Minimal nitrogen loss by dairy cattle

Theory versus practice

REDNEX

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SEVENTH FRAMEWORK PROGRAMME

Innovative and practical management approaches to reduce nitrogen excretion by ruminants

N loss EU Dairy Production

No. of cows, x 10^6	23.6	
Average milk production per cow, kg/yr	5,678	
Assumed milk protein content, g/kg	32	
EU27 milk protein yield, kg x 10^6/yr	4,300	
EU27 milk N yield, kg x 10^6/yr	675	
Assumed N efficiency: MN / NI	0.25	0.35
EU27 feed N intake, kg x 10^6/yr	2,700	1,925
EU27 annual N loss by dairying, kg x 10^6	**2,025**	**1,250**

Eurostat, 2010

Minimum N loss - outline

- Theory:
  - “Inevitable” losses
  - Improvements
  - Effect of rumen fermentation

- Practice
  - Cow
  - Herd

Theory

- Inevitable N losses
  - Digestion
    - Fermentation
  - Maintenance
  - Milk protein synthesis

- Van Vuuren & Meijs, 1987:
  600 kg cow; 25 kg milk; 33.2 g protein/kg
  170 g N/day; efficiency: **0.45**

- 25 years later?

2012

- "Dairy cow 2012"
  - Milk production: 40 kg/day
  - Milk protein content: 33.2 g/kg

Requires

- 165 MJ NE_L/d
- 2.32 kg/d Metabolisable Protein

2012

- Assumed “2012 diet” dry matter composition:
  - NEL: 6.9 MJ/kg DM
  - 89% organic matter
  - 80% digestible DM
  - 55% fermentable organic matter

2012

- "Dairy cow 2012"
  - Milk production 40 kg/day
  - 165 MJ NE_L/d
  - 2.32 kg/d Metabolisable protein

- Assumed daily intake:

