Evaluation of fill unit systems used for dairy cattle

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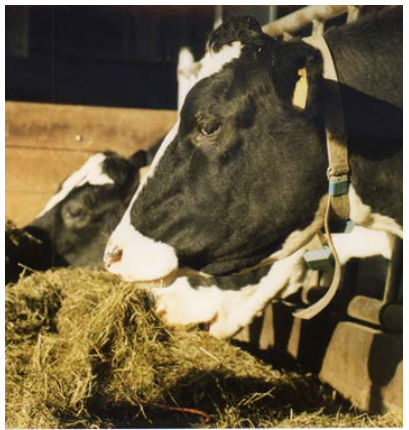
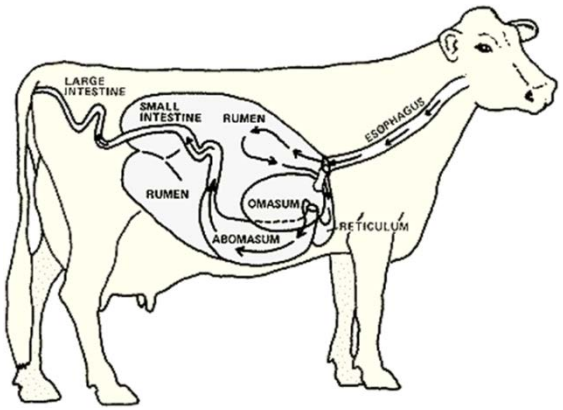
Why Prediction of Feed Intake?

- Feed budgeting & diet formulation
  - Identify feed surplus/shortage
  - Allocation of available feeds to groups of cows
  - Balancing diets
- Explore different feeding strategies
  - Alternative forage & concentrate options
  - Evaluate economical and environmental impact
    - Feed 50-70% of operational costs
    - N, P and GHG emissions



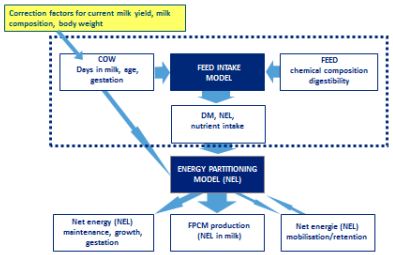
Regulation of Feed Intake

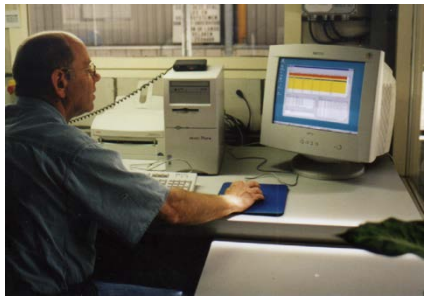
- Complex multi-pathway feedback mechanisms
  - Feedback mechanisms Central Nervous System
    - GIT: chemo- and mechanoreceptors (fill, pH, osmolality)
    - Metabolism: oxi-, gluco- and lipostatic regulation
    - Body composition (fatness)
    - Environment (housing, climate, photoperiodicity)
    - Feed: taste, smell, preference
    - Feeding method, feed availability, diet composition
- In short: Animal × Feed interactions



Feed intake models

- Flexibility
  - Suitable for various feeds
  - Easy measurable inputs
- Should include
  - Feed factors
  - Animal factors
  - External factors
- Accurate and robust





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Modelling Feed Intake

- Mechanistic models
- Multiple regression models
  - Concentrate input, cell wall fractions (forage, concentrate)
  - Stage of lactation, lactation number, Milk yield
  - Temperature
- **Fill Unit systems**
  - Separation in Animal and Feed factors
  - Flexible, suitable in many different situations

“Fill” Unit systems

- The principle of fill-unit systems

  DMI (kg/d)= IC/Fill

  IC = Intake Capacity in “Fill”-units/day

  Fill = “Fill”-units per kg DM

- Intake capacity
  - The animals ability to process the “Fill”
- “Fill”
  - Not only physical limitation of intake
  - Preference, digestibility, metabolic regulation

“Fill” Unit systems:

- France INRA (FR) (Jarrige et al. 1986, Faverdin et al. 2011)
- Netherlands (NL)(Zom et al. 2012)
- Nordic Countries NorFoR (NF) (Volden et al. 2011)

