cdot 0.025 \cdot 0.5$

Where BW_cur is current body weight, kg; r_out_OM is the amount of OM leaving the rumen and entering the small intestine, equation 7.36; si_outOM is the amount of OM leaving the small intestine and entering the large intestine equation 7.47; 0.67 is a fixed utilization coefficient of AATN for maintenance; 0.03 refers to the amount of endogenous CP, which is 3% of the OM entering the small intestine from the rumen; 3 is a multiplier to include all endogenous CP produced in the small intestine; 0.5 is the AA-N proportion of endogenous CP; 0.4 is used because of 60% of endogenous CP is reabsorbed; and 0.025 refers to the amount of endogenous CP, which is 2,5% of OM entering the large intestine from the small intestine.

Eq 9.26 $Avail\_AAT_N = AAT_N - AAT_N\_maint - AAT_N\_gain - AAT_N\_gest) + AAT_N\_mob - AAT_N\_dep$

Eq 9.29 equation should be exchanged is equal to 15.1

9.2.2 Lactation

Eq 9.30 AAT-balance is only valid for dry cows not lactating cows. Minimum level AAT-balance is 100 for dry cows and the max level is deleted.

Figure 9.6 should be excluded

9.2.3 Growth

Eq 9.32. AAT_gain is valid for both 1^{st} and 2^{nd} calvers

Eq 9.35 if energy requirement of growth is less than 0.15 MJ per day then AAT_NEG =0 (the purpose is for breeding bulls)

Eq 9.38 $AAT\_NEG\_Min = \frac{(1.88 - 0.00176 \cdot BW\_cur - 0.2283 \cdot ADG/1000 + 0.0000019014 \cdot BW\_cur^{1.83})}{0.03821 \cdot 2 - 0.000000016 \cdot 5 \cdot 14^4} - 1$

if the animal’s growth is less than 11 grams per day then AAT_NEG_Min=0 (the purpose is for breeding bulls)

9.3 PBV

Eq 9.43 $PBV\_DM\_Min = 10$ for cows

Figure 9.11 deleted

9.8 Minerals

9.8.1 Macro minerals

Eq 9.45 for lactating cows of beef breeds $Ca\_ma\,int = {0.0154 \cdot BW}/{0.5}$ according to NRC 2000 (beef)

Eq 9.50 for lactating cows of beef breeds $P\_ma\,int = {0.016 \cdot BW}/{0.7}$ according to NRC 2000 (beef)

Eq 9.61 for lactating cows of beef breeds $Na\_ma\,int = {0.015 \cdot BW}/{0.9}$ according to NRC 2000 (beef)

Eq 9.65 for lactating cows of beef breeds $K\_ma\,int = {(0.038 \cdot BW + 2.6 \cdot 0.0167 \cdot BW)}/{0.9}$ according to NRC 2000 (beef)

Eq 9.47; 9.52; 9.57, 9.62, 9.67 and 9.72 requirements for gain is valid for both 1st and 2nd calvers

9.8.2 Micro minerals

Table 9.15. Zn_DM_Min=30; Se_DM_Min=0.1 for cows of beef breeds (according to NRC 2000)

9.7 Fatty acids

NEW Eq 9.77 $IV\_DM\_Max = 45$

Where IV_DM_Max is the highest recommendation of iodine value of the ration (g iodine per kg DM) (reference M.R. Weisbjerg)

9.10 Individual amino acids

NEW Eq 9.78 $His\_AAT\_Min = 2.2$

NEW Eq 9.79 $Lys\_AAT\_Min = 6.4$

NEW Eq 9.80 $Met\_AAT\_Min = 2.2$

NEW. Regarding breeding bulls, grown-up bulls or bulls that grow less than 11 grams per day, approximately have less energy requirement for growth than 0.15 MJ per day. For calculating rations to grown up bulls, use AAT-balance, not AAT/NEG.

