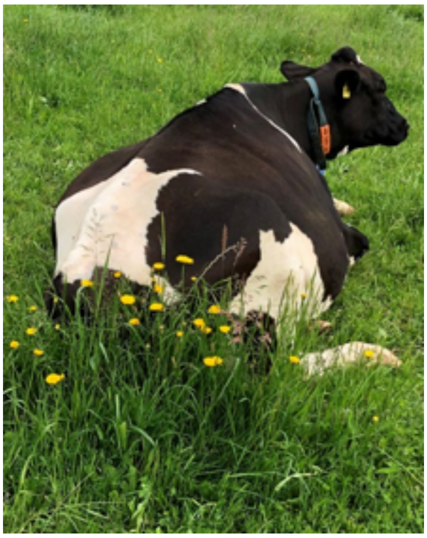
Agroscope

Protein efficiency of ruminants with a special focus on Swiss conditions



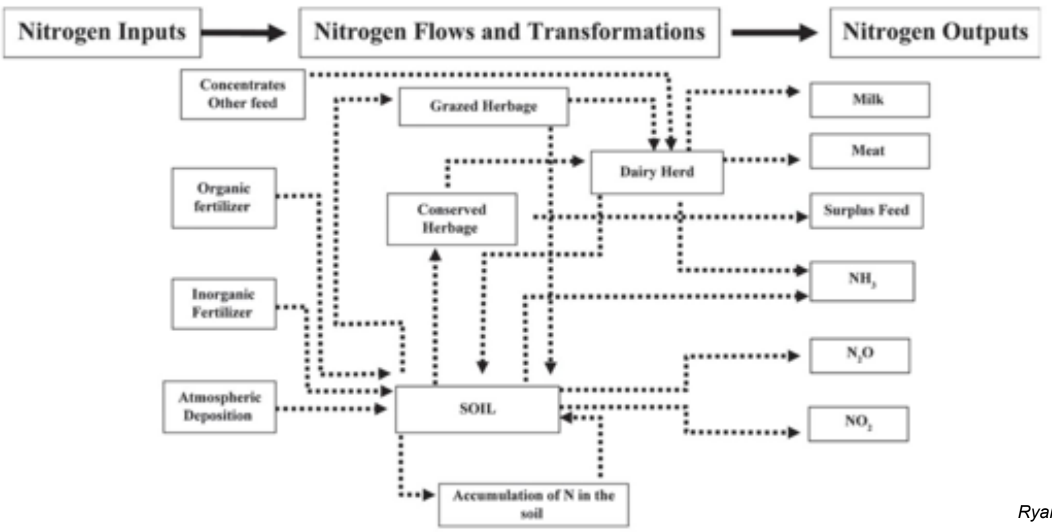
Fredy Schori, Ruminant Research Group

SVT Annual Conference 2022, 13 April 2022

www.agroscope.ch I good food, healthy environment

Agroscope

Nitrogen flows in a grass-based dairy production system



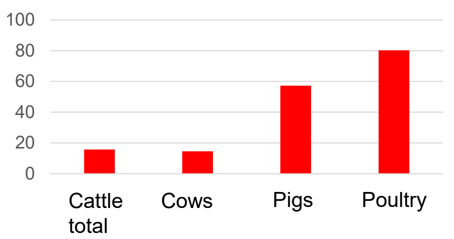
Ryan et al. 2010

Background information

- CH imports approx. 256 kT of soybean meal, 87 kT of other "meal" and 47 kT of maize gluten per year *(derived from Agristat 2021).*
- > 50 % CH open arable land cultivated with soy to compensate the protein import for feeding purposes *(own estimate)*

Proportion (%) of imported protein in the ration

Cattle on APDE and pork & poultry on CP basis (Agristat 2021)

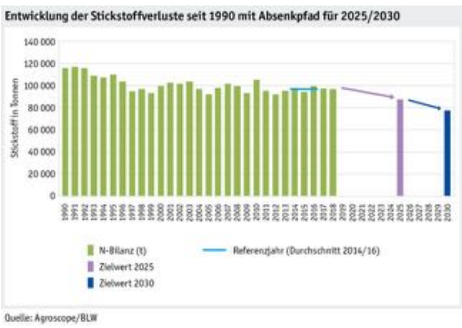


~ 40 % of protein-rich feeds for cattle
(SBV, 2011)

- 1.1.2022: 100 % Swiss Bud organic feed for ruminants on «Bio Suisse» farms
  - No protein concentrates available, dairy concentrates max. ~ 25% crude protein
- 70 % of the agr. land (0.7 m ha) is grassland plus 0.5 m ha of alpine pastures.

