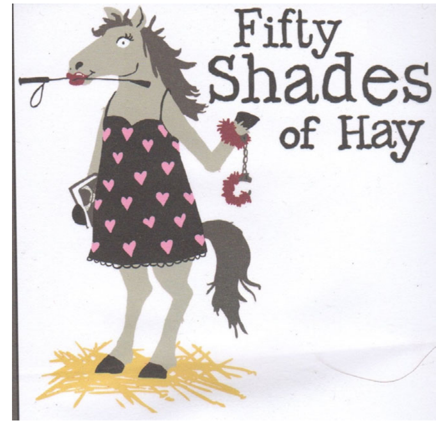
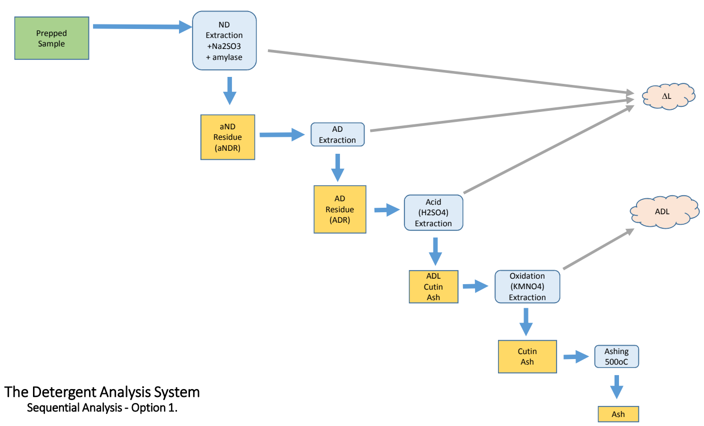
Soluble lignin and its relation to Klason lignin, acid-detergent lignin and digestibility of NDF

Peter J. Van Soest, Cornell University
James B. Robertson, Cornell University
Michael C. Barry, AgModels Foundation

Cornell University
College of Agriculture and Life Sciences

AgModels Foundation





The Detergent Analysis System
Sequential Analysis - Option 1.

Van Soest, 2015

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Recent innovations in analytical methods for the qualitative and quantitative assessment of lignin

Jason S. Lupoi [a, b], Seema Singh [b, c], Ramakrishnan Parthasarathi [b, c], Blake A. Simmons [a, b, c], Robert J. Henry [a]

[a] Queensland Alliance for Agriculture and Food Innovation, University of Queensland, St. Lucia, Queensland 4072, Australia
[b] Joint BioEnergy Institute, Lawrence Berkeley National Laboratory, 5885 Hollis Street, Emeryville, CA 94608, USA
[c] Biological and Materials Science Center, Sandia National Laboratories, 7011 East Avenue, Livermore, CA 94551, USA

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Lignin Assays (Quantitative)

Lupoi, et.al., 2015

- Wet chemistry
  - Acetyl Bromide
  - Acid-Insoluble
  - Klason
  - Permanganate oxidation
  - TAPPI
  - Van Soest
- Thermo-chemical
  - pyGC/FID
  - pyMBMS
  - TGA
- Spectroscopy
  - Fluorescence
  - FTIR
  - FT-Raman
  - NIR
  - NMR
  - Photoacoustic
  - UV-Raman
  - UV-vis
  - Visible (image analysis)

ΔL = KL - ADL

- Where:
  - ΔL = Acid Detergent Soluble Lignin, %DM
  - KL = Klason Lignin, %DM
  - ADL = Acid Detergent Lignin, %DM

Lignin

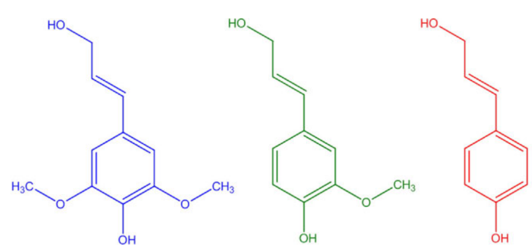
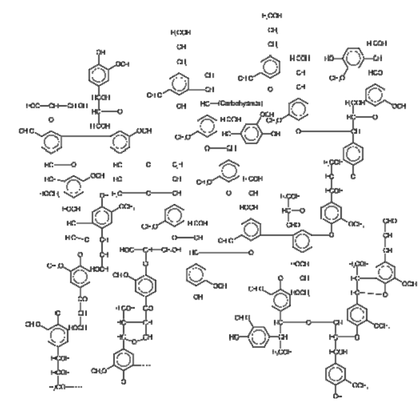


Fig. 1. Three fundamental lignin monomers (and their respective phenylpropanoids): sinapyl alcohol (syringyl (S)), coniferyl alcohol (guaiacyl (G)), and *p*-coumaryl alcohol (*p*-hydroxyphenol (H)).

