**Supplementary material: Estimating the impact of clinical mastitis in dairy cows on greenhouse gas emissions using a dynamic stochastic simulation model: a case study**

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Supplementary Table S1. Dietary composition and energy content (NE) of feed ingredients of dairy cows.

|  |  |  |  |
| --- | --- | --- | --- |
| Feed ingredient | NEa  (MJ/ kg DM) | Summer dietb (%/kg DM) | Winter dietb  (%/kg DM) |
| Concentrates standardc | 7.43 | 21 | 20 |
| Concentrates proteinc | 7.45 | 0 | 7 |
| Wet by productsd | 7.50 | 4 | 5 |
| Grass | 6.95 | 39 | 0 |
| Grass silage | 6.08 | 25 | 55 |
| Maize silage | 6.26 | 11 | 14 |

a Vellinga *et al.,* 2013

b CBS, 2014

c Nevedi, 2012, 2013, 2014, 2015

d Wet by products consisted of (%/kg DM): 29% brewer’s grain dried, 32% potato peel steamed, 16% potato pulp dried, 23% maize gluten meal

Supplementary Table S2. Composition of concentrates for dairy cows, and dry matter content per ingredient, and greenhouse gas (GHG) emissions of feed production, land use and land use change (LULuc), and enteric methane per ingredient and per composition.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Feed ingredient | Standarda  (%/kg) | Proteina  (%/kg) | Feed productionb  (g CO2e /kg) | LULucb  (g CO2e /kg) | Enteric methaneb  (g CH4 /kg) | Dry Matterb (g/kg) |
| Peas | 0.00 | 1.20 | 578 | 744 | 21.97 | 867 |
| Barley | 0.35 | 0.15 | 219 | 166 | 22.17 | 869 |
| Soya (bean) meal Mervobest | 0.00 | 0.15 | 475 | 414 | 19.21 | 872 |
| Soybean hulls CFc 320-360 | 14.52 | 19.47 | 306 | 222 | 22.94 | 883 |
| Sugarcane molasses SUGc<475 | 3.01 | 3.17 | 265 | 27 | 28.58 | 734 |
| Rape seed, expeller | 0.17 | 0.99 | 270 | 184 | 17.36 | 894 |
| Rye | 5.15 | 1.10 | 274 | 237 | 23.27 | 872 |
| Wheat | 2.05 | 2.17 | 216 | 147 | 22.9 | 868 |
| Palm kernel expeller CF<180 | 11.80 | 15.95 | 417 | 30 | 17.07 | 961 |
| Sugarbeet pulp SUG>200 | 3.80 | 4.70 | 366 | 0 | 25.76 | 915 |
| Maize | 15.87 | 6.57 | 390 | 167 | 20.09 | 872 |
| Soybean meal CF45-70 CPc<450 | 0.14 | 2.95 | 463 | 401 | 20.27 | 876 |
| Wheat middlings | 11.32 | 2.07 | 158 | 77 | 20.34 | 865 |
| Palm kernel oil | 0.21 | 0.42 | 2606 | 301 | 0 | 995 |
| Maize glutenfeed CP200-230 | 8.60 | 1.65 | 1632 | 186 | 19.78 | 893 |
| Sunflower seed meal CF>240 | 0.67 | 1.00 | 375 | 410 | 16.97 | 887 |
| Salt | 0.46 | 0.56 | 180 | 0 | 0 | 998 |
| Chalk (finely milled) | 0.99 | 1.28 | 18.5 | 0 | 0 | 990 |
| Triticale | 5.45 | 6.03 | 305 | 254 | 23.2 | 877 |
| Rape seed, extruded CP>380 | 0.18 | 0.47 | 253 | 163 | 18.79 | 906 |
| Rape seed, extruded CP 0-380 | 1.78 | 5.38 | 251 | 161 | 18.69 | 873 |
| Rape seed meal Mervobest | 0.00 | 0.15 | 258 | 168 | 17.51 | 872 |
| Soybean meal CF45-70 CP>450 | 0.09 | 0.48 | 478 | 418 | 20.27 | 875 |
| Premix Dairy 31 | 1.00 | 1.00 | 4999 | 0 | 0 | 1000 |
| Vinasses Sugarbeet CP<250 | 2.99 | 3.00 | 393 | 0 | 21.69 | 663 |
| Magnesiumoxide | 0.04 | 0.01 | 1060 | 0 | 0 | 1000 |
| Distillers grains and solubles | 9.36 | 17.93 | 295 | 0 | 19.51 | 901 |
| GHG emissions |  |  |  |  |  |  |
| Ingredients (g CO2e /kg DM) | 669 | 571 |  |  |  |  |
| Transport to farm (g CO2e /kg DM) | 11 | 11 |  |  |  |  |
| Feedmill (g CO2e /kg DM) | 82 | 81 |  |  |  |  |
| Total feed production (g CO2e /kg DM) | 762 | 664 |  |  |  |  |
| LULuc (g CO2e /kg DM) | 142 | 142 |  |  |  |  |
| Enteric methane (g CH4/kg DM) | 23.1 | 22.7 |  |  |  |  |

a Nevedi, 2012, 2013, 2014, 2015

b Vellinga *et al.*, 2013

c CF= Crude fiber, CP= crude protein, SUG= sugar in (g/kg)