Chapter 10 Prediction of voluntary feed intake

Eq. 10.2

$$IC\_cow = a \cdot DIM^b \cdot exp^{c \cdot DIM} - DIM^{-d} + e \cdot \left(ECM + \frac{(-NEL\_mob + NEL\_dep) \cdot h}{3.14}\right) + (BW - f) \cdot g$$

where IC_cow is the intake capacity of a lactating cow (FV/day), the factors a, b, c, d, e, f, g and h is taken from Table 10.5, DIM is the days in milk, ECM is the production of energy corrected milk (kg/day) described in eq 3.2, NEL_mob is the energy supply from body reserve mobilization (MJ/day) described in eq 9.18, NEL_dep is the energy requirement for deposition (MJ/day) described in eq 9.17 and BW is the live body weight (kg)

Table 10.5

Cow category	a	b	c	d	e	f	g	h
1st calvers large breeds	3.07	0.134	-0.00045	0.003	0.091	500	0.006	0.7
older large breeds	3.30	0.134	-0.0004	0.003	0.091	575	0.006	0.5
1st calvers JER	2.50	0.134	-0.0005	0.06	0.110	360	0.006	0.4
Older JER	2.70	0.134	-0.0002	0.03	0.110	405	0.006	0.4
1st calvers ISL	2.51	0.134	-0.0012	0.025	0.091	370	0.006	0.5
Older ISL	2.77	0.134	-0.0011	0.003	0.091	450	0.006	0.5

Eq 10.7

$$FV\_SubR = 0.97 + 5.62 \cdot \left(\frac{ST\_SU\_DM}{1000} - 0.2119\right) \cdot 0.1 - 0.1932 \cdot \left(\frac{ST\_SU\_intake}{1000} - 5.122\right) \cdot 0.05$$

where FV_SubR is the roughage substitution correction factor, 0 to 1; ST_SU_DM is the proportion of starch and sugars in the diet, g/kg DM; ST_SU_intake is the starch and sugar intake, g/d; 0.1 and 0.05 are constants for facilitating the optimization when formulating rations.

Eq 10.8 $FV\_MR = 1.453 - \frac{2.530}{1+exp\left({(0.466-FV\_r)}/{0.065}\right)}$

Eq 10.9, 10.10, 10.12, 10.13

$$IC\_animal = (factor\_1 \cdot BW\_cur + factor\_2 \cdot ADG\_LW) \cdot IC\_exercize \cdot IC\_gest$$

Where

Maturing	Gender	factor_1	factor_2
Early	Heifers, Steers	0.008787	0.00041996
Early	Bulls	0.006132	0.0006797
Late	Heifers, Steers	0.006940	0.0002699
Late	Bulls	0.004169	0.0009847

early maturing breeds: HO, JER, DR, NR, SR, ISL, AA, HRF, DEX, TIR, HIG, GAL, BSH, BSW, PIN

late maturing breeds: CHA, BLO, SIM, LIM, BB, PIE, CHI, WAG, SAL, Crossbreds

Eq 10.11 IC_gest=1 for steers and bulls

NEW equation IC_exercize 1.0 for tied up and 1.05 for loose housed animals or animals on pasture

Eq 10.15 where the FV_SubR is the roughage substitution correction factor, shown in figure 10.5; conc_share is the proportion of concentrate in the diet on a DM basis, %.

Eq 10.15 $FV\_MR = 0$

Chapter 12 Predictions

Eq 12.2

$$Protein\_respons = Avail\_AAT_N \cdot \left(189.4 - 11.14 \cdot \frac{Avail\_AAT_N}{ECM\_response \cdot 3.14} + 0.215 \cdot \left(\frac{Avail\_AAT_N}{ECM\_response \cdot 3.14}\right)^2\right) \Big/ 100$$

Where the expression ECM_response times 3.14 is equal to the net energy available for milk production

NEW eq 12.21

Enteric methane production of cows according to Nielsen *et al*. (2013)

$$CH4 = 1.23 \cdot DMI - 0.145 \cdot FA\_DM + 0.012 \cdot NDF\_DM$$

Where CH4 is enteric methane production (MJ per day), DMI is the dry matter intake (kg per day) and FA_DM the fatty acid concentration in the ration (g/kg DM)

Enteric methane production of growing cattle

$$CH4 = (1.6105 + 0.5615 \cdot DMI\_c + 1.3511 \cdot DMI\_f + 0.000309 \cdot rd\_NDF - 0.00379 \cdot FA\_intake - 0.00266 \cdot Ash\_intake)$$

