# Hungry cows chew a lot – what stimules cows to chew?

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CPH Cattle seminar 24th of November 2022 University of Copenhagen, Frederiksberg

**Based phd thesis by**

Louise F. Kornfelt, 2012
Alireza Jalali, 2013
Anne-Katrine Schulze, 2014
Laura M. Jensen, 2015

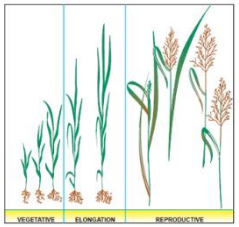
# Outline

**Physical effective** fibre (peNDF) in forage

**Particle size distribution in faeces and in rumen content**

**Chewing time per NDF unit at different stage of maturity**

**Factors affecting feed intake**




**An new intake models based on chewing index**

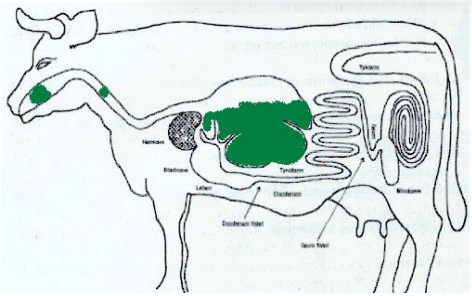
**Effect of concentrate supplementation on forage intake**

**Summary**

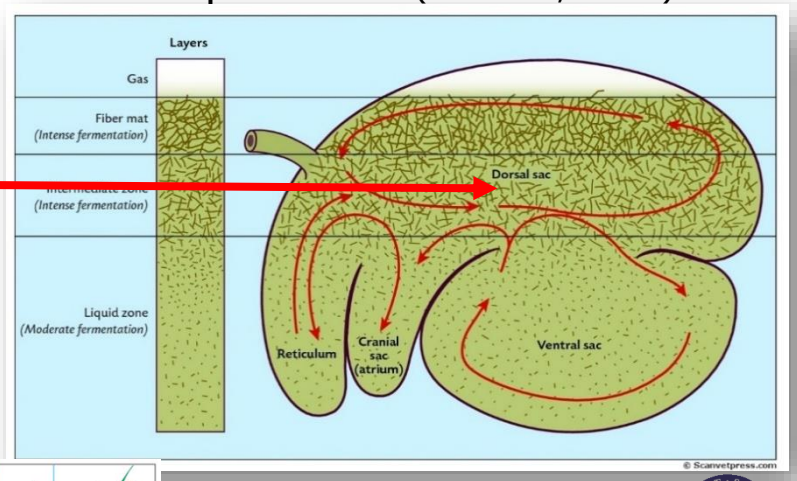
# Fiber concepts

**Non structural:** ex. pectin's, β-glucans

**Structural**: NDF & crude fibre

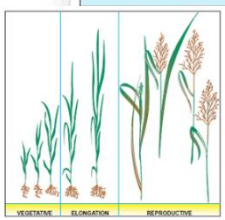


- Not physical effective:
  - Feed particles < particles in faeces
- **Physical effective (peNDF)**
  - Feed particles> faeces particles
    - Paricles retained on sieve with 1.18 mm pore size (Mertens, 1997)
  - **Particles which stimulates**
    - Rumination
    - Rumen motility
    - Flowing layer in rumen
  - **Selective retained in rumen**
  - **Constrain intake**



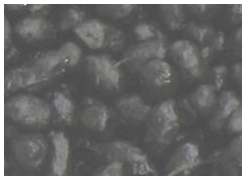

**Forage is not just forage!**

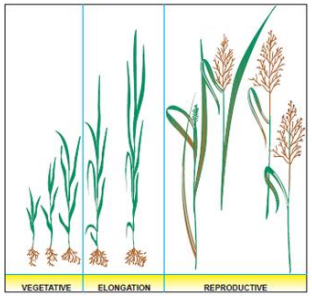
- Grass: ↑NDF & ↓INDF*/NDF
- Legumes:↓NDF, ↑INDF/NDF
- Stage of maturity at harvest



