Estimation of NDF degradation parameters in practice

REDNEX

Martin Riis Weisbjerg

Faculty of Agricultural Sciences,

Aarhus University, PO Box 50,

Tjele, Denmark

SEVENTH FRAMEWORK PROGRAMME

Innovative and practical management approaches to reduce nitrogen excretion by ruminants

61st EAAP – Heraklion, Crete Island, Greece, 23-27 August 2010

Some explanations:

Ruminants

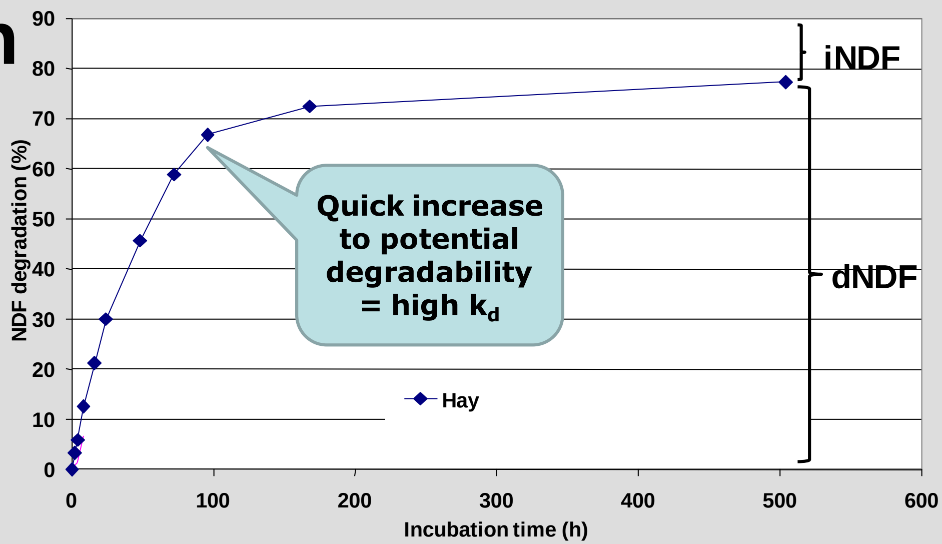
Estimation of NDF degradation parameters in practice

NDF – Neutral detergent fibre

Degradation vs. digestion

Degradation parameters

- Potential degradability
- Rate of degradation, k_d



Content:

New feed evaluation systems for ruminants – challenge to feed evaluation

Importance of NDF in feed rations

- **Physical structure**
- **Feed intake**
- **Energy supply**

Estimation of NDF degradability

- **Research methods**
- **Practical methods**

Conclusion

New feed/ration evaluation systems for ruminants

Understanding of the ruminal ecosystem has shown the shortcomings of the classic additive feed evaluation systems

Future feed/ration evaluation tools should improve simulation/prediction/monitoring of nutrients available, to predict and optimise production

Examples of ration formulation systems:
- **CNCPS (Cornell net carbohydrate and protein system)**
- **NorFor (Nordic countries)**

The challenge - feed evaluation

Feed evaluation will still be based on individual feeds

The challenge → provide data for potential digestibility and rate of digestion for main nutrients

Need for tabulated values as default values

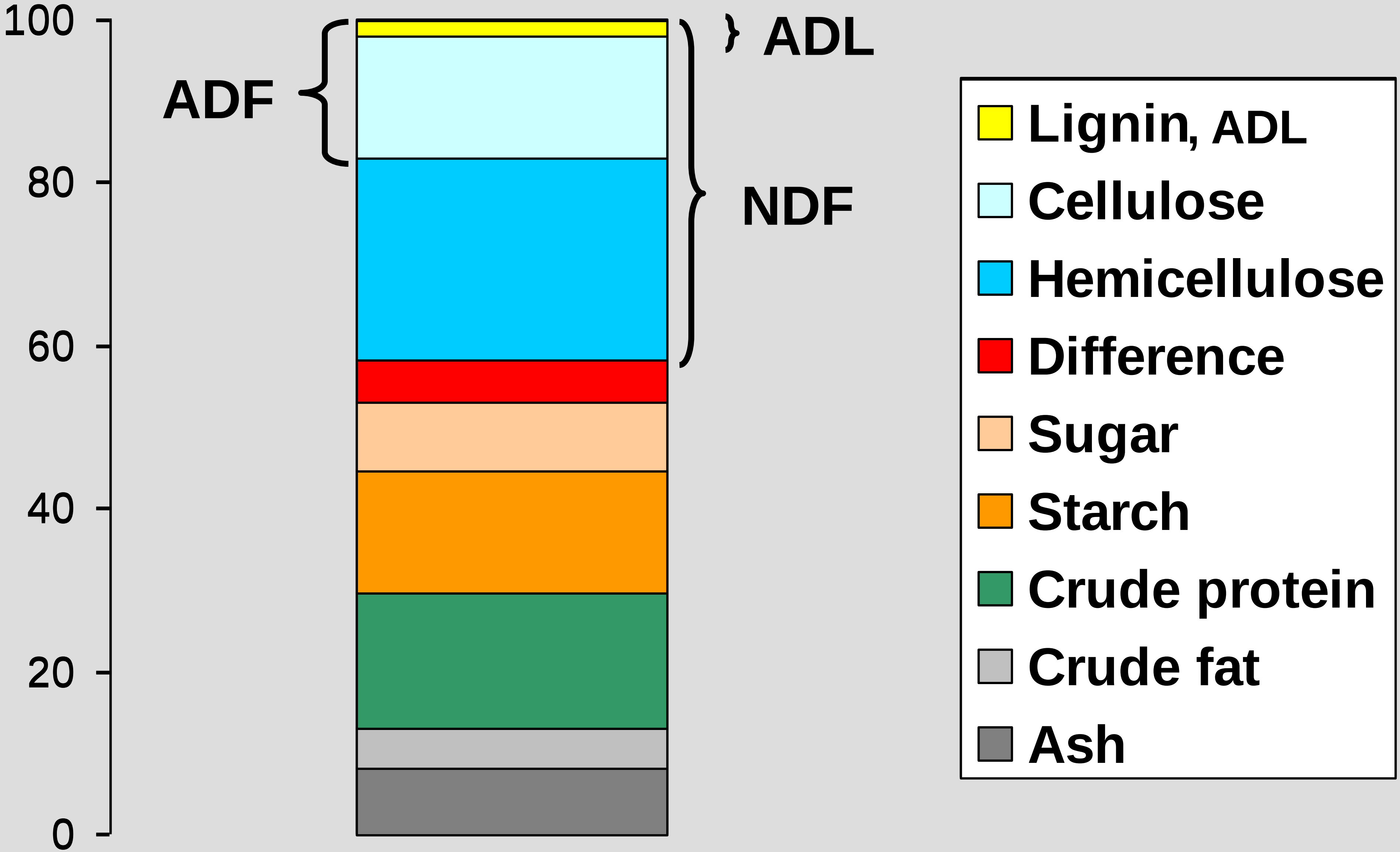
Challenge is to develop analytical tools for estimation of degradation parameters on samples from practical agriculture