Where CH4 is enteric methane production (MJ per day), DMI_c is intake of concentrate (kg DM/day), DMI_f is intake of forage (kg DM/day), rd_NDF is tha rumen degraded NDF (g/day), FA_intake is the intake of fatty acids (g/day) and Ash_intake is the intake of ash (g/day)

NEW eq 12.22

$$Ym = \frac{CH4}{GE} \cdot 100$$

Where Ym is the efficiency (%), CH4 is the enteric methane production (MJ/day) and GE is the gross energy intake (MJ/day)

NEW eq 12.23

$$CH4\_g = \frac{CH4}{55.65} \cdot 1000$$

Where CH4_g is the enteric methane production in gram (g/day), 55.65 is the conversion factor from ICCP

NEW eq 12.24

$$CO2e = \frac{CH4\_g \cdot 25}{1000}$$

Where CO2e is the carbon dioxide equivalents (kg /day) from CH4_g enteric methane production (g/day) and the conversion factor 25 (ICCP)

NEW eq 12.25 $kg\_faeces = (DM\_faeces)/0.135$

NEW eq 12.26 $DM\_faeces = OM\_faeces + Ash\_faeces$

NEW eq 12.27 A$sh_faeces = Ash_intake \cdot 0.5$

if a value is missing of Ca, P, Mg; k; Na, Cl or S. where 0.5 is an average from 145 observations.

else

$$Ash\_faeces = Ash\_intake - (Ca\_intake \cdot 0.5 + P\_intake \cdot 0.7 + Mg\_intake \cdot 0.16 + K\_intake \cdot 0.9 + Na\_intale \cdot 0.9 + Cl\_intake \cdot 0.9 + S\_intake \cdot 0.6)$$

Where 0.5, 0.16 and 0.9 are digestibility factors from NRC (2001), 0.7 is a digestibility factor in NorFor book (2011), and 0.6 is from Gustafson and Olsson (2004)

NEW eq 12.28 $OM\_faeces = DMI * 1000 - Ash\_intake - td\_OM$

NEW eq 12.29 . $CP\_faeces = (CP\_intake - rd\_CP - jed\_CP + r\_mCP \cdot 0.15 + r\_outOM \cdot 0.03 \cdot 3 \cdot 0.4 + je\_outOM \cdot 0.025 + co\_mCP)$

NEW eq 12.30 $CFat\_faeces = (CFat\_intake - rd\_CFat - jed\_CFat + r\_mCFat \cdot (1 - 0.85 \cdot 0.65) + co\_mCFat)$

NEW eq 12.31 $CHO\_faeces = NDF\_faeces + ST\_faeces + RestCHO\_faeces$

NEW eq 12.32 $NDF\_faeces = (NDF\_intake - rd\_NDF - cod\_NDF)$

NEW eq 12.33 $ST\_faeces = (ST\_intake - rd\_ST - jed\_ST - cod\_ST + r\_mST - jed\_mST + co\_mST)$

NEW eq 12.34 $RestCHO\_faeces = (RestCHO\_intake - rd\_restCHO + r\_mRestCHO - rd\_mRestCHO + co\_mRestCHO)$

Unit g/day

NEW eq 12.35 . $Ash\_DMfaeces = (Ash\_faeces)/(DM\_faeces) \cdot 1000$

NEW eq 12.36 . $CP\_DMfaeces = (CP\_faeces)/(DM\_faeces) \cdot 1000$

NEW eq 12.37. $CFat\_DMfaeces = (CFat\_faeces)/(DM\_faeces) \cdot 1000$

NEW eq 12.38. $NDF\_DMfaeces = (NDF\_faeces)/(DM\_faeces) \cdot 1000$

NEW eq 12.39. $ST\_DMfaeces = (ST\_faeces)/(DM\_faeces) \cdot 1000$

NEW eq 12.40. $RestCHO\_DMfaeces = (RestCHO\_faeces)/(DM\_faeces) \cdot 1000$

Unit g/kg DM

Chapter 13. Standard feed values

Eq 13.1. $RLI_{std} = \frac{DMI_{std} \cdot 280}{DMI_{std} \cdot 370}$

Table 13.1 Fixed values

Parameter	8 kg DMI	20 kg DMI
Passage rate for NDF in roughage, %/h	0.795600	1.73671