Fill unit systems: animal factors

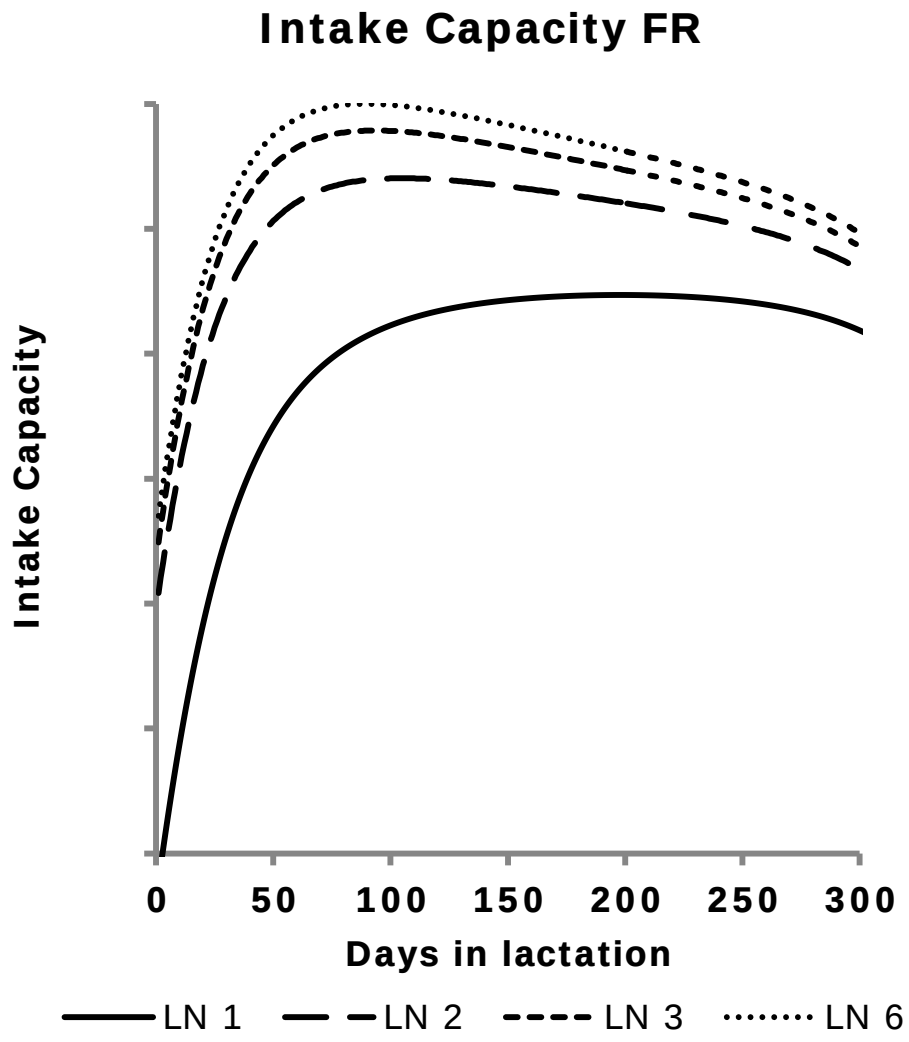
- Model inputs to predict Intake Capacity

	FR	NL	NF
Stage of lactation	×	×	×
Stage of gestation	×	×	×
Lactation number	×	×	×
Age	×		
Breed	(×)	×	×
BCS	×		×
BW	×		×
Milk yield	× maxPotMY kg/d Max Pot.		× ECM kg/d