This presentation will focus on NDF

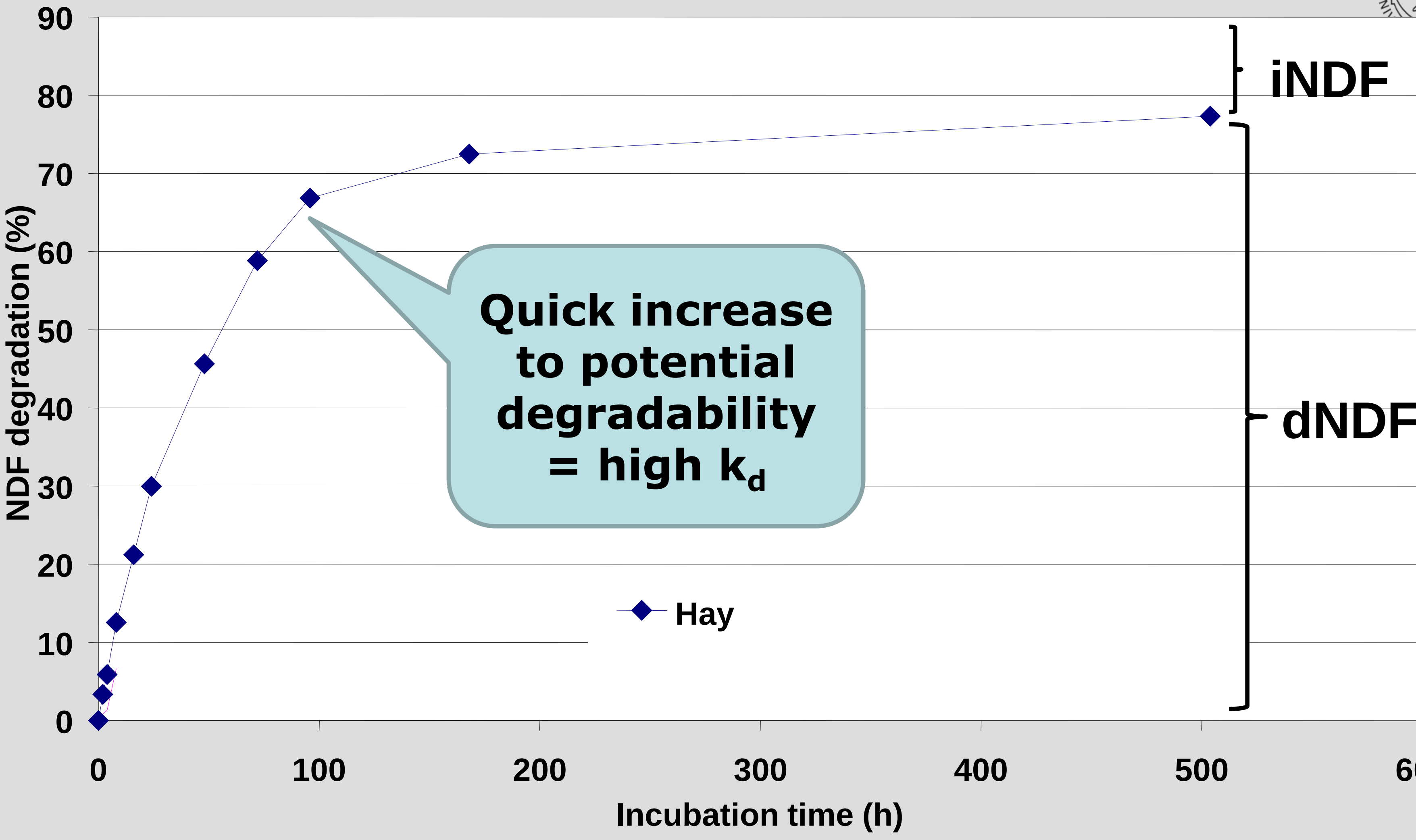
Based on:

- Experience from ‘NorFor Feed table working group’
- Results and plans - RedNex WP1 project - Tools for feedstuff evaluation to predict protein supply in dairy cows

What is NDF? The residue not solubilised after boiling with a neutral detergent solution