  24.0 kg DM

  21.4 kg OM

  13.2 kg FOM

Theory - Inevitable N losses

- Digestion
  - Fermentation
- Maintenance
- Milk protein synthesis

N losses during digestion

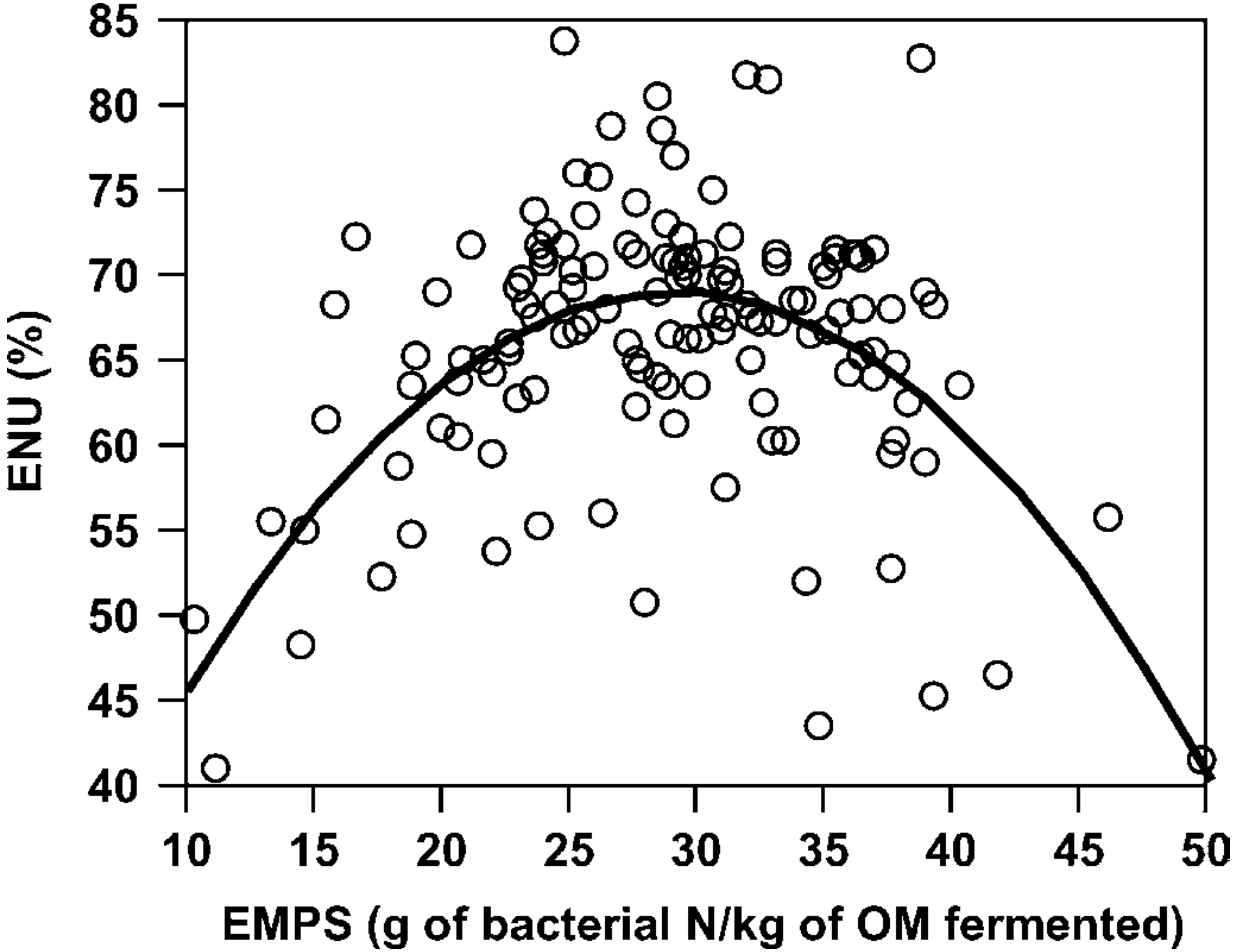
- Ruminal fermentation
  - Microbial protein synthesis
    - Balanced to rumen-degradable feed protein?

Ruminal N use efficiency

- Relationship between
  - efficiency micr. protein synth. (g micr. N/kg FOM) &
  - N utilisation (g micr. N/kg rumen available N)

(Bach et al., 2005)

Efficiency microbial utilisation of rumen available N



Bach et al. (2005)