* Indigestible NDF

# Particle length and width in faeces from sheep fed early, medium or late cut grass silage





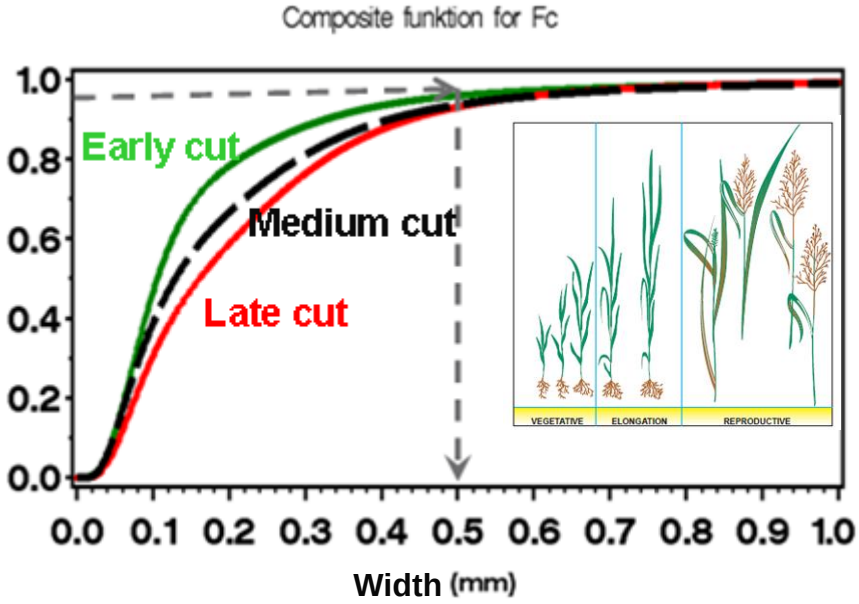

Jalali, Nørgaard et al. 2012, Animal,6

Vash

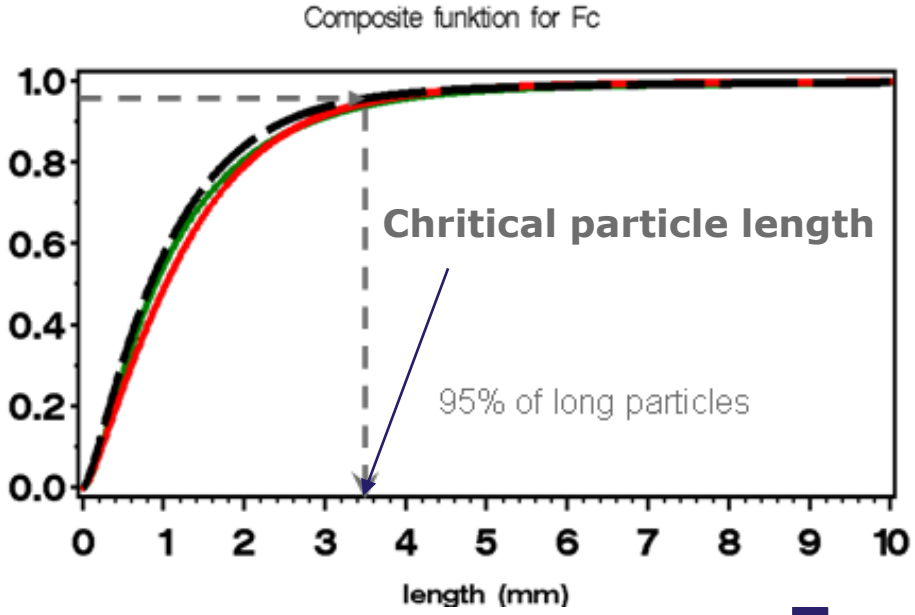
→Drying→Sieving→

**Image analysis**

Particle width distribution



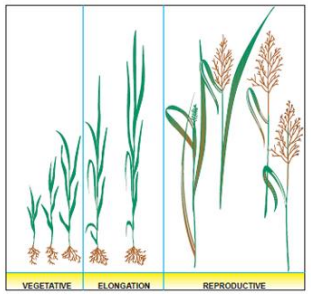

Particle length distribution

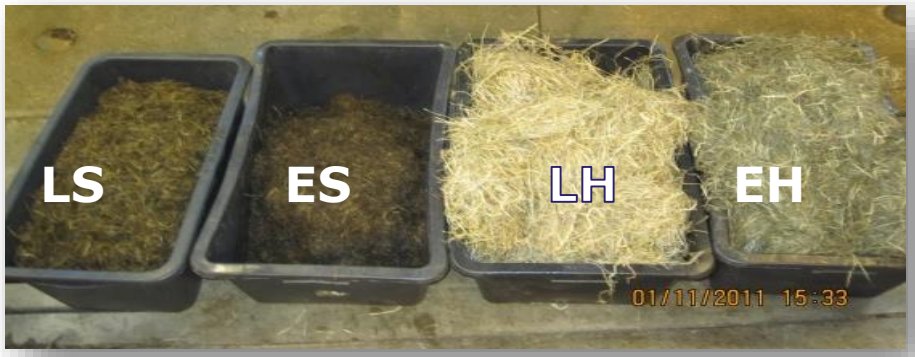


# Clover grass hay or - silage harvested at 2 stage of maturity fed to Jersey heifers

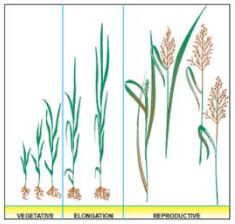
Schulze ..Nørgaard et al. 2014, Animal

| **Treatment** | **ES** | **EH** | **LS** | **LH** |
|---|---|---|---|---|
| Maturity stage at harvest | Early | | Late | |
| Conservation | Silage | Hay | Silage | Hay |
| Fiber components | | | | |
| NDF, % of DM | 31 | 44 | 41 | 50 |
| iNDF, % of NDF | 8 | 7 | 12 | 11 |