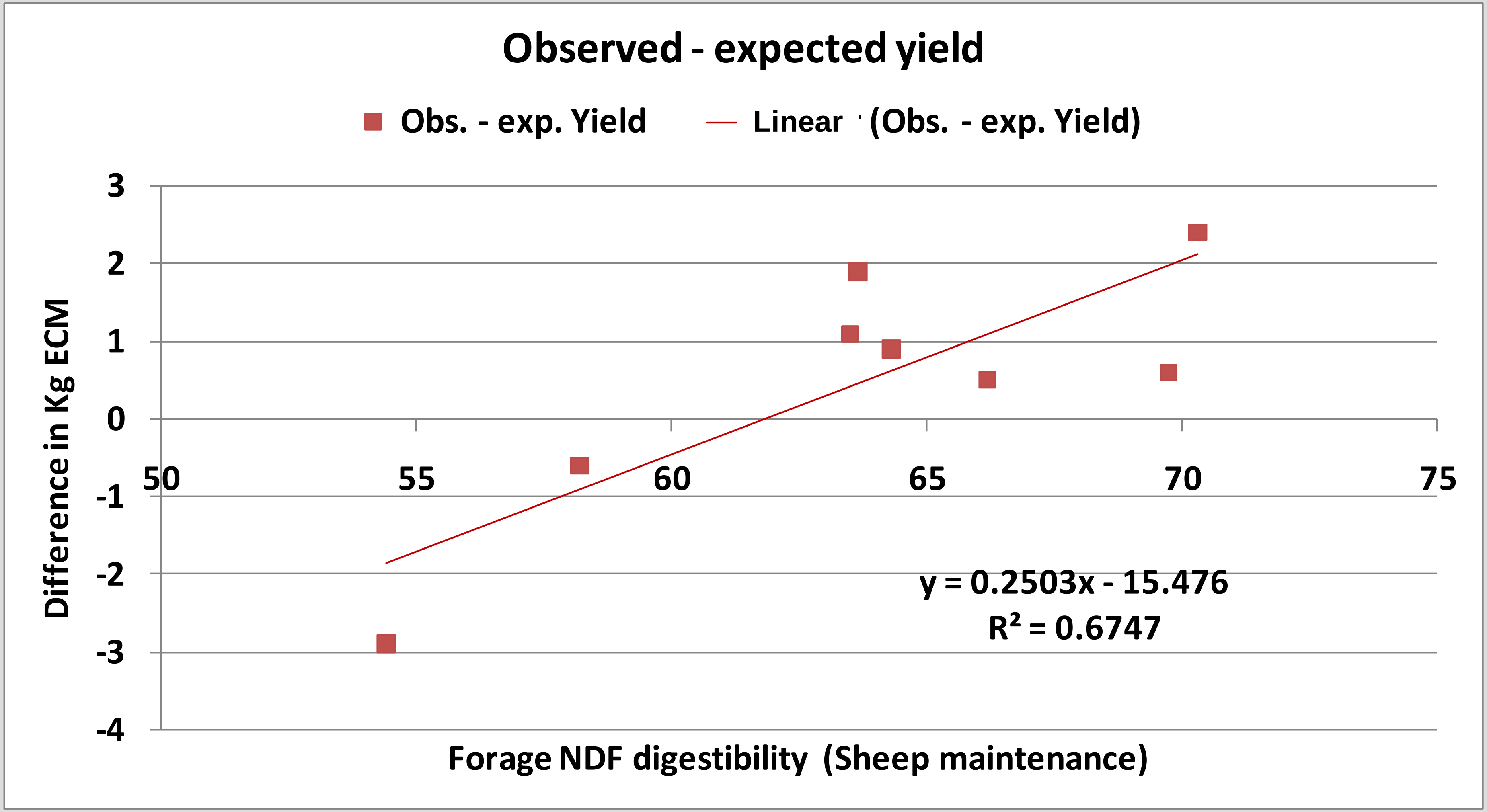


Degradation parameters



$$\text{Degradation} = \text{dNDF}(1 - e^{-kdt})$$

NDF digestibility main factor for milk production - Classical feed evaluation systems failed



Lehmann, Thøgersen, & Weisbjerg. 2010.

Physical structure:

NDF gives the physical structure in feed

- **Chewing, rumination**
- **Rumen motility**
- **Rumen environment**
- **Rumen mat – rumen stratification**

But is all NDF equal?
Roughage vs. concentrate
Particle size (Physical effective NDF >1.18 mm)
Digestibility – indigestibility
Associative effects of ration, on digestibility etc.

Feed intake:

NDF gives the bulk of the ration – therefore ration NDF concentration and digestibility are the main factors determining *ad libitum* feed intake in a physical regulated ruminant

Energy supply:

NDF is the largest individual nutrient fraction in most feed rations to ruminants (30% of DM in Danish rations)

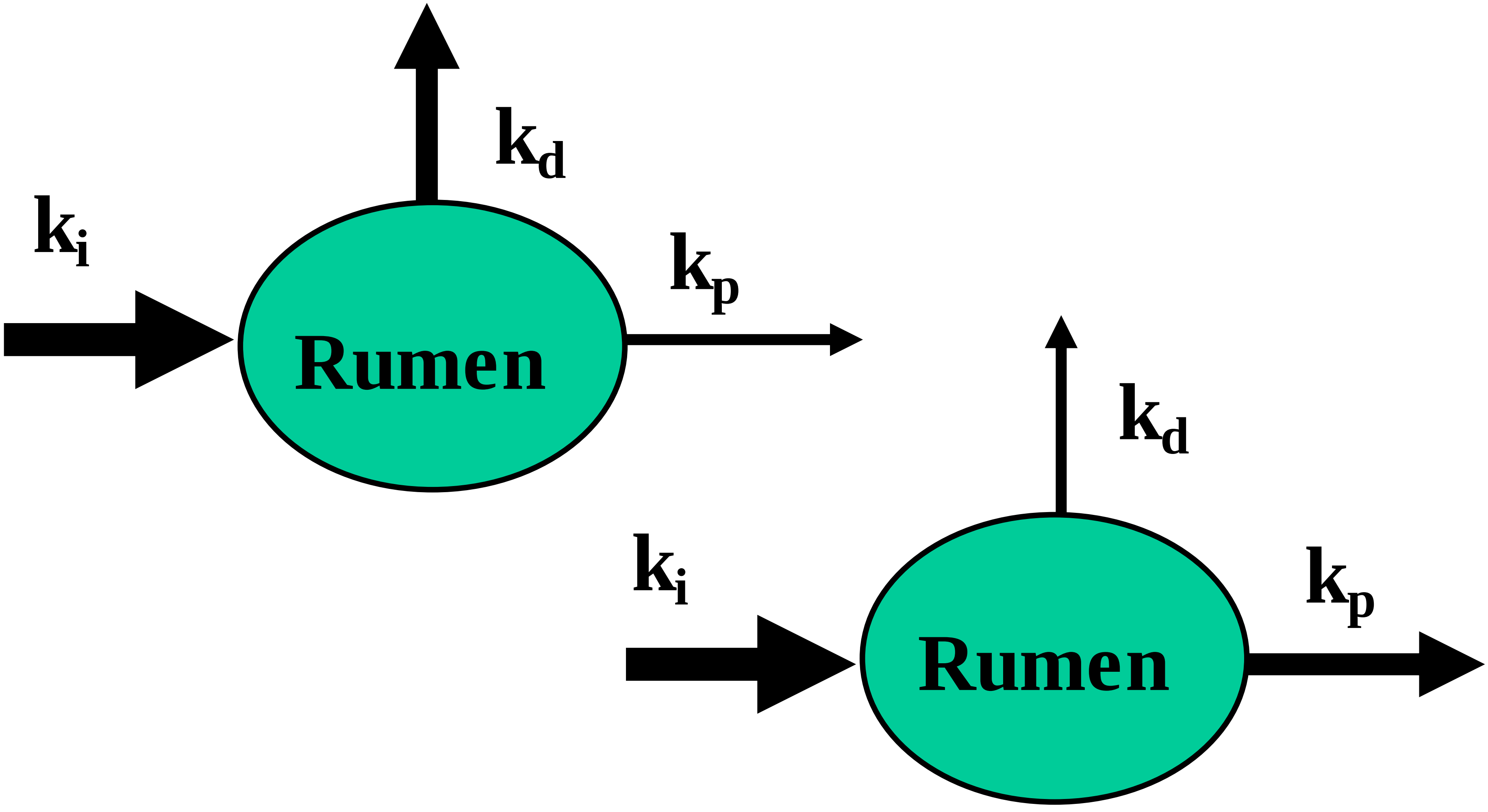
Organic matter (OM) digestibility is determined by NDF