Ruminal N use efficiency

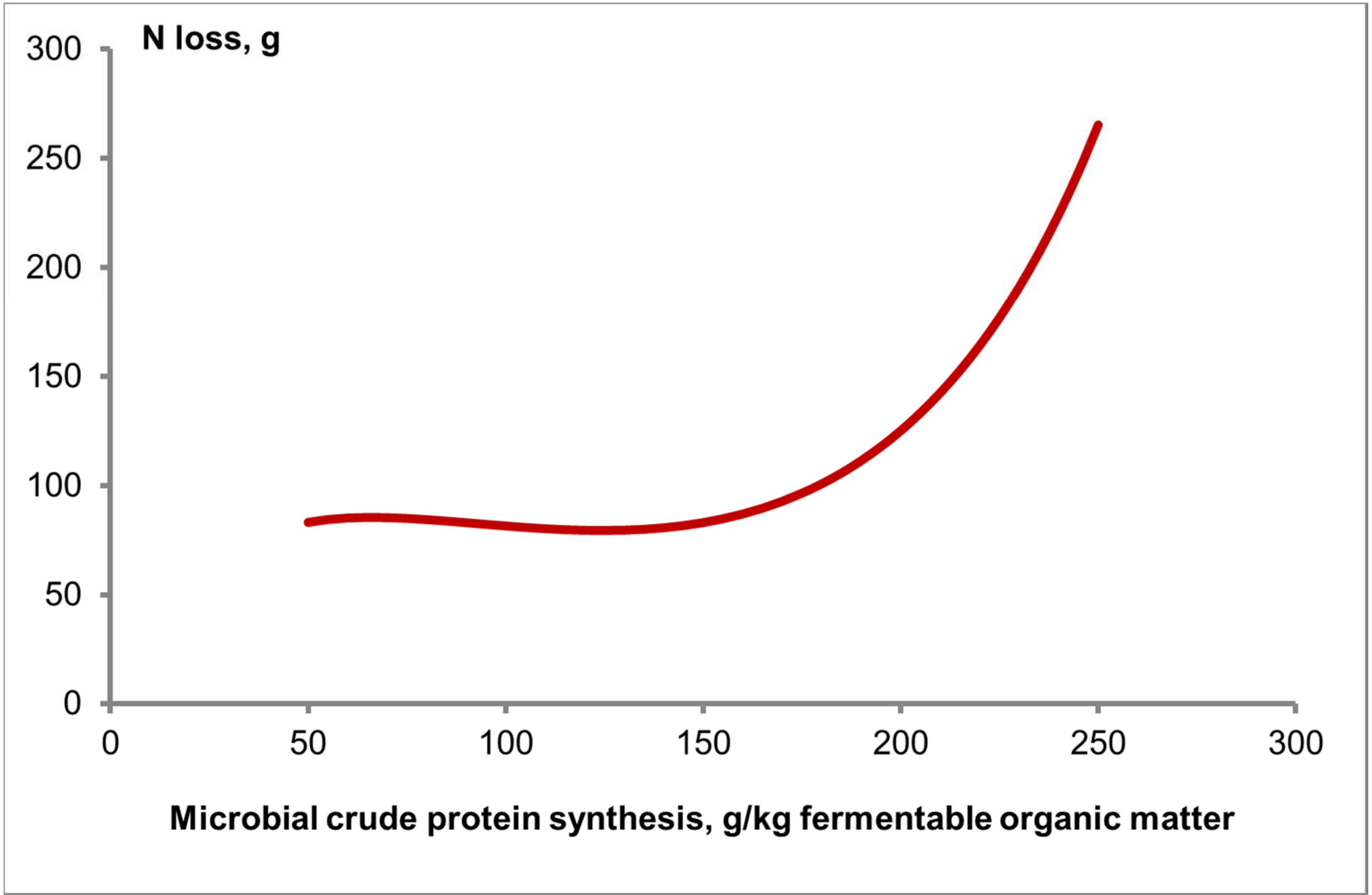
- Relationship between
  - efficiency micr. protein synth. (g micr. N/kg FOM) &
  - N utilisation (g micr. N/kg rumen available N)

(Bach et al., 2005)

- Rumen available N = RDN_{feed} + N $entry_{urea}$
- N $entry_{urea}$ in rumen ~ 70 g N /d

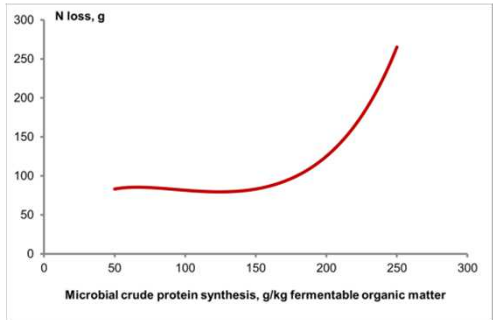
(Reynolds & Kristensen, 2008)

Net N loss - fermentation



N losses during digestion

- Ruminal fermentation
  - Microbial protein synthesis
    - Balanced to rumen-degradable feed protein?
    - NO!
    - Optimum at EMPS of 150 g/kg FOM: maximum MPS at minimal N loss!