Supplementary Table S3. Greenhouse gas emissions of feed production and land use and land use change (LULuc), enteric methane emissions, and nitrogen content of feed ingredients of dairy cows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Feed ingredient | Feed productiona  (g CO2e /kg DM) | LULuca  (g CO2e /kg DM) | Enteric methanea  (g CH4/kg DM) | Na  (g /kg DM) |
| Concentrates standardb | 762 | 142 | 23.1 | 26.1 |
| Concentrates proteinb | 664 | 142 | 22.7 | 31.4 |
| Wet by productsc | 388 | 20 | 19.2 | 46.5 |
| Grass | 439 | 69 | 21.2 | 37.3 |
| Grass silage | 426 | 78 | 20.1 | 28.3 |
| Maize silage | 148 | 92 | 17.7 | 12.6 |

a Vellinga *et al.*, 2013

b Nevedi, 2012, 2013, 2014, 2015

c Wet by products consisted of (%/kg DM): 29% brewer’s grain dried, 32% potato peel steamed, 16% potato pulp dried, 23% maize gluten meal

Supplementary Table S4. Emissions factors (EF) forCH4 andN2O emissions, NO3-N leaching and NH3-N + NOX-N volatizing of manure from dairy cows in stable and manure from dairy cows from grazing.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Stable/storage |  |  |  | |  | |  | |
| N2O-N direct | kg/kg TANa | | | 0.0015 | (De Vries *et al.*, 2011) | | | |
| NH3-N | kg/kg TAN | | | 0.1000 | (De Vries *et al.*, 2011) | | | |
| NOx-N | kg/kg TAN | | | 0.0015 | (De Vries *et al.*, 2011) | | | |
| CH4 | kg/ton manure | | | 0.746 | (De Mol and Hilhorst, 2003) | | | |
| Grazing |  |  | |  |  | |  | |
| N2O-N direct | kg/kg N | | | 0.033 | (Vonk *et al.*, 2016) | | | |
| NOx-N | kg/kg N | | | 0.012 | (Vonk *et al.*, 2016) | | | |
| NH3-Nb | kg/kg TAN | |  | 0.053 | (Vonk *et al.*, 2016) | | | |
| NO3-N leach | kg/kg N | |  | 0.12 | (Velthof and Mosquera, 2011) | | | |
| CH4 | kg/m3 manure | |  | 0.11 | (De Mol and Hilhorst, 2003) | | | |
| All |  | | |  |  |  | |  |
| N2O-N indirect | kg/kg NH3-N + NOX-N | | | 0.01 | IPCC, 2006 | | | |
|  | kg/kg NO3-N | | | 0.0075 | IPCC, 2006 | | | |

a TAN= Total Ammoniacal Nitrogen

b EF NH3 grazing = 1.98 x 10-5 x (Ncontentdiet)3.664

**References**

CBS 2014. Centraal Bureau voor de Statistiek. Dierlijke mest en mineralen 2013 (Animal manure and minerals 2013). CBS, Den Haag, the Netherlands.De Mol RM and Hilhorst MA 2003. Emissions of methane, nitrous oxide and ammonia from production, storage and transport of manure. Institute of Agricultural and Environmental Engineering, Wageningen, the Netherlands.

De Vries JW, Hoeksma P and Groenestein CM 2011. LevensCyclusAnalyse (LCA) pilot mineralenconcentraten. Wageningen UR Livestock Research, Wageningen, the Netherlands.

IPCC 2006. 2006 Intergovernmental Panel on Climate Change. Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, forestry and other land use. In Emissions from livestock and manure management (ed. HS Eggleston, L Buendia, K Miwa, T Ngara and K Tanabe), pp 10.1-10.87. Institute for Global Environmental Strategies (IGES), Hayama, Japan.

Nevedi 2012. De Nederlandse Vereniging Diervoederindustrie. The Dutch Feed Industry Association. Lineaire programmeringen rundvee-, varkens en pluimveevoerders. Linear Programming Cattle-, Pig, and Poultry Feed, volume 5 t/m 12. Schothorst Feed Research B.V, Lelystad, the Netherlands.

Nevedi 2013. De Nederlandse Vereniging Diervoederindustrie. The Dutch Feed Industry Association. Lineaire programmeringen rundvee-, varkens en pluimveevoerders. Linear Programming Cattle-, Pig, and Poultry Feed, volume 1 t/m 12. Schothorst Feed Research B.V, Lelystad, the Netherlands.

Nevedi 2014. De Nederlandse Vereniging Diervoederindustrie. The Dutch Feed Industry Association. Lineaire programmeringen rundvee-, varkens en pluimveevoerders. Linear Programming Cattle-, Pig, and Poultry Feed, volume 1 t/m 12. Schothorst Feed Research B.V, Lelystad, the Netherlands.

Nevedi 2015. De Nederlandse Vereniging Diervoederindustrie. The Dutch Feed Industry Association. Lineaire programmeringen rundvee-, varkens en pluimveevoerders. Linear Programming Cattle-, Pig, and Poultry Feed, volume 1 t/m 5. Schothorst Feed Research B.V, Lelystad, the Netherlands.

Vellinga TV, Blonk H, Marinussen M, Van Zeist WJ and De Boer IJM 2013. Methodology Used in Feedprint: A Tool Quantifying Greenhouse Gas Emissions of Feed Production and Utilization. Wageningen UR Livestock research, Lelystad, the Netherlands.

Velthof GL and Mosquera J 2011. Calculation of nitrous oxide emission from agriculture in the Netherlands. Alterra, Wageningen, the Netherlands.

Vonk J, Bannink A, van Bruggen C, Groenestein CM, Huijsmans JFM, van der Kolk JWH, Luesink HH, Oude Voshaar SV, van der Sluis SM and Velthof GL 2016. Methodology for estimating emissions from agriculture in the Netherlands Calculations of CH4, NH3, N2O, NOx, PM10, PM2.5 and CO2 with the National Emission Model for Agriculture (NEMA). The Statutory Research Tasks Unit for Nature and the Environment (WOT Natuur & Milieu), Wageningen, the Netherlands.