The calculation of standard feed value of essential amino acids Histidine (His_{20}), Lysine (Lys_{20}) and Methionine (Met_{20}) are calculated as eq 8.12 on basis of the fixed values in table 13.1 %of AAT

NEW eq.13_10 $Histidine_{20} = sid\_His + sid\_mHis + sid\_eHis$

Where Histidine20 is the standard feed value of Histidine (g/kg DM), sid_His is the rumen undegraded histidine absorbed in the small intestine (g/day) described in eq 7.39, sid_mHis is the histidine absorbed in the small intestine which is derived from microbial CP (g/day) described in eq 7.42 and table 7.2, sid_eHis is the histidine absorbed in the small intestine derived from endogenous CP (g/day) described in eq 7.46 and table 7.2. The fixed values in table 13.1 must be used.

NEW eq.13_11 $Ly\sin e_{20} = sid\_Lys + sid\_mLys + sid\_eLys$

Where Lysine20 is the standard feed value of Lysine (g/kg DM), sid_Lys is the rumen undegraded lysine absorbed in the small intestine (g/day) described in eq 7.39, sid_mLys is the Lysine absorbed in the small intestine which is derived from microbial CP (g/day) described in eq 7.42 and table 7.2, sid_eLys is the lysine absorbed in the small intestine derived from endogenous CP (g/day) described in eq 7.46 and table 7.2. The fixed values in table 13.1 must be used.

NEW eq.13_12 $Methionine_{20} = sid\_Met + sid\_mMet + sid\_eMet$

Where Methionine20 is the standard feed value of Methionine (g/kg DM), sid_Met is the rumen undegraded methionine absorbed in the small intestine (g/day) described in eq 7.39, sid_mMet is the Methionine absorbed in the small intestine which is derived from microbial CP (g/day) described in eq 7.42 and table 7.2, sid_eMet is the methionine absorbed in the small intestine derived from endogenous CP (g/day) described in eq 7.46 and table 7.2. The fixed values in table 13.1 must be used.

NEW eq.13_13 $NDFD20 = \frac{rd\_NDF + lid\_NDF}{NDF} \cdot 100$

Where NDFD20 is the standard feed value of NDF total tract digestibility (%) at 20 kg DMI, rd_NDF is the rumen degraded NDF (g/day) described in eq 7.21, lid_NDF is the degraded NDF in the large intestine (g/day) described in eq 7.48, NDF is the content of NDF in the feedstuff (g/kg DM). The fixed values in table 13.1 must be used.

Alvarez *et a*l (2021) developed a static empirical model for estimation of net energy content of compound feeds in a dynamic feeding system using NEL20 values calculated by the NorFor model

New eq 13.4 $NEL20_{comp} = 3.69 - 0.0435 * \frac{\mathrm{NDF}}{10} + 0.0997 * \frac{\mathrm{CFat}}{10} + \ 0.0393 * \mathrm{DOM} + 0.0234 * \frac{\mathrm{CPcorr}}{10}$

Where NEL20_comp is net energy of lactation at 20 kg DMI/d (MJ/kg DM) for compound feed when analysed (MJ net energy per kg DM), NDF is the analysed neutral detergent fibre (g/kg DM), CFat is the analysed crude fat (g/kg DM), DOM is the digested organic matter (% of DM; eq 13.5) and CPcorr is the corrected crude protein (eq 4.4) based on analysed crude protein and added urea reported by the manufacturer.

New eq 13.5 $DOM = (1000 - Ash)/10 * EFOS/100$

Where DOM is the digested organic matter (% of DM)

References

Alvarez, C., N. I. Nielsen, M. R. Weisbjerg, H. Volden and E. Prestløkken, 2021. A static model for estimating energy content of compound feeds in a dynamic feed evaluation system. Journal of Dairy Science 104:9362-9375.

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Chapter 14. System evaluation

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