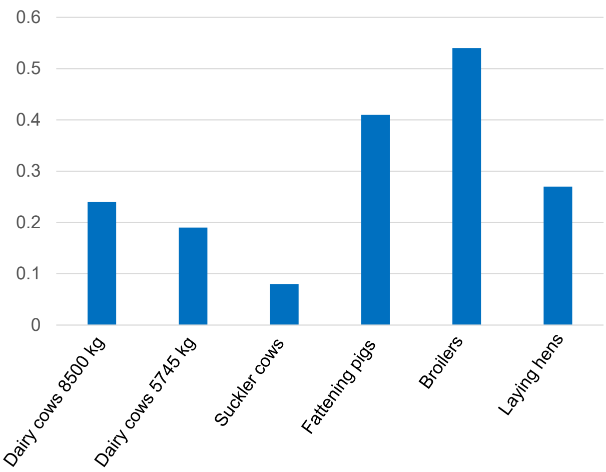
Background information

- Failure to achieve the environmental goals for agriculture with regard to N *(FOEN and FOAG, 2016)*
  - Greenhouse gas emissions including nitrous oxide (N_2O) (By 2050: reduce by 1/3 compared to 1990)
  - Air pollutants containing N (ammonia emissions max. 25'000t N/year)
  - Nitrate (25 mg nitrate per L in water bodies for drinking water use)
    - Agricultural N-inputs to water bodies (50% compared to 1985)
- Binding setback paths for N (see figure)
- Limiting protein supply in cattle feeding *(Schori, 2020; Mack and Möhring 2021)*



Protein efficiency criteria: Gross

Gross Protein Utilisation Efficiency (GPUE)



- Data from France *(Laisse et al. 2018)*
- Not 100 % comparable with CH
- Ratios are correct
- Includes entire production (e.g. rearing, lactation, dry period)

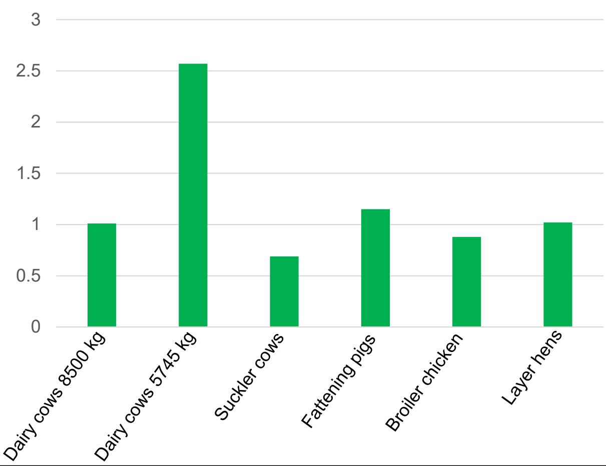
$$\text{GPUE} = \frac{\sum_{i=1}^{n} (\text{kg Product}_i \times \text{CP}_i)}{\sum_{j=1}^{n} (\text{kg Feed}_j \times \text{CP}_j)}$$

CP = crude protein (g/kg)

Monogastric animals perform significantly better!

Protein efficiency criteria: Net

Net protein utilisation efficiency (NPUE)



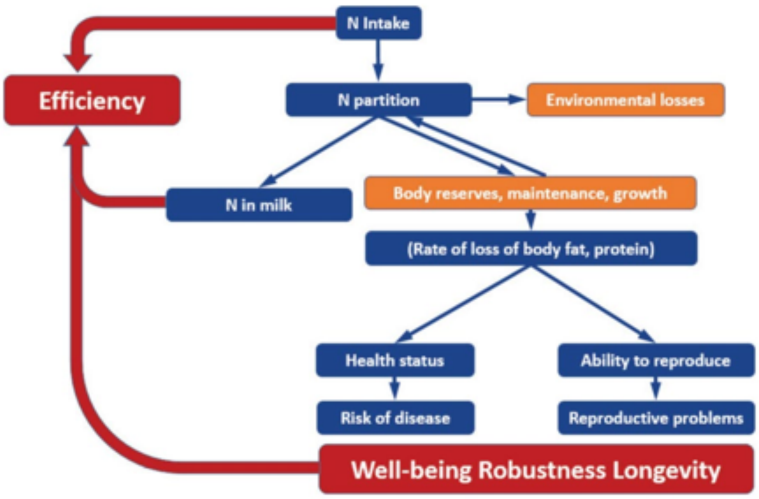
- Data from France *(Laisse et al. 2018)*
- Calculation complex (protein quality, area competition,...)