Because:

- **Cell content (NDS, neutral detergent solubles) true digestibility ~ 100**
- **Thereby variation in OM digestibility is due to variation in NDF concentration and digestibility**

Therefore, rate and extent of NDF degradation is of outmost importance for the energy supply to the ruminant – increased by the effect on feed intake

Rumen digestibility – competition between digestion and passage



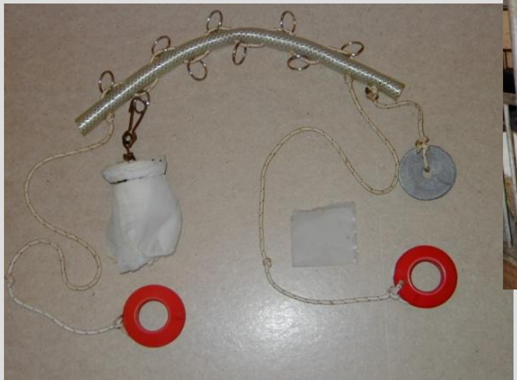
$$Digestibility = k_d/(k_d+k_p)$$

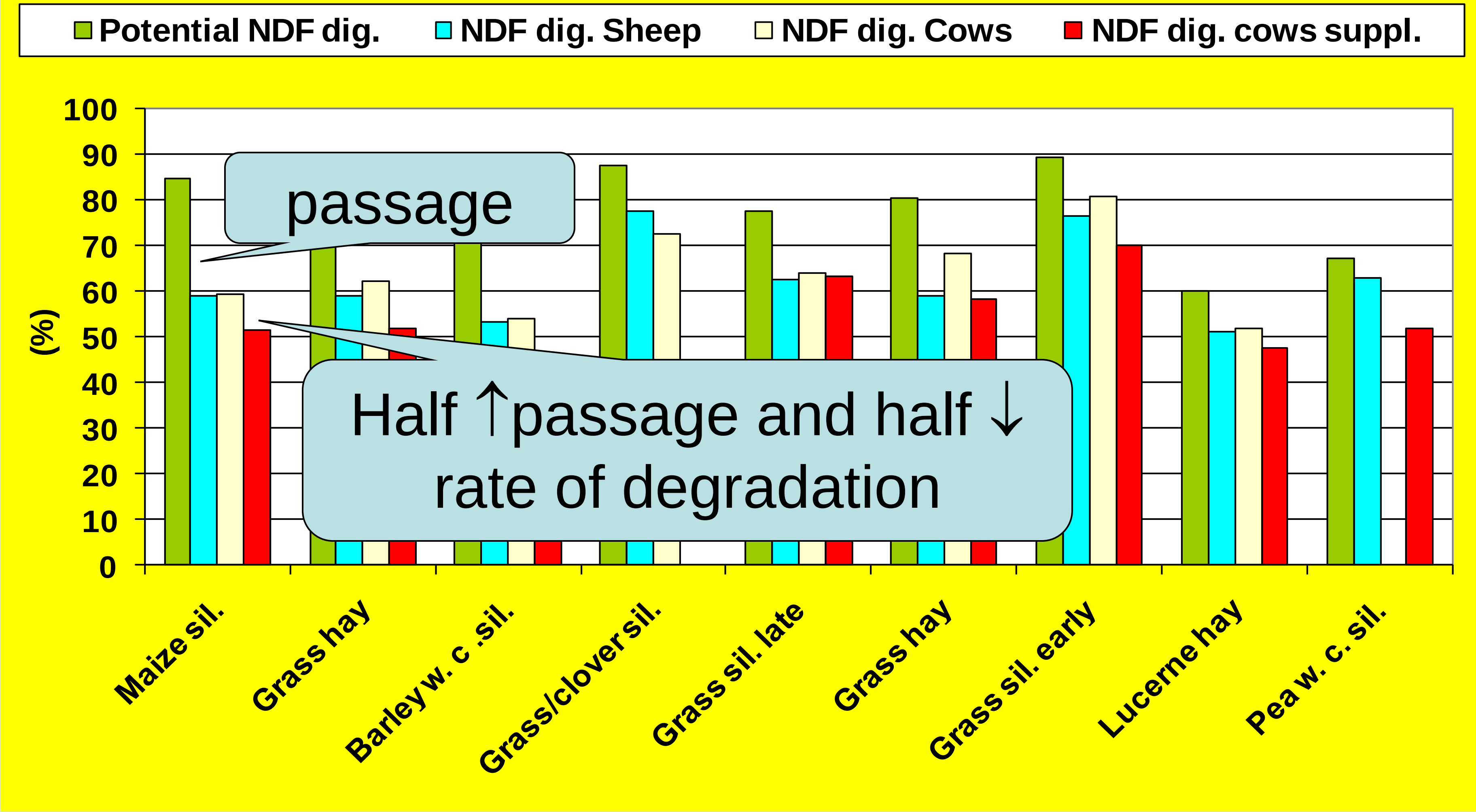
Methods – digestibility and degradation

In vivo – feed - faeces difference

In vitro - solubility after in vitro treatment with rumen fluid or commercial enzymes

In situ – degradation after feed has been incubated in the rumen in nylon/dacron bags with pores