# Chewing activity in 4 Jersey heifers



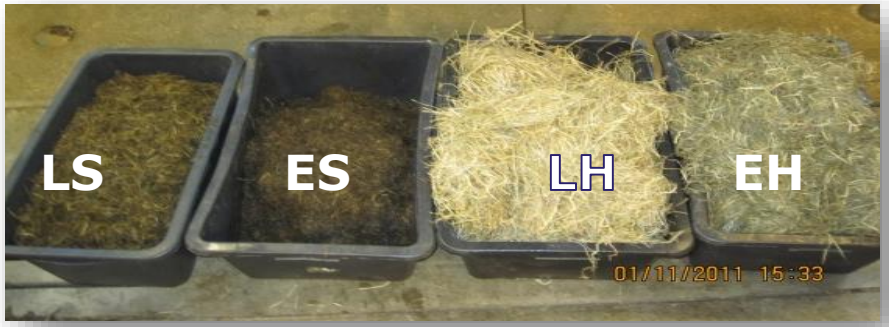

| | Forage | | | | *P*-value | |
|---|---|---|---|---|---|---|
| | Early silage | Early hay | Late silage | Late hay | Harvest | Conservation |
| Chewing time, min/kg NDF intake | | | | | | |
| Eating | 96 | 59 | 119 | 66 | NS | * |
| Rumination | 138 | 94 | 150 | 133 | ** | ** |

**Early compared with late harvest**

- Similar eating time per kg NDF
- ↓ Rumination time per kg NDF

**Silages compared with hays**

- ↑ Eating time per kg NDF
- ↑ Rumination time per kg NDF




**Related to NDF intake and iNDF:NDF?**

Schulze ..Nørgaard et al. 2014, Animal

# Chewing activity related to NDF intake and INDF:NDF

Multiple linear regression
- NDF intake per kg BW
- iNDF:NDF ratio


| | ↑NDF intake, g/kg BW | | ↑ iNDF*:NDF | |
|---|---|---|---|---|
| Chewing time, min/kg NDF intake | | | | |
| Eating | ↑ | * | | NS |
| Rumination | ↓ | *** | ↑ | ** |

* Indigestible NDF

Schulze ..Nørgaard et al. 2014, Animal

# Conclusion


| Treatment | ES | EH | LS | LH |
|---|---|---|---|---|
| Maturity stage at harvest | Early | | Late | |
| Conservation | Silage | Hay | Silage | Hay |
| Fiber components | | | | |
| NDF, % of DM | 31 | 44 | 41 | 50 |
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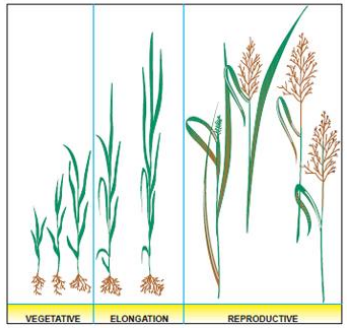
Schulze Nørgaard et al. 2014




**Early compared with late maturity at harvest**

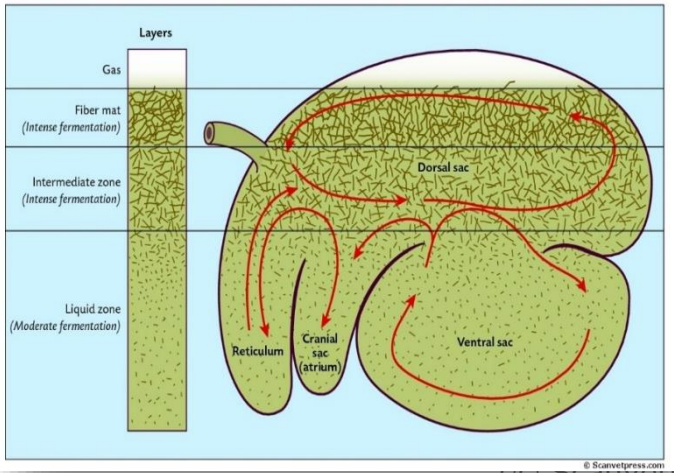
- Same eating time per kg NDF
- ↓ Rumination time per kg NDF ↑ NDF digestibility