$$\text{NPUE} = \frac{\sum_{i=0}^{n} (\text{kg Product}_i \times \text{CP}_i \times \text{CF}_i)}{\sum_{j=0}^{n} (\text{kg Feed}_j \times \text{CP}_j \times \text{PFF}_j)}$$

CP = Crude protein (g/kg), CF = Consumable fraction (%), PFF = Potential food fraction (%)).

- **Grass-based, milk-producing systems perform significantly better!**
- **Both protein efficiency characteristics should be taken into account.**

Protein efficiency and animal welfare



(Chen et al. 2021)

- Gross N-use efficiency (GNUE)
  - Range 14 to 45 % *(Huhtanen & Hristov, 2009)*
- Challenges
  - Time and duration of survey
  - Determination of the individual feed intake
    - Estimation GNUE via markers
  - Relationship to animal welfare
    - Negatively correlated with udder health, fertility, longevity and calving ease *(Chen et al. 2021).*
    - Beginning of lactation

Relationship between efficiency criteria (Dissertation Thorsten Haak)

Correlation coefficients (r)	FCR	NUE	RFI	REI	RNI
Feed conversion ratio (FCR)	1				
N-use efficiency (NUE)	-0.78	1			
Residual feed intake (RFI)	0.78	-0.56	1		
Residual energy intake (REI)	0.65	-0.67	0.73	1	
Residual nitrogen intake (RNI)	0.56	-0.81	0.48	0.73	1

Feed conversion ratio: feed DM/energy corrected milk
N-use efficiency: N-milk/N-intake
Residual feed intake: effective - estimated DM intake
Residual energy intake: effective - estimated energy intake (NEL)
Residual nitrogen intake: effective - estimated nitrogen intake

r = 0.62 between energy and protein utilisation efficiency (based on digestible energy or protein intake, Phuong et al. 2013)

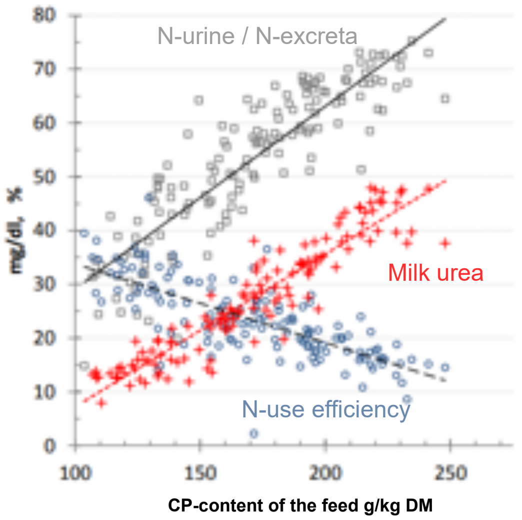
Markers for protein efficiency (Dissertation Thorsten Haak)

Marker groups	n	NUE R^2	NUE Best markers	RNI R^2	RNI Best markers
Animal characteristics	13	0.01 - 0.57	Milk yield	0.01 - 0.21	Body weight
Behaviour & Activity	46	0.00 - 0.38	Strides	0.00 - 0.74	Strides
Blood	35	0.00 - 0.38	Δ^{15} N	0.00 - 0.48	Urea
Breathing gases	3	0.00 - 0.38	O_2 , CH_4	0.00 - 0.73	O_2 , CH_4
Hair cortisol	1	0.14		0.13	
Milk	202	0.00 - 0.51	Δ^{15} N	0.00 - 0.72	Urea
NIRS faeces & milk	2	0.58 - 0.69	Faeces	0.72 - 0.93	Faeces
Rectal Temperature & Thermal Imaging	84	0.00 - 0.38	Hind leg back right average	0.00 - 0.56	Udder back average

R^2 : coefficient of determination,[2] NUE: nitrogen use efficiency,[3] RNI: Residual nitrogen intake