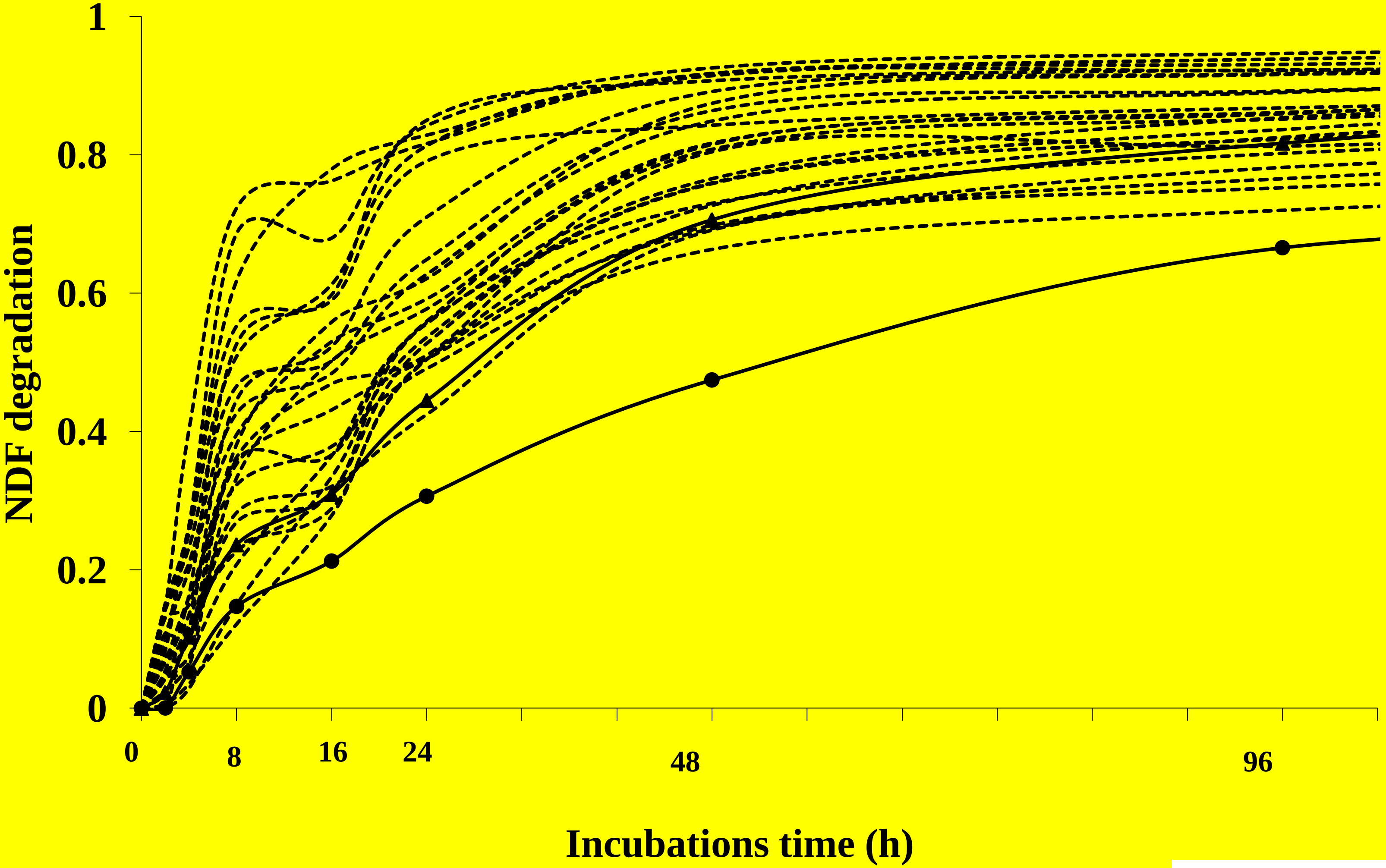




Potential NDF dig.
NDF dig. Sheep
NDF dig. Cows
NDF dig. cows suppl.
(%)
100
90
80
70
60
50
40
30
20
10
0
passage
Half ↑passage and half ↓ rate of degradation
Maize sil.
Grass hay
Barley w. c .sil.
Grass/clover sil.
Grass sil. late
Grass hay
Grass sil. early
Lucerne hay
Pea w. c. sil.

Lund 2002

Examples of NDF degradation profiles – fresh and ensiled grass and grass/clover



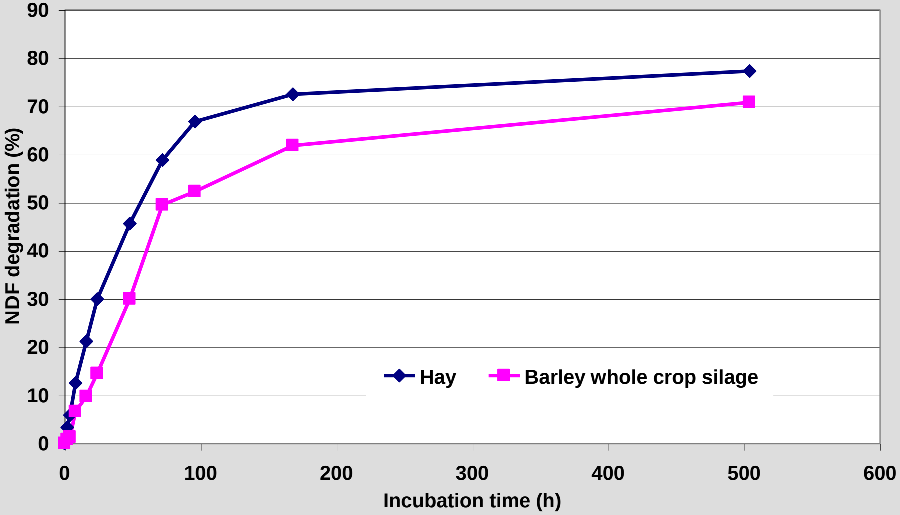
Koukolová et al., 2004

Estimation of NDF degradability
Research methods

Main research methods

Rate of degradation (k_d)