Effects of **conservation method** were mainly caused by differences in NDF intake per kg BW and iNDF:NDF ratio

↑ **NDF intake** →

- ↓ Eating and ↑rumination time per kg NDF
- ↑ Large particles in feces
  (Jalali.. Nørgaard et al. 2015)

↑ **iNDF*:NDF** ratio → ↑ rumination time/NDF

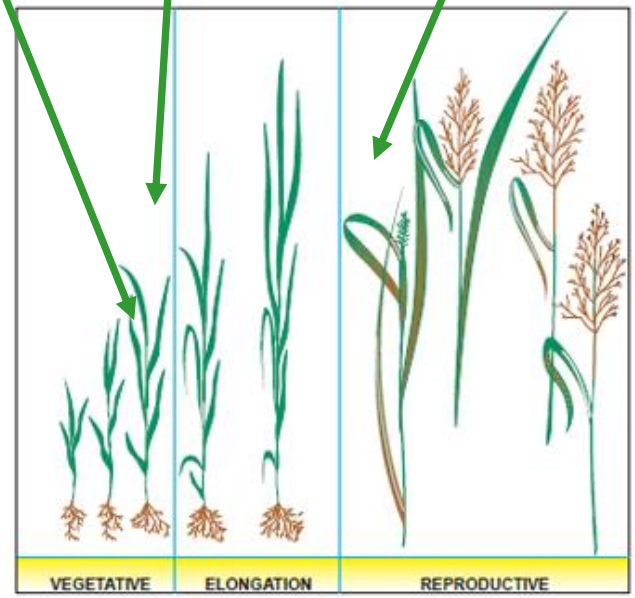



* Indigestible NDF

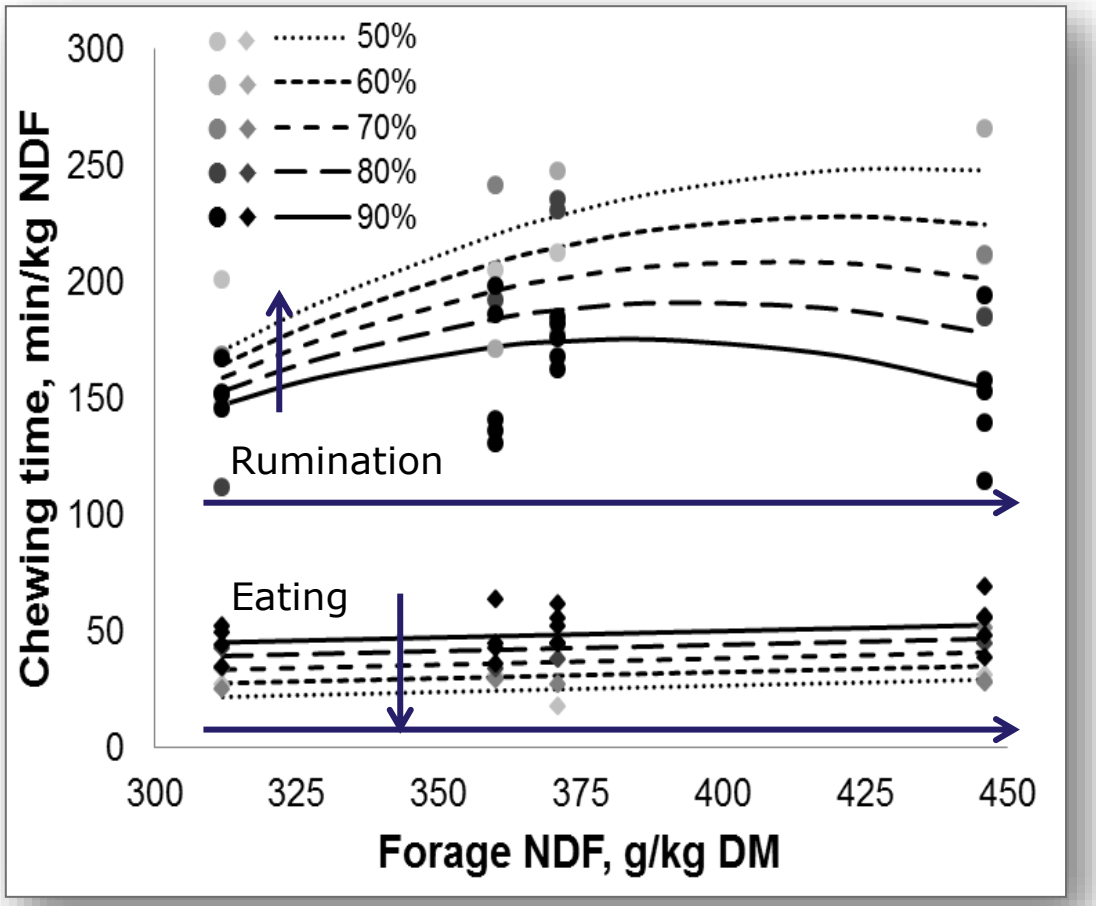
# Grass silages harvested at different stage of maturity and fed to 4 Jersey heifers at different intake levels