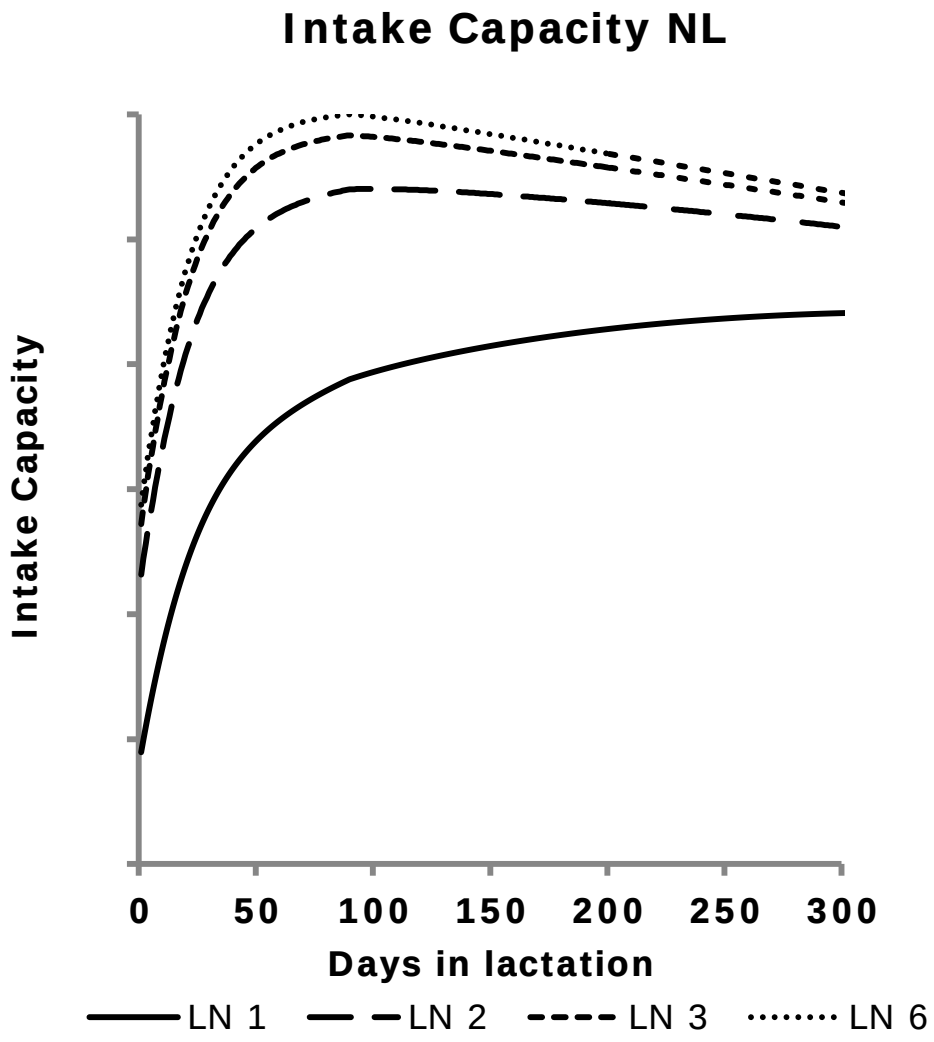
Animal factors

- Animal factors represent the physiological and metabolic state of the cow
- Animal outputs (actual Milk Yield, BW, BCS) as input
  - Difficult to combine with predictive models of animal production
  - Require assumptions of a “potential” production
    - Potential production requires non limiting conditions
  - Iterative routines