Lupoi, et.al., 2015

Lignin

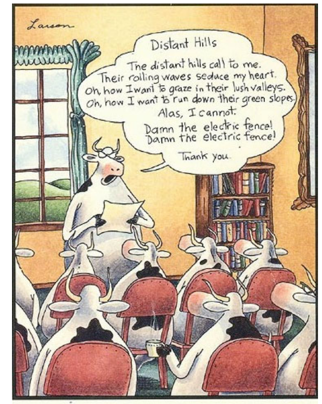
- One example of a possible lignin structure.
  - 28 monomers (mostly coniferyl alcohol)
  - $C_{278}H_{407}0_{94}$



- https://en.wikipedia.org/wiki/Lignin
  - Accessed: 2018-08-28T12:19:26Z

The Data

- Cornell
  - 39 Forages
    - 7 C_3 grasses
    - 17 C_4 grasses
      - 13 maize plants
      - 4 corn silages
    - 15 Legumes
      - 15 alfalfa hays
- Jung
  - 36 Forages
    - 16 C_3 grasses
    - 8 C_4 grasses
    - 12 Legumes
      - 6 alfalfas
      - 6 other legume species



Cow poetry

Results

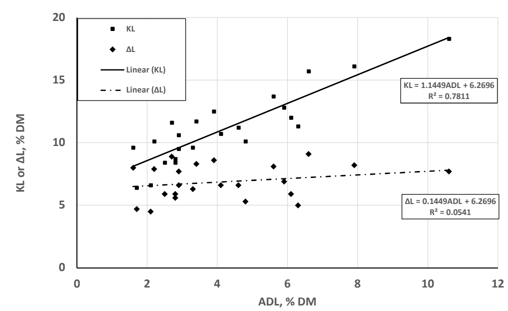
Table 2: Mean values of Klason, acid detergent lignin, ΔL/KL and their ranges.

Component	**N**	**KL**	**ADL**	**ΔL/KL (%)**	**Range ΔL/KL**
Cornell Data					
Grasses	7	13.8	6.4	55	42 – 73
Maize Plants	13	6.4	2.8	56	47 – 70
Maize Silage	4	7.7	3.2	59	53 – 65
Alfalfa	15	11.3	6.6	41	25 – 52
Jung et al. (1997)					
C_3 Grasses	16	9.9	3.3	67	49 – 83
C_4 Grasses	8	8.5	3.4	59	46 – 70
Alfalfas	6	12.0	8.4	30	22 – 36
Other Legumes	6	12.2	7.1	43	28 - 54

KL – Klason lignin
ADL – Acid detergent lignin
ΔL/KL – Acid detergent soluble lignin divided by Klason lignin (%)

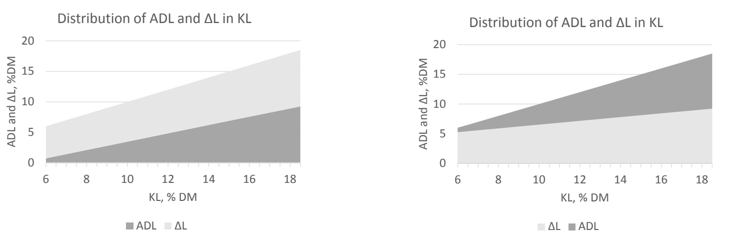
Results

Figure 1: Relationships of KL and ΔL with ADL for C_3 forages from Van Soest and Robertson and Jung et al. (1997).



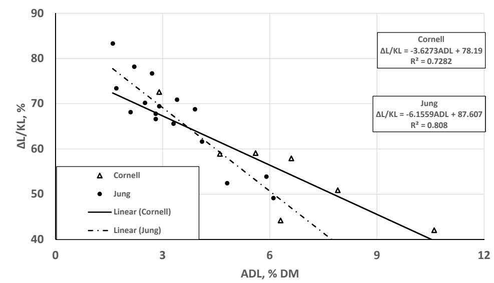
Results

Figure 5: Relationships of KL and ΔL with ADL for C_3 forages from Van Soest and Robertson and Jung et al. (1997) – Two perspectives.



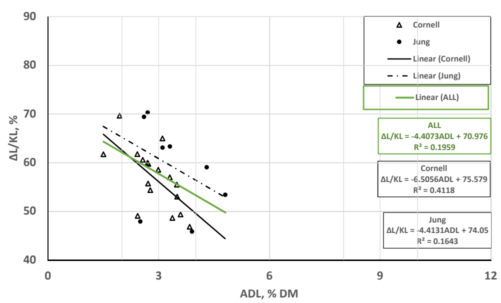
Results

Figure 2: Relation of acid-detergent soluble lignin as a percent of Klason lignin with acid-detergent lignin as a percent of dry matter. Combined data for forage grasses from Robertson (Cornell) and Jung et al 1997.