(Schulze .. Nørgaard et al. 2014, Animal, 8)

| **Treatment** | **S1** | **S2** | **S3** | **S4** |
|---|---|---|---|---|
| Growth | Spring | 3rd | 3rd | 1st |
| Maturity stage | early | early | late | beg. heading |
| Fiber components | | | | |
| NDF, % of DM | 31 | 36 | 37 | 45 |
| iNDF, % of NDF | 8 | 10 | 12 | 13 |



# Eating and rumination, min/kg NDF intake



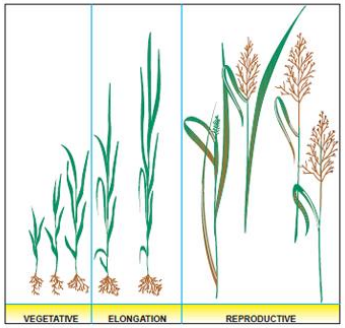

Rumination time / kg NDF

- More with ↑ NDF content (**), depending on feeding level
- More with ↓ feeding level

Eating time / kg NDF

- No effect of NDF content
- ↓ with ↓ feed intake (***)

↓ Eating:rumination with
↓ NDF intake




Schulze .. Nørgaard et al. 2014, Animal, 8

# **Summary on chewing** = eating + rumination

- **Daily Chewing time** depends on peNDF intake/BW
- **Chewing time per kg $NDF_{forage}$** depends on
  - Intake of $NDF_{forage}$/BW
  - $INDF/NDF_{forage}$
- **Chewing index (CI) (NorFor)**
  - 4 min/kg conc. DM
  - 150 min /kg $NDF_{forage}$ , dep. on INDF/NDF and particle length

# Background – Feed intake

- **Accounts for variation** → productivity → economic benefits
- **Why modelling of feed intake**?
  - Optimal concentrate allocation →optimal milk production
  - → Reduce risk of ketosis & rumens acidosis, laminitis
- Factors affecting intake (Invartsen, 1994; Mertens,2007):