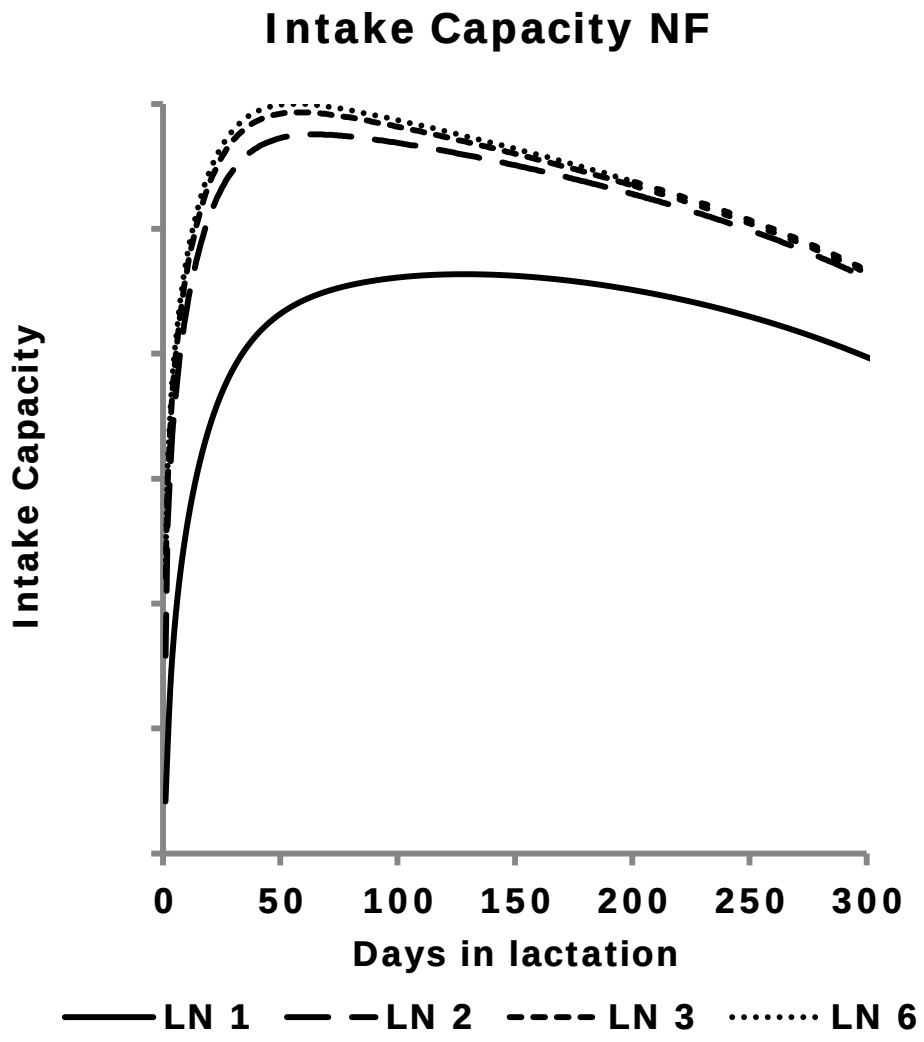
Intake Capacity FR



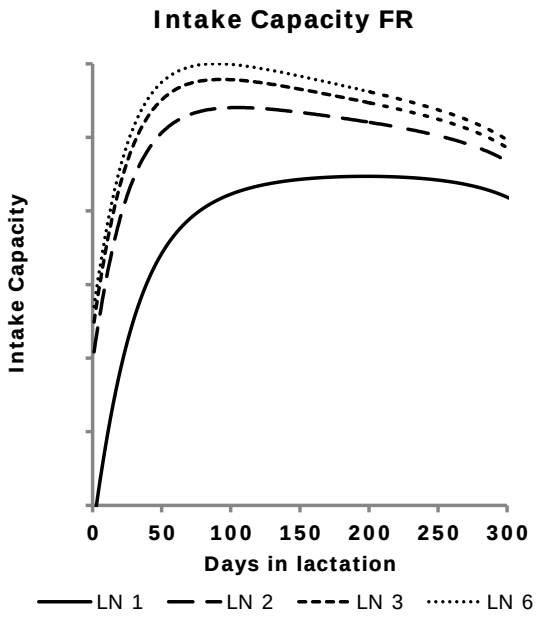
Intake Capacity NL

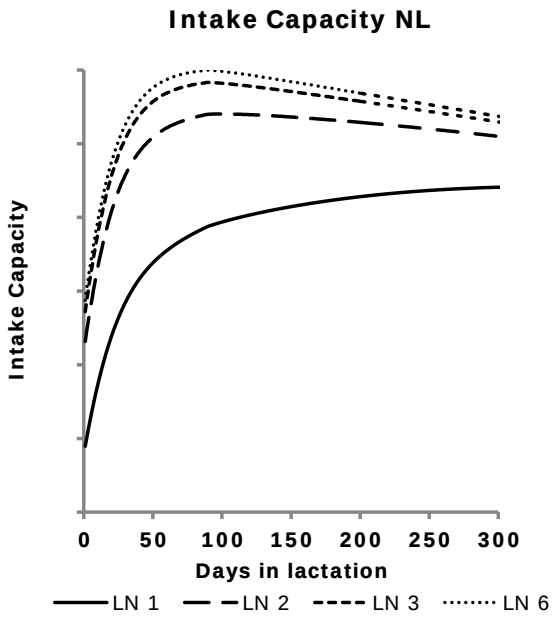


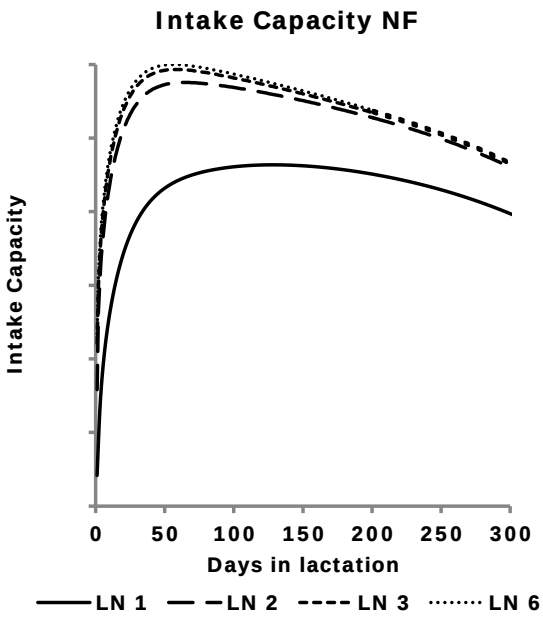
Intake Capacity NF



Intake Capacity







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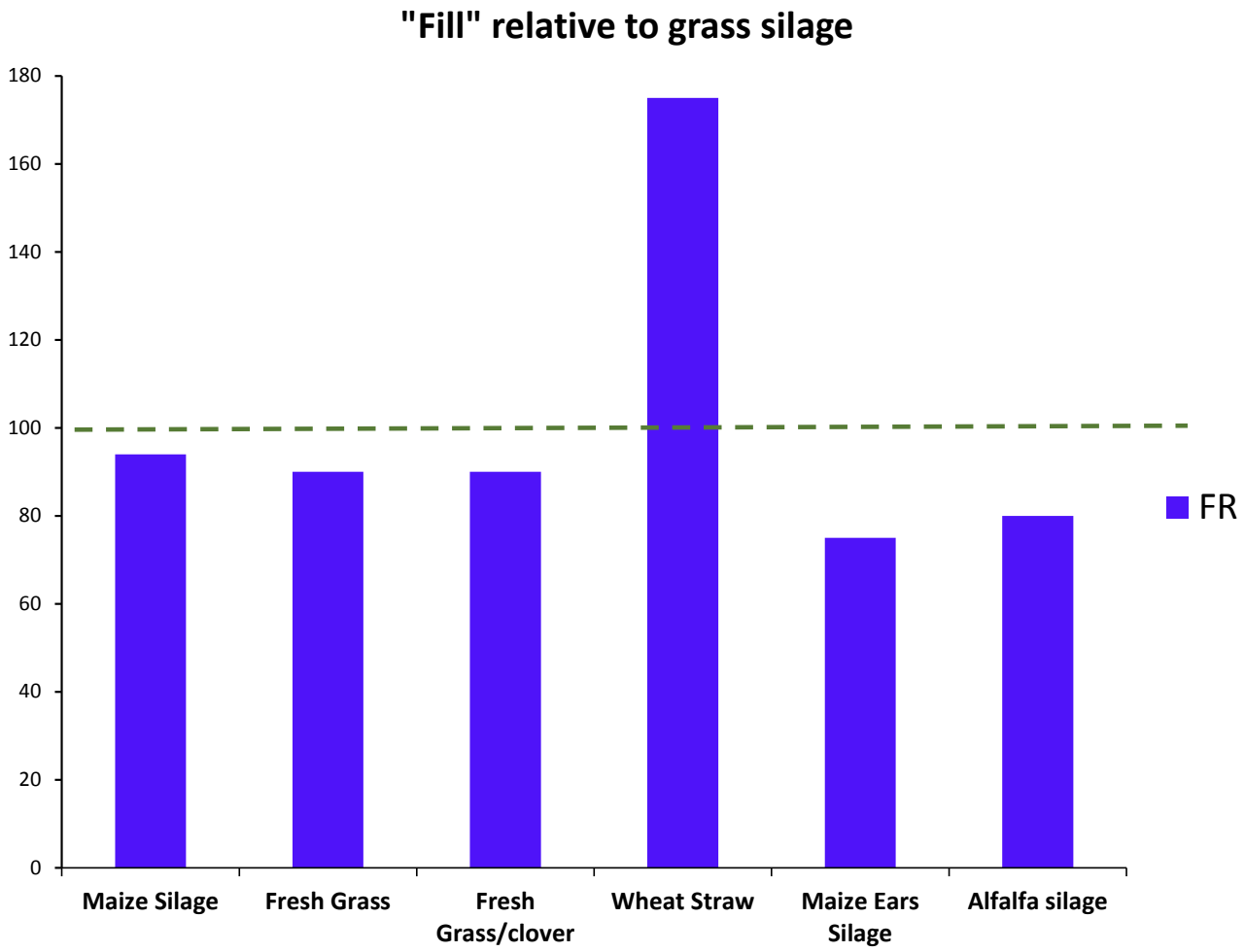
Fill unit systems: feed factors

	"Fill" Value Forage	"Fill" Value Concentrate
FR	Table Values & equations Inputs: DM, Cfibre, CP	Variable Energy balance
NL	Feed specific equations Inputs: DM, Cfibre, CP Ash, %OMD	Variable equation