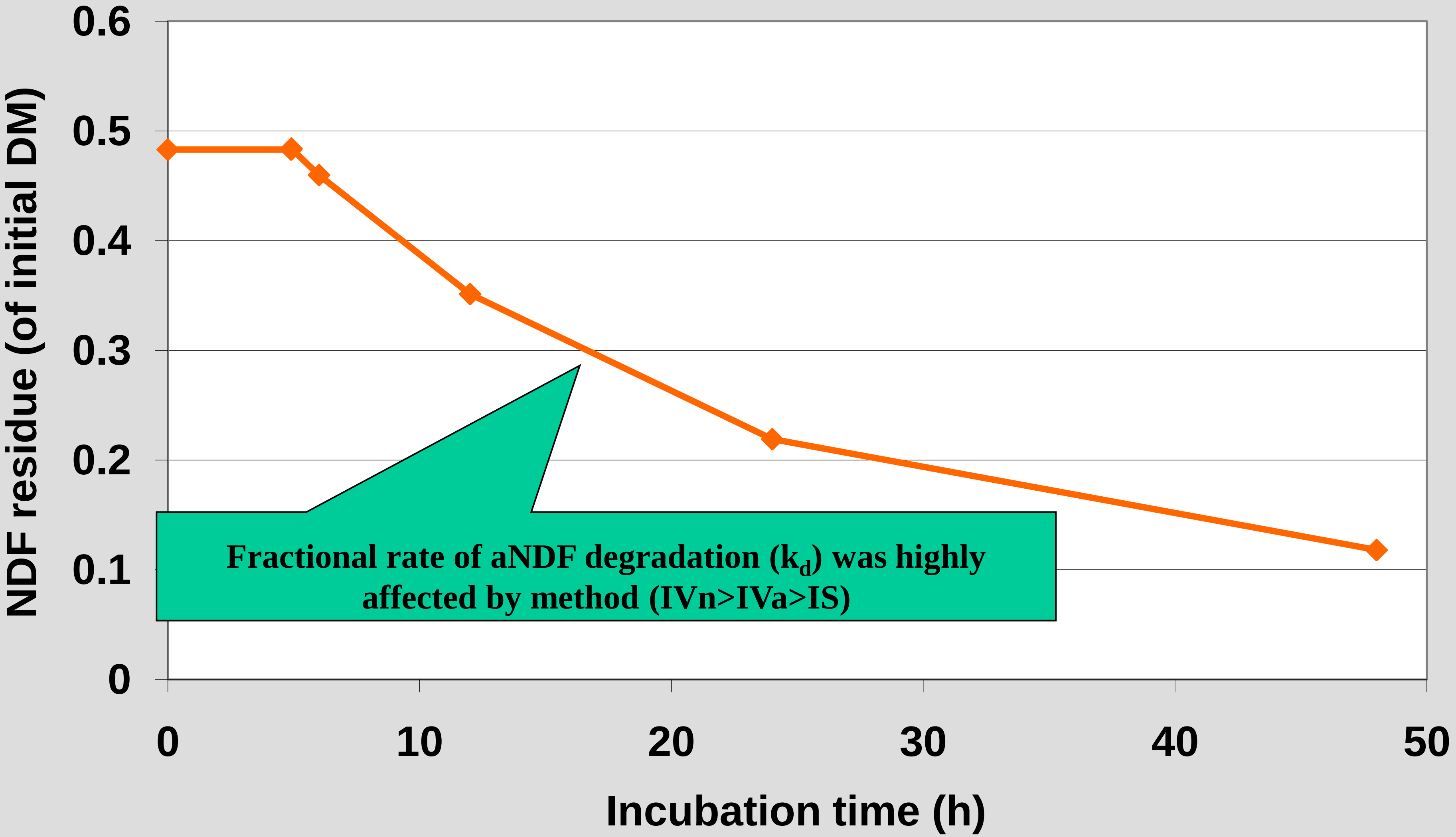
- In situ degradability
- In vitro degradability
- In vitro gas production



Potential degradability (dNDF, iNDF)

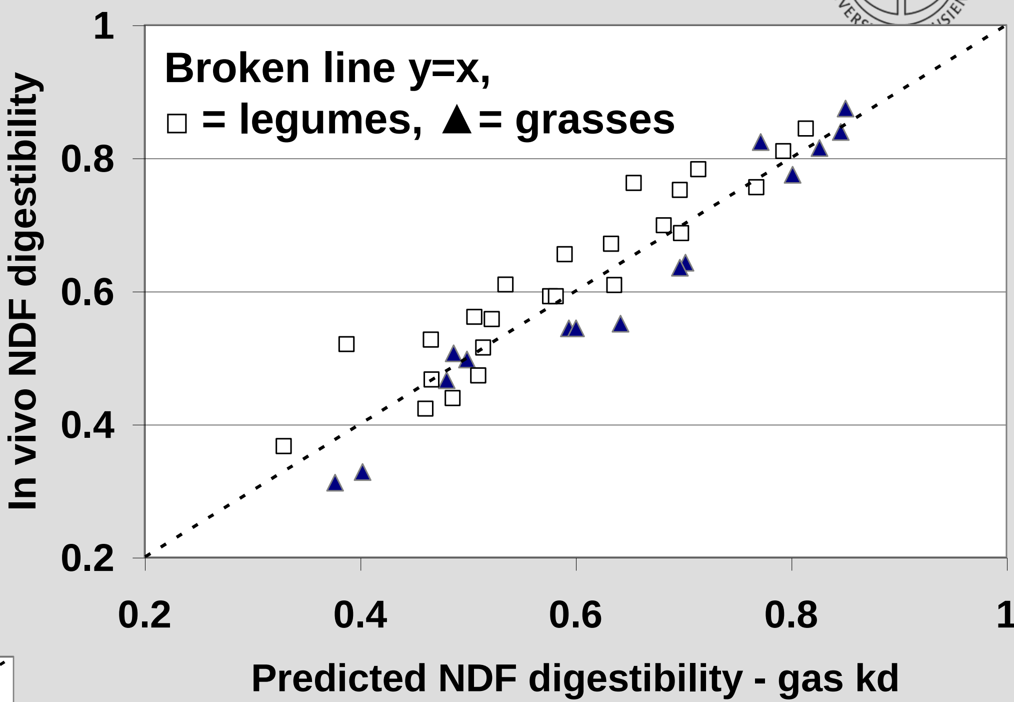
- In situ degradability
- In vitro degradability

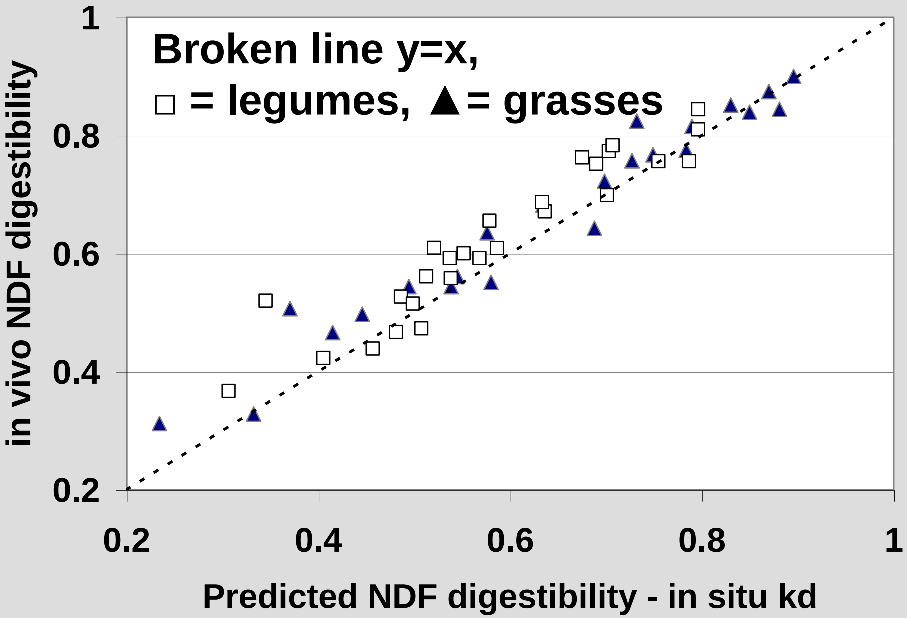
Effect of methods (in situ, in vitro, pH) on NDF degradation profiles



Bossen, Mertens & Weisbjerg, J. Dairy Sci. 2008

In situ vs. gas production – Test against in vivo data - Both methods predict in vivo digestibility well





Weisbjerg, Rinne & Huhtanen, ISRP 2009

Conclusions k_d

All methods have in build problems

Difficult to say some are better, some worse

Very few tests on in vivo data!!!!!!