Results

Figure 3: Relation of acid-detergent soluble lignin as a percent of Klason lignin with acid-detergent lignin as a percent of dry matter for C_4 mature plants. Combined data from Robertson (Cornell) and Jung et al 1997 n25.



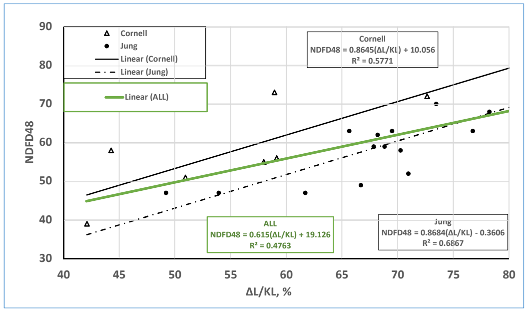
Results

Table 3: Correlation between acid detergent soluble lignin expressed as percentage of Klason Lignin (ΔL/KL) with acid detergent lignin (ADL) on a dry matter basis and with in-vitro digestibility of neutral detergent fiber (NDFD48).

Forage Class	**N**	**ΔL/KL * ADL**	**ΔL/KL * NDFD48**	**ADL * NDFD48**
Cornell				
Grasses	7	-0.85 *	+0.76 *	-0.95 **
Maize Plants	17	-0.64 **	+0.44	-0.78 **
Alfalfas	15	+0.07	+0.12	-0.55 *
Jung				
C_3 Grasses	16	-0.90 **	+0.83 **	-0.79 **
C_4 Grasses	8	-0.41	+0.73 *	-0.59
Legumes	12	-0.81 **	+0.58 *	-0.69 *
All Legumes Combined	27	-0.48 *	+0.34	-0.53 **

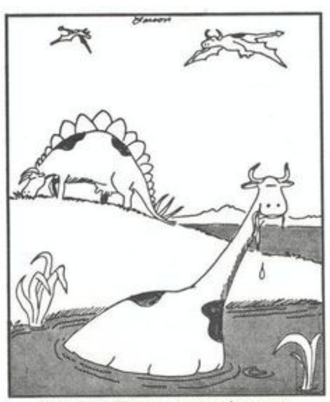
Results

Figure 4: Relation between the in vitro digestibility of NDF (NDFD48) with acid-detergent soluble lignin as a percent of Klason lignin (ΔL/KL). Combined data for forage grasses (n=23).



Conclusions

- Klason Lignin is a heterogeneous mix
  - KL = ΔL + ADL
- ΔL is soluble in the rumen but is unfermentable
- ΔL dilutes energy of solubles
- ΔL has no effect on NDFD
- ADL (insoluble) is the main factor limiting NDFD



Sixty-five million years ago, when cows ruled the earth

Proposed Collaborative Fiber Study?

- Standard reference forages
  - 12 each of:
    - Corn Silage
    - Alfalfa
    - Grass
- Multiple Sites
  - USDFRC
  - Miner
  - Cornell
  - Texas A&M
- Analyses
  - NDFom
  - ADFom
  - ADL
  - Klason
  - Acetyl Bromide Lignin
  - uNDF48
  - uNDF240
  - Spectral Scans of all samples & filtrates
    - UV
    - NIR
    - MIR?

"The objectives of statistical efficiency and mechanistic understanding are sometimes incompatible."

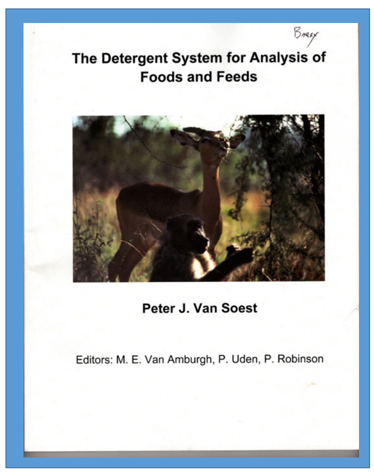
Peter J. Van Soest, 1994. Nutritional Ecology ot the Ruminant, 2nd Edition.

Then again, sometimes not.

Shameless Plug

Available NOW from Cornell CALS

Contact Heather Darrow for details



The Detergent System for Analysis of Foods and Feeds

Peter J. Van Soest

Editors: M. E. Van Amburgh, P. Uden, P. Robinson

Thank You

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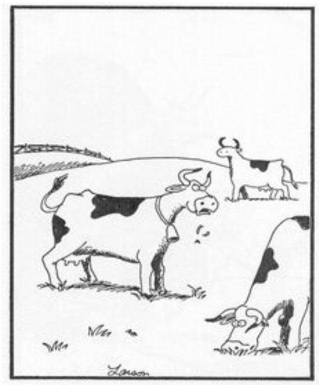

"Hey, wait a minute! This is grass! We've been eating grass!"