NF	Non specfic equation Inputs: NDF, %OMD fermentation products	Fixed

Fill unit systems: feed factors

- Dry Matter
  - Bulk volume, silage preservation, hydration, microbial colonisation …
- Crude Protein
  - Nitrogen availability for rumen microbes …
- Crude Fibre / cell walls
  - Particle size reduction, passage rate …
- Digestibility / OMD%
  - ruminal VFA production, ruminal disappearance …

Approximate Fill value relative to grass silage



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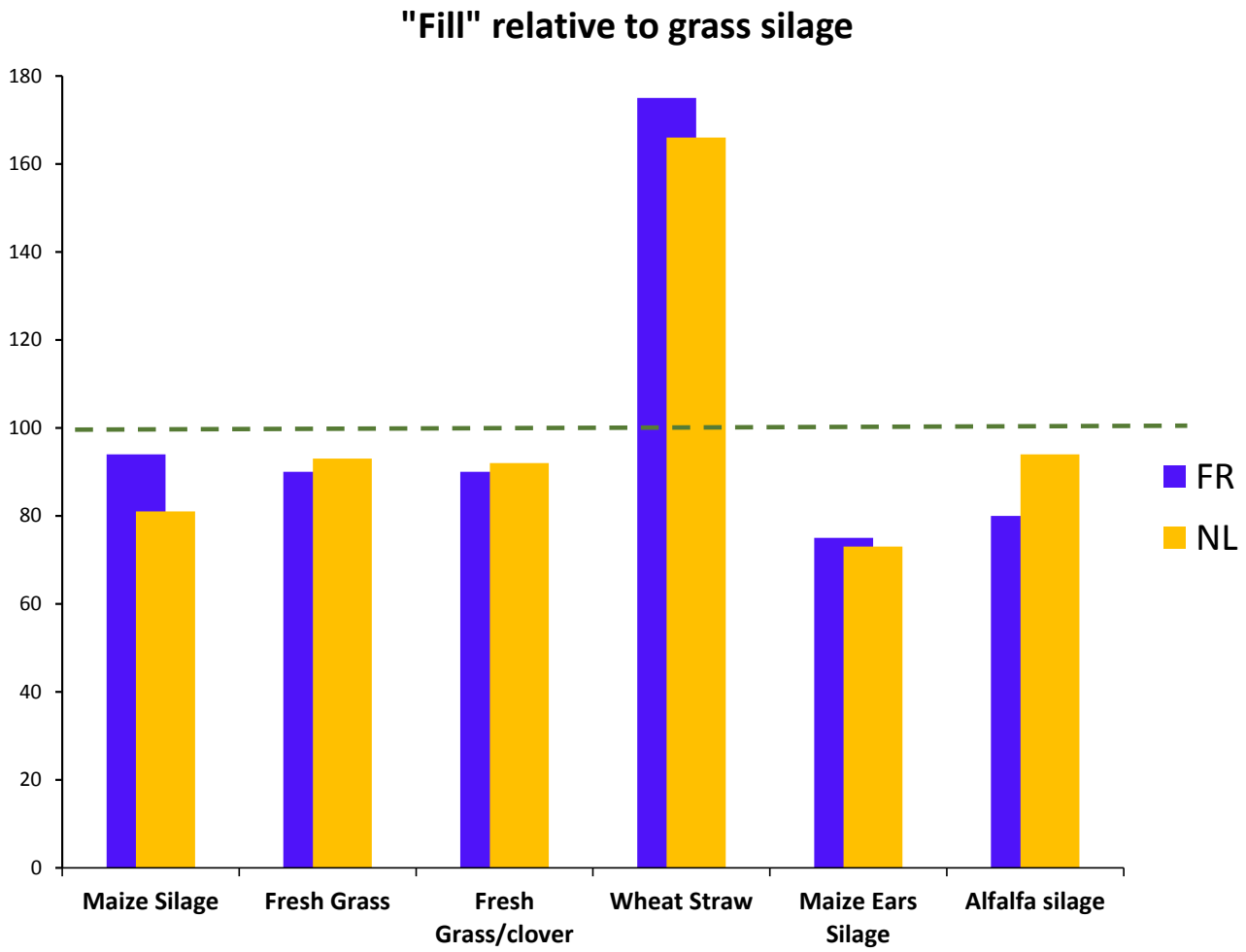