Potential degradability (dNDF, iNDF)

- In situ degradability
- In vitro degradability

- Estimation based on residue after long time incubation

- Main problems:
- Particle loss in situ
- Maintaining fermentation in vitro

Estimation of NDF degradability

Practical feed evaluation

NorFor

In situ standard

Feed table

http://www.norfor.info/

NorFor
Nordic Feed Evaluation System

September 10, 2007

NorFor in sacco standard

At the seminar "Laboratory methods to predict in situ degradation profiles" held in Uppsala November 17, 2004, methodological aspects on in sacco determination of rumen degradability were discussed by invited scientists and the NorFor Feed Table Group. One important goal with the seminar was to standardize the in sacco procedure as much as possible to minimize between-laboratory variation. Critical parts of the method were listed at the seminar and completed by literature review of other published standards (Madsen & Hvelplund, 1994; Madsen et al., 1995; VanZant et al., 1998; IAEA, 2000; NRC, 2001) and papers on methodological details (Lindberg, 1985; De Boer et al., 1987; Cherney et al., 1990; Varvikko and Vanhatalo, 1990; Uden, 1992; Madsen and Hvelplund, 1994; Wilkerson et al.,1995; Coblentz et al., 1997; Huntington and Givens, 1997a; Huntington and Givens, 1997b; Huntington and Givens, 1997c). Preliminary proposals for the standard have been modified by the NorFor Feed Table Group after consulting scientists that attended the Uppsala seminar. The standard presented in Table 1 is the final agreement of the NorFor Feed Table Group.

The Feed Table Group in NorFor:
Torsten Eriksson, Swedish University of Agricultural Sciences
Erica Lindberg, Swedish Dairy Association
Odd-Magne Harstad, Norwegian University of Life Sciences (UMB)
Lars Bævre, TINE, Norway
Bragi Líndal Olafsson, Agricultural Research Institute, Iceland
Martin Weisbjerg, University of Aarhus
Rudolf Thøgersen, Danish Agricultural Advisory Service, National Centre, Danish Cattle Federation

Table 1. NorFor In sacco standard

Item	NorFor standard
Animal	
Type	Dry cow, dairy breed, representative animal
Feeding level	Maintenance
Diet	(Hay+straw):concentrate 67:33. CP content of ration DM >12%. The concentrate should contain a minimum of 3 sources of protein
Meals	Daily ration should be divided in 2 or more meals of equal size
Minimum adaptation period to diet	14 days but if the animal has been on pasture or otherwise been fed on a diet and level totally different from the standard, minimum adaptation period is 21 days
Replication	
Number of animals	3 cows except for INDF determination where 2 cows is sufficient
Bags per animal	Not specified
Number of days when sample is replicated	1 (=days are not replicated)
Sample preparation	
Drying	Freeze-drying preferable but oven drying at 45° C also allowed. For NDF determination, a drying temperature of 60° C is allowed
Grinding	Screen aperture 1.5 mm. Cutter mill preferable but hammer mill allowed during NorFor's introduction phase
Sample size	1.0 – 2.0 grams dried sample. See "Sample size to surface area" below

Methods to be used in practice

Rate of degradation (k_d)

- In situ degradability
- In vitro degradability
- In vitro gas production
- NIRs
- Multiple regressions on chem. and dig. measures
- Backwards calculation

Potential degradability (dNDF, iNDF)

- In situ degradability
- In vitro degradability
- NIRs
- Multiple or simple regression (chem., dig.)

Rate of degradation (k_d)

NIRs

Limited success predicting rate of degradation for both NDF and other nutrients

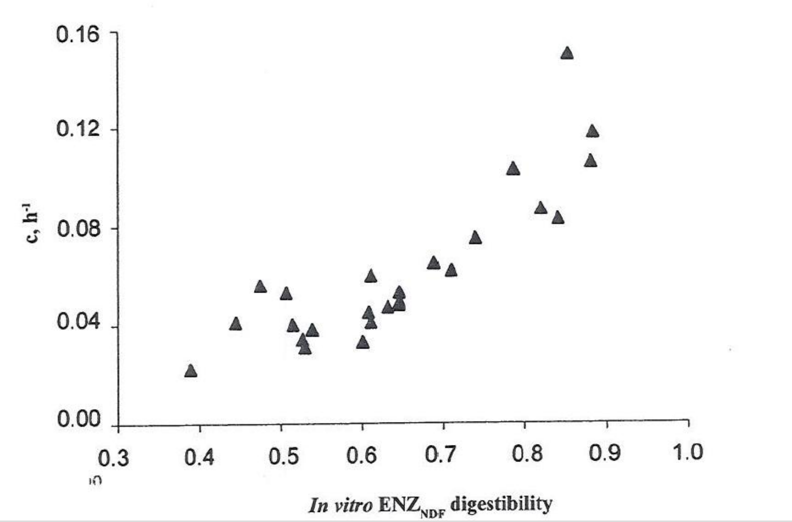
More efficient in predicting solubilities and potential digestibilities

Ohlsson, Houmøller, Weisbjerg, Lund, Hvelplund, T. 2007. J. Anim. Physiol. Anim. Nutr.

Rate of degradation (k_d)

Regressions on chemical or digestibility measurements

On grass – grass/clover, possible to explain 86% of variation in k_d by in vitro enz. NDF digestibility



Koukolová et al., J. Anim Feed Sci. 2004

Also high for barley and wheat whole crops, 0.81 and 0.77, respectively, to in vitro enz. OM digestibility

Weisbjerg, M.R., Mikkelsen, M., Bossen, D. & Lund, P. J. Dairy Sci. 2003

Rate of degradation (k_d)

’Backwards’ calculation

Information needed

OM digestibility
Ash concentration
NDF concentration
iNDF concentration

All except iNDF classical feed analysis

Idea:
NDS digestibility estimated using Lucas principle
NDF digestibility calculated by difference
Kd NDF ‘backwards’ calculated assuming 2 pool rumen model