## Dietary characteristics

**Energy value**

Digestibility

**NDF**

**Particle length**

Protein value

Fermentation products

## Animal characteristics

Breed

**Body weight/metabolic size**

Parity

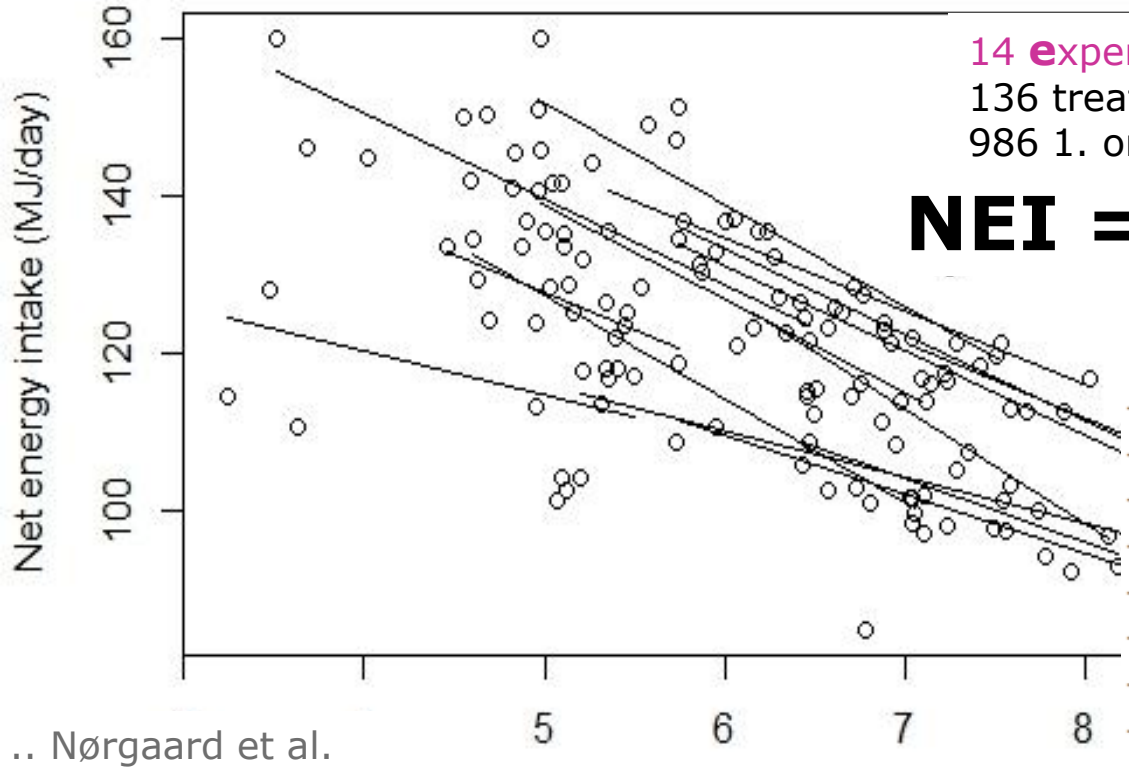
**Days in milk (DIM)**

Days in gestation

Body condition

**Milk yield/ ECM**

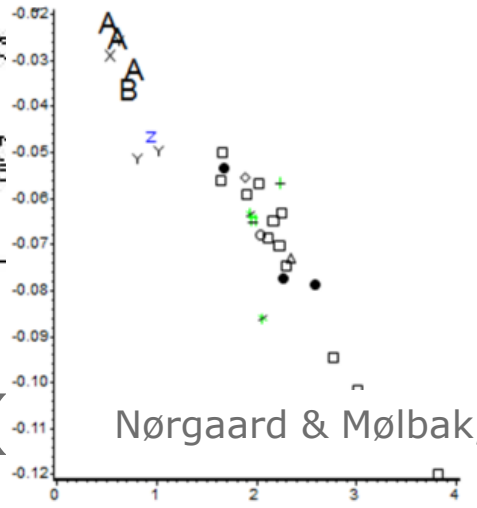
# Linear relation within experiments:
## Net Energy Intake in dairy cows related to the dietary chewing index value




14 **e**xperiments
136 treatments
986 1. or higher parity cows

$$NEI = NE_{0e} - b_e * CI_{cor}$$

$$b_e = k * NE_{0e}^2$$




Nørgaard & Mølbak, 2001

Jensen .. Nørgaard et al. 2016, JDS 99

Chewing index ($CI_{cor}$ (

$NE^2_{0e}$

$$NEI = NE_0 - \frac{NE_0^2}{4 * CT_{max}} * \left(\frac{625}{BW}\right) * CI_{cor}$$

# Effect of forage quality & metabolic capacity on substitution

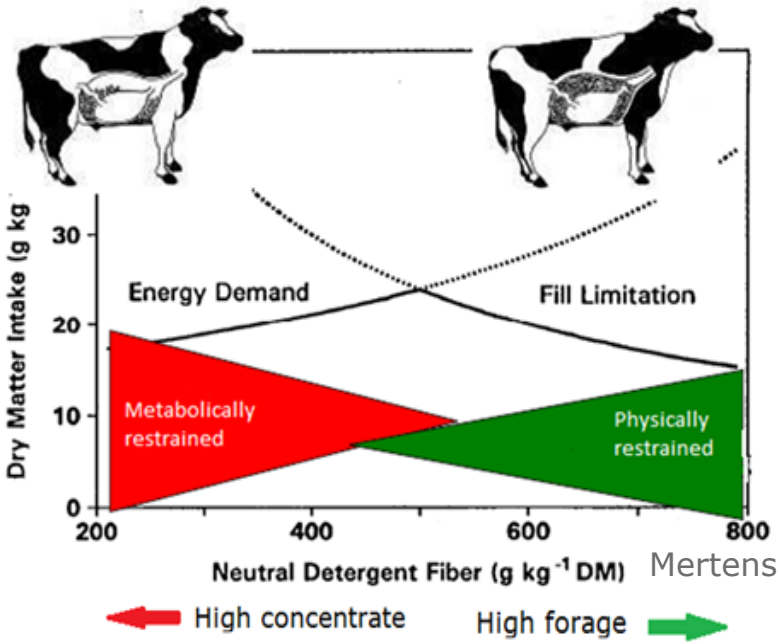
$$NE_{forage} = NE_0 - \frac{NE_0^2}{4 * CT_{Max}} * \left(\frac{625}{BW}\right) * CI - NE_{concentrate}$$