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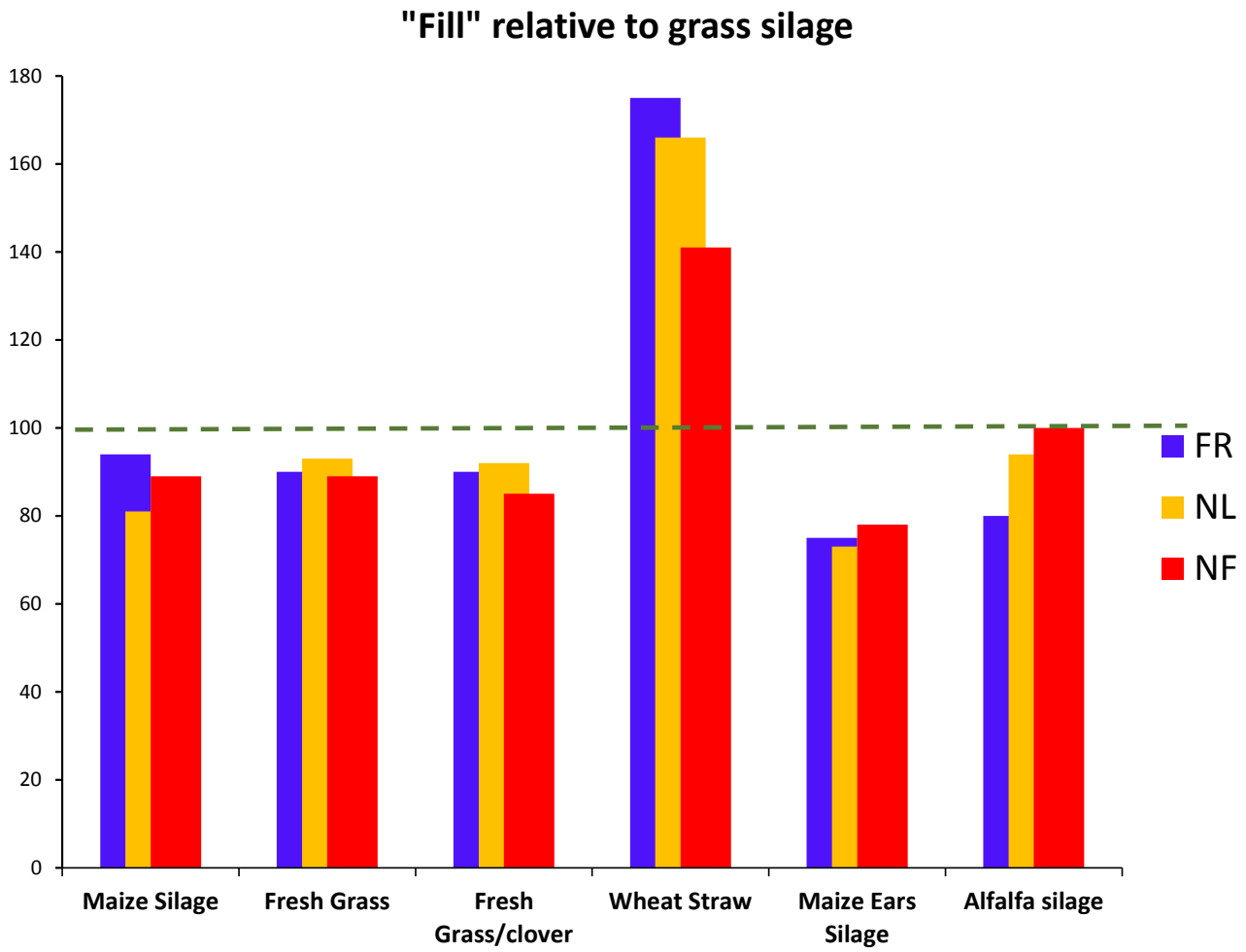