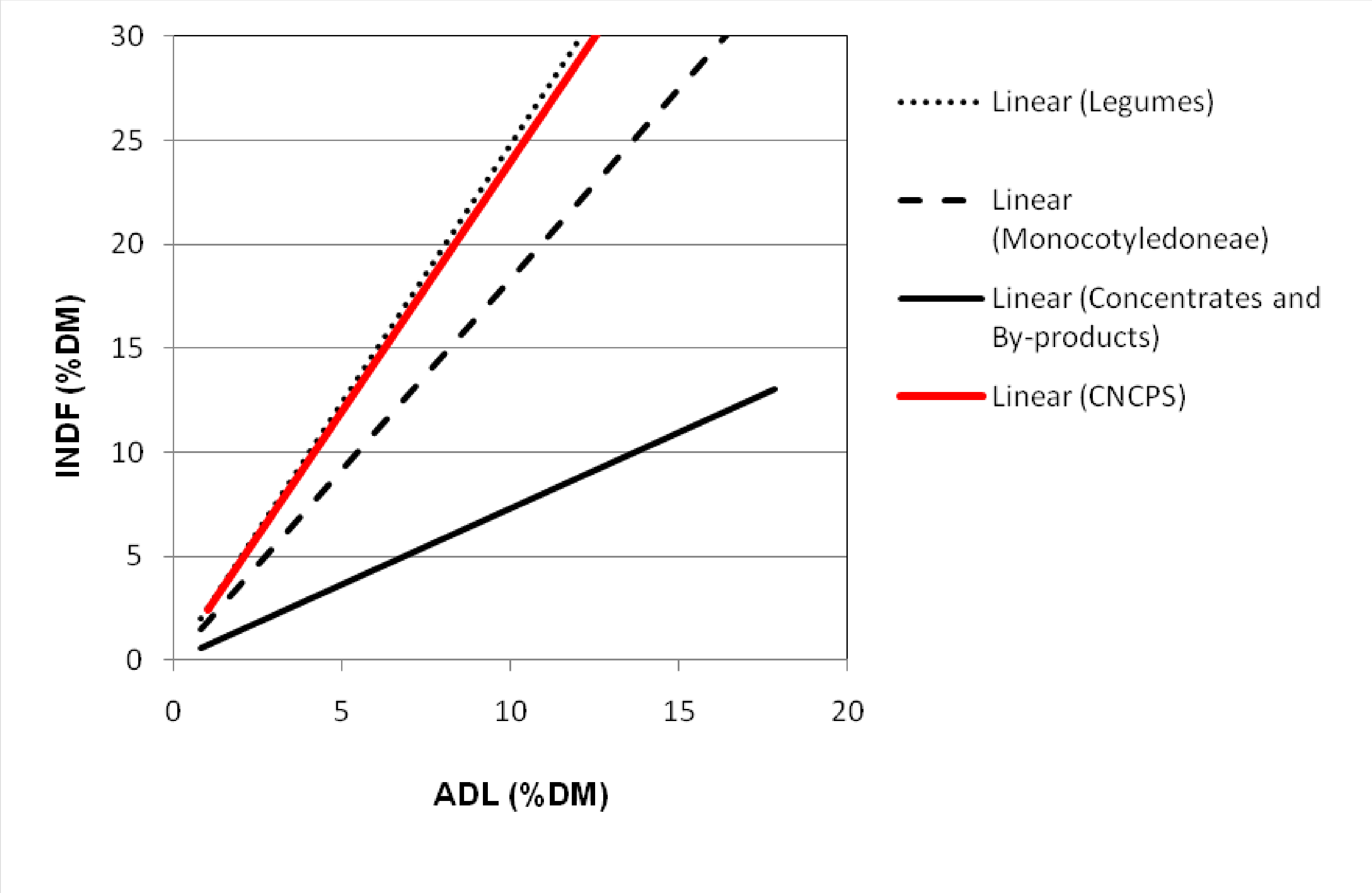
Potential degradability (dNDF, iNDF)

iNDF in feeds in practice

- Large variations in values
  - Between feedstuff groups
  - Within group
  - Within feedstuff type (maturity, processing etc.)

Potential degradability (dNDF, iNDF)

iNDF vs. ADL



Krämer, Weisbjerg & Lund, 2010

Potential degradability (dNDF, iNDF)

NIRs calibration

In the Nordic countries we pt. use calibrations calibrated directly on in situ iNDF

Potential degradability (dNDF, iNDF)

Lack of good, reliable and cheap lab methods, for NIRs calibration

iNDF= 2.4 x ADL (CNCPS ratio) only fits for maize silage, barley whole crop, lucerne, wheat

ADL content and/or IVOMD acceptable predictors of iNDF within feedstuff group

Important research area in coming years

Conclusions

New feed/ration evaluation systems require cheap/efficient methods for estimation of NDF degradability
•Rate of degradation
•Potential degradability

Research methods available, however quality and in vivo documentation problematic!

Practical methods:

Rate of degradation
NIRs problematic
Simple regressions useful within feedstuff type
The backwards calculation might be the future

Potential degradability
NIRs or similar ‘cheap’ methods the future
However, reliable laboratory methods needed for NIRs calibration

This presentation has been carried out with financial support from the Commission of the European Communities, FP7, KBB-2007-1.

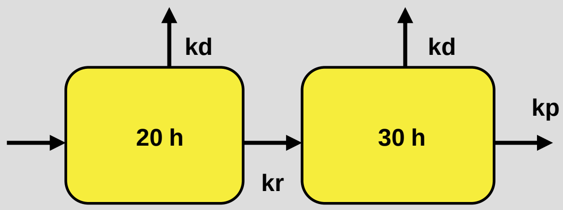
REDNEX

SEVENTH FRAMEWORK PROGRAMME

Innovative and practical management approaches to reduce nitrogen excretion by ruminants

kdNDF in Forage

The backward calculation method (Weisbjerg et al 2004, 2007)



$$ED = \left(\frac{kd}{(kd + kr)} \cdot \left(1 + \frac{kr}{(kd + kp)} \right) \right) \cdot Pd$$

Allen & Mertens, 1988

$$kdNDF = 1{,}21 \cdot 100 \cdot \left(-0.041667 + \frac{\sqrt{0.006944 + \frac{0.0066667 \cdot D}{1 - D}}}{2}\right) - 1{,}24$$

Huhtanen et al, 2006

NDS = 1000 – Ash – NDF

NDSdig = (101.3 – (902/NDS/10))/100

uOM = (1000 – Ash) *(1-**OMD**/100)

uNDS = NDS*(1 – NDSFK)

uNDF = uOM – uNDS

NDFdig = (NDF – uNDF)/NDF

pdNDF = NDF - **iNDF**

D = NDFdig/(pdNDF/1000)

OMD estimated from sheep fed at maintenance