$CT_{Max}$ max chewing time ~ 900-1000 min/d at physical constraint on intake

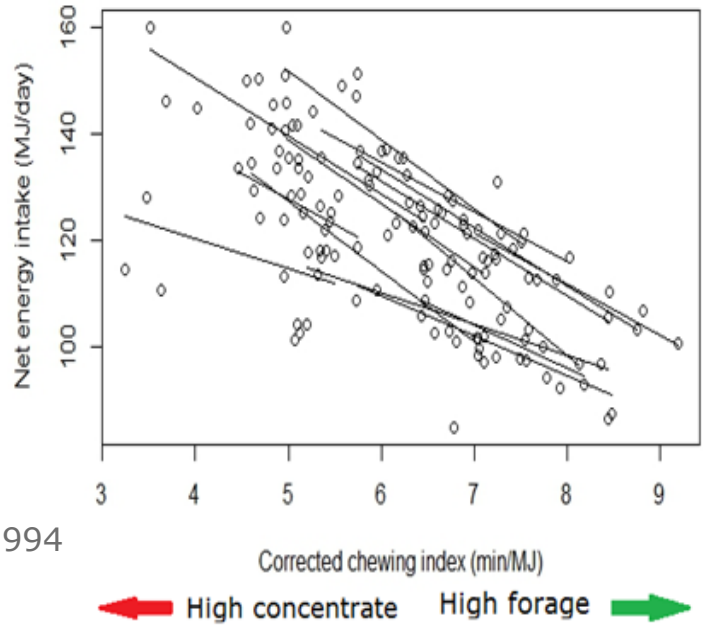
$NE_0$ metabolic capacity for use of E for maintance, lactation, growth, fat, reprod.

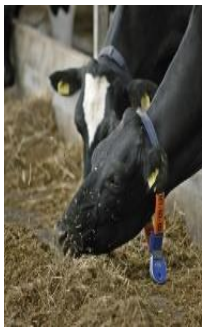
- **Substitution: ↑Concentrate → ↓Forage intake**
  - $dNE_{forage} / dNE_{conc.}$ ~ **0** (physical constrained): NEI<½ $NE_0$

→ **-1** (metabolic constrained) NEI ~ $NE_0$




Mertens 1994



# Substitution rate df/dC=$NE_f'$ :
# Interaction: Forage quality($Cl_f$) x metabolic capacity($NE_0$)

**Physical constrain, high rumination & weigth loss**
**Risk of ketosis**

# Summary on **N**et **E**nergy **I**ntake model

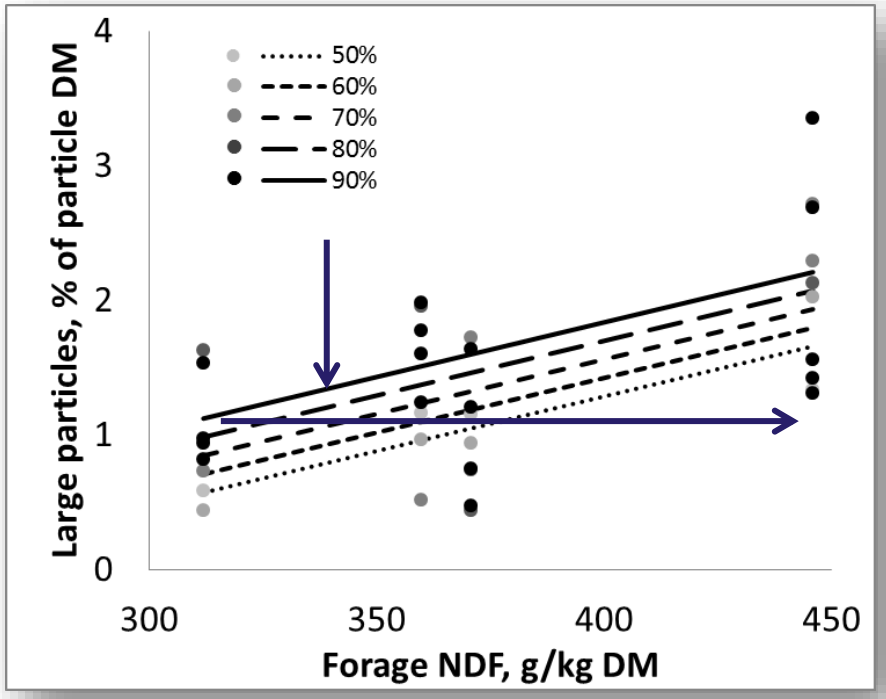
$$\mathbf{NEI} = \mathrm{NE_0} - \frac{\mathrm{NE_0^2}}{4 * \mathrm{CT_{max}}} * \left(\frac{625}{BW}\right) * \mathrm{CI_{cor}}$$