Fill value of forage

- Within forage differences in relative “Fill”
- FR – NL – NR
  - Ranking of “Fill” of feeds similar
  - Fill Maize silage & Fresh grass < Grass silage
  - Fill Straw > Grass silage

Fill value of concentrate and substitution (I)

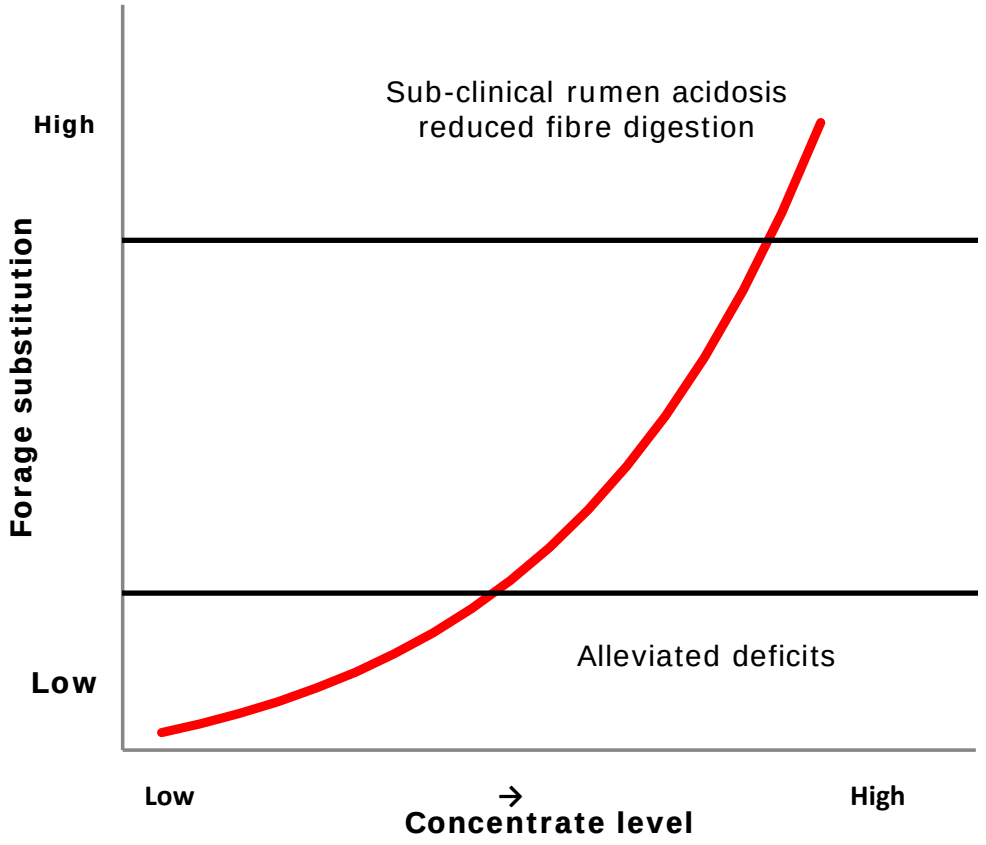
- Substitution of forage intake by concentrate intake
- “Concentrate” has no clear definition → arbitrary
- Systems are different
  - NL → simple
  - NR → linear with adjustment for sugar and starch content
  - FR → interaction with energy balance

Fill value of concentrate and substitution (II)

- Non-linear substitution rate (SR)
  - Low substitution at low concentrate levels
    - Alleviate deficits (readily available CHOs, N, etc.)
  - High substitution at high concentrate levels
    - (Sub)-clinical rumen acidosis, reduced fibre digestion

Fill value of concentrate and substitution (III)

- Systems are different with regard to substitution of forage
- Non-linear



Fill value of concentrate and substitution (IV)