Ideal "2012 dairy cow" looses 80 g/d by microbial synthesis

- 13.2 kg FOM requires 2.5 kg RD CP (10.4% of DM)

N losses during digestion

- Ruminal fermentation
  - Microbial protein synthesis
    - Balanced to rumen-degradable feed protein?
    - NO: Ideal "2012 dairy cow" looses
      80 g/d by microbial synthesis
  - Microbial crude protein ≠ amino acids
    - 25% of rumen microbial N in nucleic acids
    - Ideal "2012 dairy cow" looses
      80 g/d as nucleic acid N

Inefficiency intestinal digestion

- Microbial true protein digestibility: 82%
  Undigested microbial true protein N: 50 g/d

- Endogenous N:
  - Small intestine: 3.1 g/kg OMI
  - Large intestine: 5.0 g/kg OMI (Marini et al., 2008)

  - EN loses: 21.4 x 8.1 = 173 g N/d as endog. N
  - High! / Reabsorbed?
  - In DVE/OEB: 55 g N/d (Tamminga et al., 1994)

Theory - Inevitable N losses

- Digestion
  - Rumen fermentation: 160 g
  - Undigested microbial protein: 50 g
  - Endogenous N: 55 g
  - Total: 265 g

- Maintenance
  - DVE/OEB: 15 g

- Milk protein synthesis?

Efficiency milk protein synthesis

- Efficiency: 0.67
- Milk protein yield: 40 x 33.2 = 1.33 kg
- "2012 Dairy cow" looses: 70 g N/d

Theory - Inevitable N losses

- Digestion: 265 g
- Maintenance: 15 g
- Milk protein synthesis: 70 g
- Total: 350 g

- In 1987: 25-kg MY: 170 g
  40-kg MY: 230 g

without inefficiency in microb. protein synthesis and no indigestible microb. protein

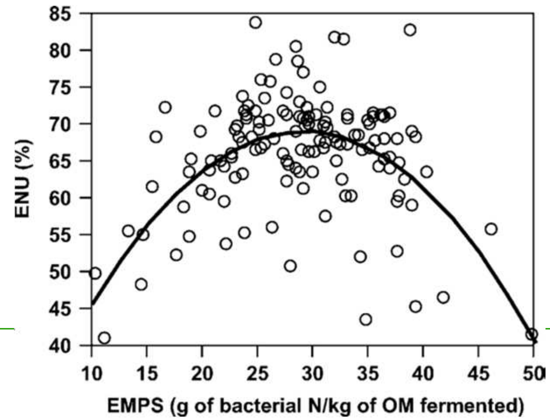
Theoretical efficiency

- Milk protein yield: 1.3 kg/d = 208 g N/d
- Inevitable loss: 350 g N/d
- Efficiency: 208 / 558 = 0.37
- In 1987: 0.45

Improvements

Source	g N /d
Inefficient microbial synthesis	80
Nucleic acids	80
Indigestible microbial protein	50
Maintenance	15
Inefficient milk synthesis	70

Improvements - rumen



Source	g N /d
Inefficient microbial synthesis	80
Nucleic acids	80
Indigestible microbial protein	50
Maintenance	15
Inefficient milk synthesis	70

Improvement – unused metab. prot.

Source	g N /d
Inefficient microbial synthesis	65
Nucleic acids	80
Indigestible microbial protein	50
Maintenance	15
Inefficient milk synthesis	70