Influencing factor ration / feeding

- Ration / feeding *(Bracher 2011, Schori 2020)*
  - N-supply or N-content of the diet is positively correlated with feed intake and milk yield and negatively correlated with NUE
  - Energy intake (carbohydrates) improves NUE, decreasing with increased supply.
  - Amino acids (methionine, lysine, histidine) can improve e.g. reduced N supply NUE *(Laroche et al. 2021)*
  - Effects of synchronous energy and protein intake are less important in vivo than theoretically assumed *(Cabrita et al. 2006)*
  - Preservation, heat treatments, tannin and saponin-containing feeds as well as essential oils have inhibitory effects on individual steps of the protein degradation *(Walker et al. 2005).*



(Bracher 2011)

Influencing factors animal

- Few studies with dairy cows on animal-specific influencing factors and NUEs.
  - Body size, age, stage of lactation and milk yield potential *(Blake & Custodio, 1984, Huthanen et al. 2015).*
    - NUE: 0.24 - 0.35 *(derived from Huthanen et al. 2015)*
  - Breed and crossbreed animals (genotype and heterosis effect) *(McDowell & McDaniel 1968)*
    - NUE: 0.286 - 0.326

Control of rations and improved management show greater potential to improve N-efficiency in lactating cows than selection of efficient cows *(Huthanen et al. 2015)*

Limiting protein supply in cattle diets

- Further development of the Grassland-based Milk and Meat Production (GMM) programme
  - Current GMM: meadow fodder share (v a l l e y : 7 5 % , m o u n t a i n a r e a : 8 5 concentrated feed.
    - 2/3 farms, 3/4 grassland, 110 million Fr./year
  - Under discussion: 12% and 18% CP variants (Limiting the amount of concentrates?)
    - Goal:
      - Protein from herbage and not from protein concentrate
      - Ruminant-friendly feeding
      - Production adapted to the location (forage production - animal)
      - Little competition with arable food production.

Effects of protein reduction on milk yield

Beginning of lactation (90 days)

- **GMM today:**
  - 2 kg cereal mixture
  - 1 kg protein concentrate
- **GMF 12 %:**
  - 3 kg grain mixture

Organic farm, School Farm Sorens, mountain zone 1
32 cow pairs (Holstein, Swiss Fleckvieh)
Results of the first 6 milk recordings (fortnightly)
Grouped calving 1/3 of the year (2021)
Contents per kg dry matter
Hay: 5.3 MJ NEL, 118 g RP (22 g RP/MJ NEL)
Pasture herbage: 6.1 MJ NEL, 158 g RP (26 g RP/MJ NEL)
Cereal mixture: 7.7 MJ NEL, 136 g RP (18 g RP/MJ NEL)
Protein concentrate: 8.2 MJ NEL, 412 g RP (50 g RP/MJ NEL)

	GMF today	GMF 12%	SE	*P*
Milk (kg d^{-1})	29.6	27.9	0.76	***
ECM (kg d^{-1})	29.1	27.4	0.78	***
Milk fat (g kg^{-1})	40.7	40.3	0.55	-
Milk protein (g kg^{-1})	30.6	30.8	0.29	-
Lactose (g kg^{-1})	48.1	48.4	0.20	**
Urea (mg dl^{-1})	19.7	15.9	0.58	***
Somatic cells (log 10 ml^{-1})	4.58	4.59	0.05	-

ECM: energy corrected milk, SE: standard error: P: probability of error

- Protein use pays off!
  - At least in conventional milk production
- 2022: Dairy cattle feed 25 % CP

Conclusions

- Switzerland imports considerable quantities of protein-rich feeds and a large proportion is used for ruminants.
- Net efficiency characteristics that distinguish between feed and potential food shall be taken into account.
- Animal welfare, fertility and longevity are to be tested in protein-efficient dairy cows.
- Protein efficiency of dairy cows can be estimated by markers without knowing the feed intake.
- The protein intake or content of the ration plays the biggest role in terms of protein efficiency or nitrogen excretion.
- The discussed variants of the Grassland-based Milk and Meat Production programme will limit the protein supply in ruminants.
- At least in conventional dairy production farms, protein supplementation seems to be worthwhile - even above the protein requirements.

Thank you for your attention!

(fredy.schori@agroscope.admin.ch)