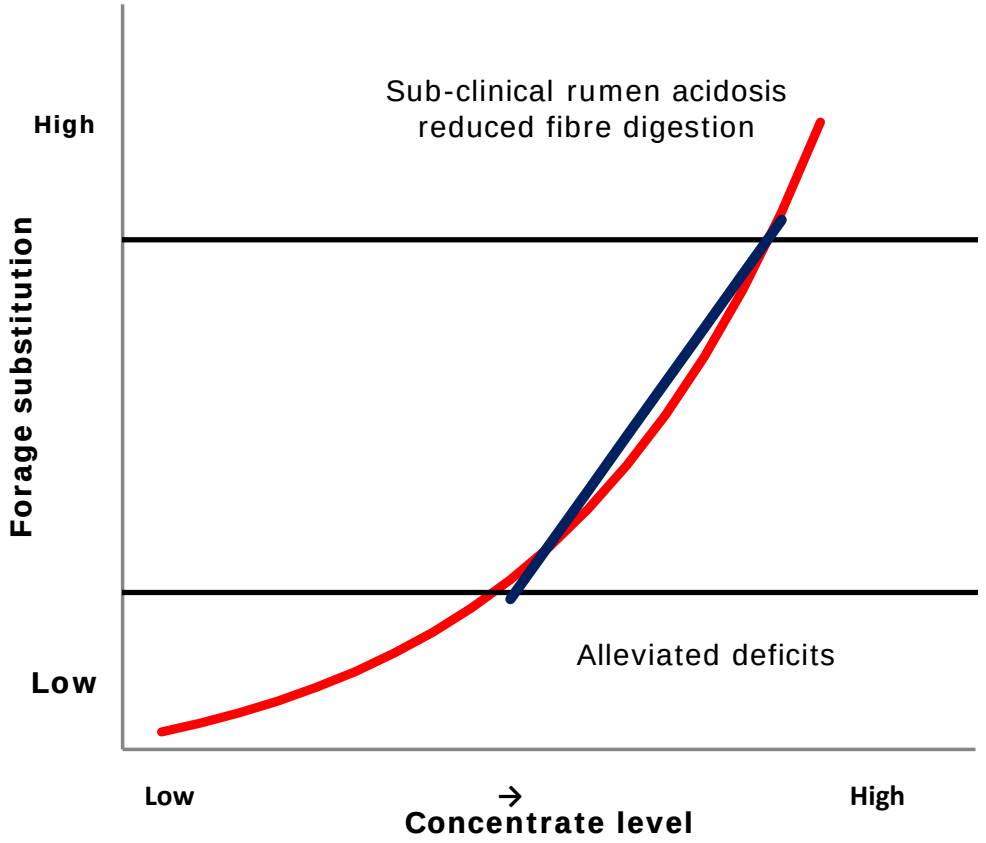
- Systems are different with regard to substitution of forage
- INRA system rather complex
  - Takes the energy balance into account
  - Reflects metabolic regulation
  - Needs an output (milk production) as an input
  - Feed intake model can only be used in conjunction with the UFL energy system

Fill value of concentrate and substitution (V)

- Systems are different with regard to substitution
- NL system:
  - Linear substitution → $SR = Fill_{Concentrate} / Fill_{Forage}$
  - Non-specific, substitution of any feed “x” by any feed “y”
  - Limitation: general “nutrition rules” have to taken into account
    - Minimum levels of physical structure (effective fibre)
    - Avoid deficits (N, minerals, physical structure), e.g. Rumen Degradable Protein balance >0
  - Suitable under practical conditions

Fill value of concentrate and substitution (VI)

- Linear substitution
  - Practical conditions



Fill value of concentrate and substitution (VII)

- NR: Linear with adjustment for diet composition
  - NorFor system
    - Fixed Fill value for concentrate
    - Substitution rate is linear
    - Substitution is not a “concentrate” effect per se
    - Taking the whole diet into account
    - Adjustments for starch and sugars in the diet

Discussion (I)

- Fill Unit systems differ in:
- Animal factors:
  - Actual and “potential” milk production
    - MY correlated with DMI → MY is pushed by (energy) intake
    - Intake lags behind milk yield
    - Potential milk production is not really known
    - Milk production may be associated with metabolic state (pull)
  - Genetic level or breed
    - Scaling factors
    - Genetic theoretic intake potential

Discussion (II)

- Fill Unit systems differ in:
- Feed factors:
  - Limitations in available data, e.g.
    - Proportion of concentrates
    - Feed variables
    - Growing condition grass (N fertilization)

Discussion (III)

- National research efforts in feed evaluation
  - national systems create national “nutritional languages”
  - fragmentation of research efforts
  - individual EU countries: risk for reduced expertise, funding and involvement of young scientists

Discussion (IV)

- Harmonizing of feed evaluation systems in Europe
  - systematically compare feeding systems in use in EU
  - work towards a more unified system of farm animal nutrition in Europe
  - stimulate “European thinking” and shared language
  - collaborative capacity and network building
  - accelerate innovation

Discussion (V)

- Harmonizing Fill Unit systems in Europe:
  - Cross validation
    - Testing the models in different situations
    - Harmonizing datasets and feed variables
    - Parameterization to other datasets
  - Improve models
    - Harmonize models
    - Collaboration in future innovations

Discussion (VI)

- Future developments in fill unit systems
  - Fill systems integrated with grazing systems
    - FR: GrazeIn (2011), NL: GrazeVision (2011)
  - Modelling differences in genetic potential
  - …
  - …

Thanks for your attention!

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