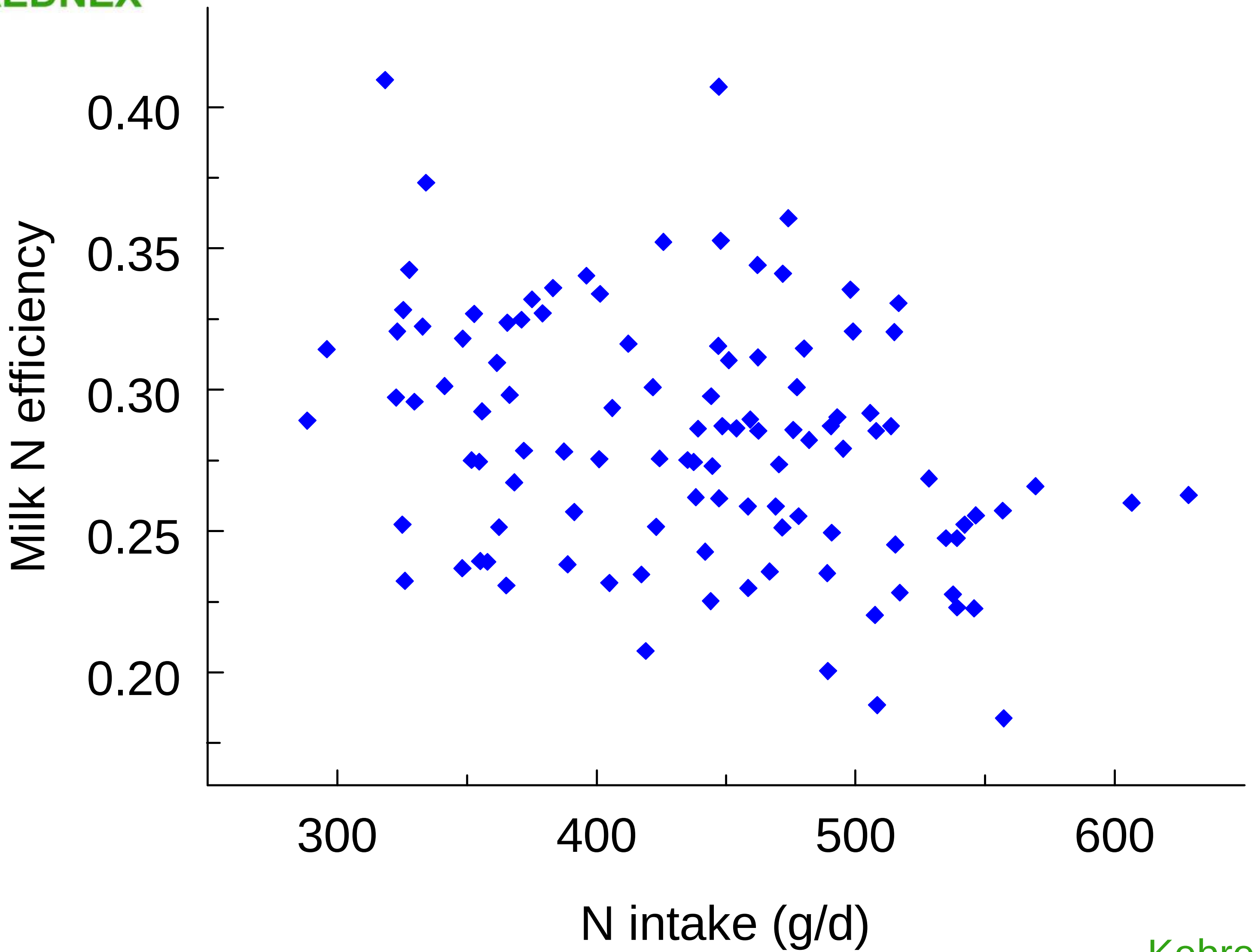
Role of rumen fermentation?

Source	g N/d
Inefficient microbial synthesis	80
Nucleic acids	80
Indigestible microbial protein	50
Maintenance	15
Inefficient milk synthesis	70

Theoretical efficiency

- Milk protein yield: 1.3 kg/d = 208 g N/d
- Inevitable non-microb. loss: 85 g N/d
- Efficiency: 208 / 293 = 0.71