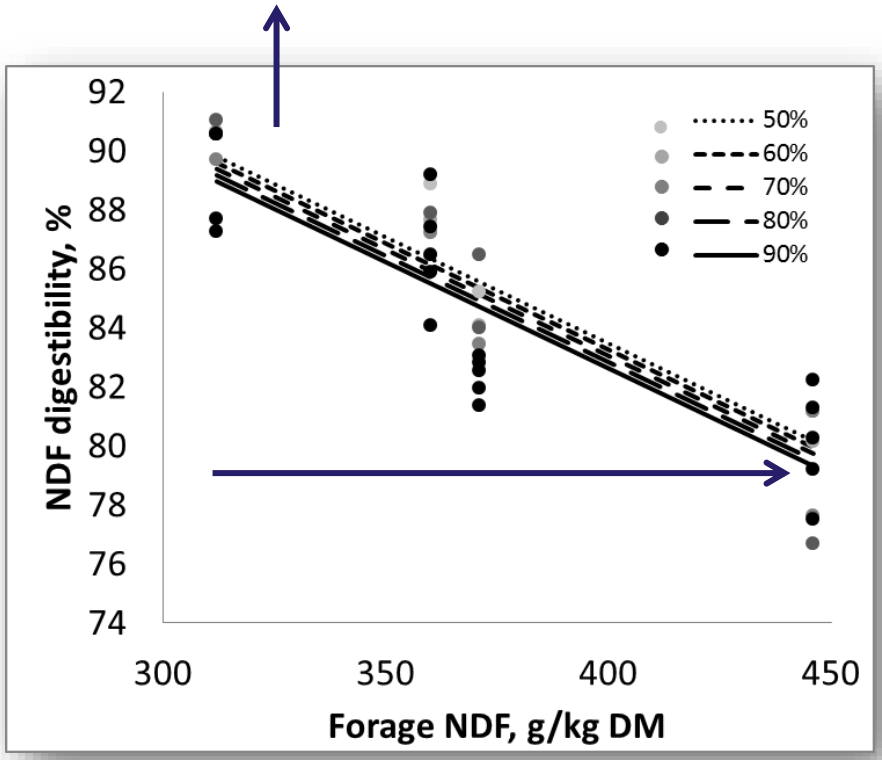
- **Valid for NEI >½ $\mathrm{NE_0}$ (metabolic capacity)**

- **Validation vs Norfor:** performs similar (Jensen .. Nørgaard et al. 2016)
- Shown to **model ad lib intake** in
  - Lactating dairy cows (Jensen .. Nørgaard et al. 2016, JDS)
  - 2 breeds of pregnant suckler cows (Nielsen , 2016 phd thesis)
  - Pregnant and nursing ewes (Nielsen Nørgaard.., 2015; 2017)
  - Dry cow and growing bulls (Nørgaard & Mølbak,2001)

- A **unike variable** forage to concentrate **substiution rate**
- **Maximal chewing ($\mathrm{CT_{max}}$)** occurs in **metabolic hungry cows at physical constraint on intake: NEI < ½ $\mathrm{NE_0}$**

# Proportion of large faecal particles and NDF digestibility depending on forage NDF content and intake level (% of ad libitum)




- ↑ NDF content → ↑LP in feces (**)
- No effect of ↓ feeding level

↑ NDF % → ↓ NDF digestibility (***)

↓ feeding level tended to ↑NDF digestibility

Schulze .. Nørgaard et al. 2014, Animal, 8

# Parameterization of Net Energy Intake model

(Jensen . Nørgaard et al. 2016)

$$NE_0 = a_0 + a_4*BW^{0.75} + a_1*DIM + a_2*(DIM)^2 + a_3*ECM$$

$a_0$ = Intercept
$BW^{0.75}$ = Metabolic body size
DIM = Days in milk
$DIM^2$ = (Days in milk)$^2$
ECM = Energy corrected milk yield

| | | | | 95% confidence interval | |
|---|---|---|---|---|---|
| Variable | Estimate | Units | Std. Error | Min | Max |
| $a_0$ | -46 | MJ NE/day | 34 | -111 | 24 |
| $a_4$ | 0.39 | MJ NE/kg$^{0.75}$ | 0.29 | -0.2 | 0.9 |
| $a_1$ | 0.7*** | MJ NE/day | 0.1 | 0.5 | 1.0 |
| $a_2$ | -0.002*** | MJ NE/day$^2$ | 5*10$^{-4}$ | -0.003 | -0.001 |
| $a_3$ | 4.7*** | MJ NE/kg | 0.6 | 3.5 | 5.9 |