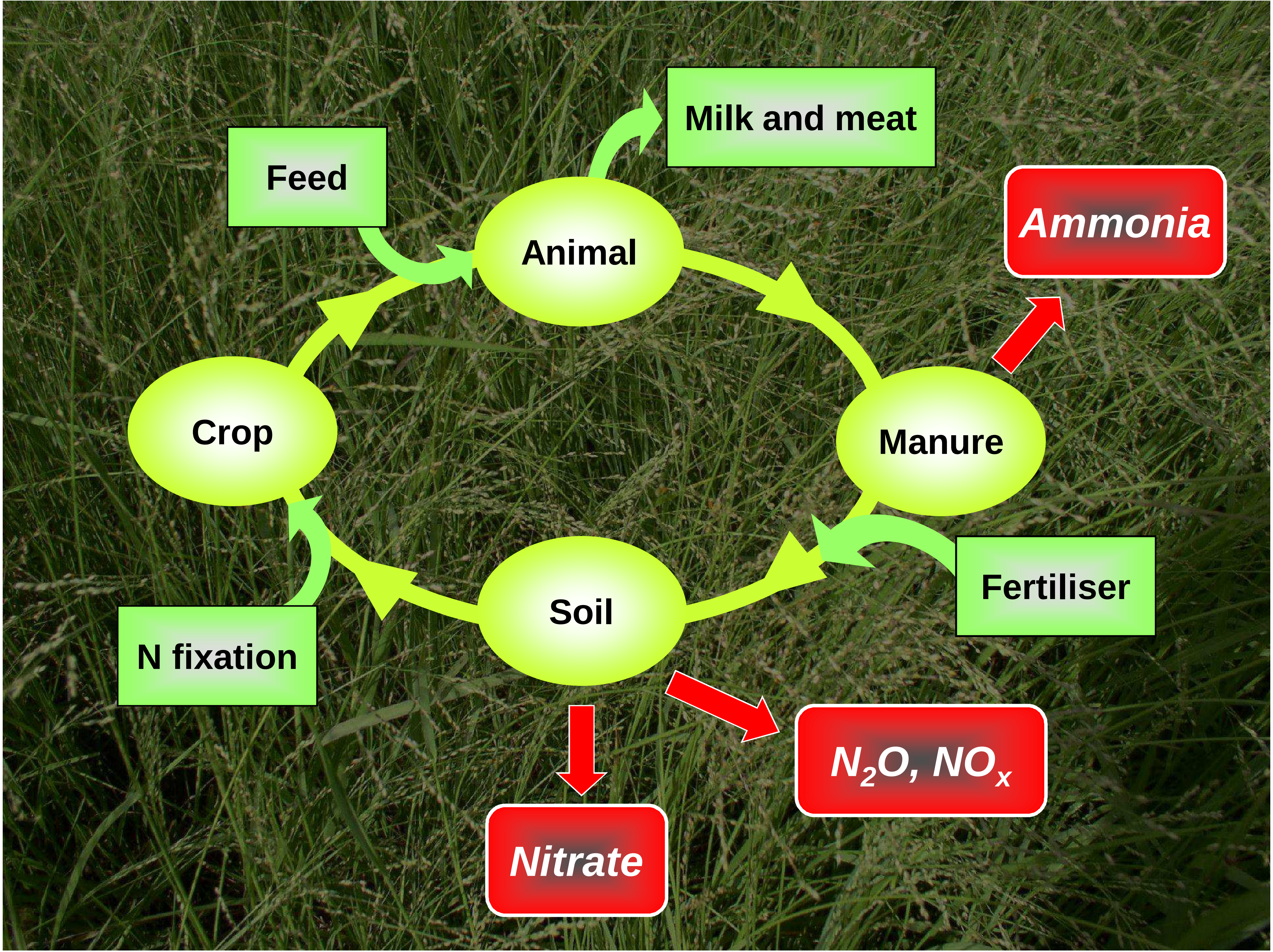
Milk N efficiency in practice



Kebreab et al. (2002)

Farm level

Item	Low input	High input
milk yield, kg/ha	8,700	20,500
milk protein yield, kg/ha	290	680
N surplus, kg/h	376	650
efficiency	0.11	0.14


Milk and meat
Feed
Animal
Ammonia
Crop
Manure
Fertiliser
Soil
N fixation
N_2O, NO_x
Nitrate

Intensification dairy production

- More feed: forage / concentrates
  - Increase crop dry matter yield
- Higher feed quality
  - Younger crop maturity
  - More starch and highly digestible protein
- More fertiliser N
- Increase import of concentrates

Conclusions

- Main factor: ruminal fermentation

  N loss, **BUT** conversion of low quality feed CP (N) into high quality microbial protein

- Fate of unused metabolic protein?

- **Challenge: maintain milk performance at lower N imports (fertilizer + feed)**

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It does not necessarily reflect its view and in no way anticipates the Commission's future policy in this area.

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