Ensiling as a method to preserve energy crops and to enhance the energy yields

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Raw materials

Maize

- *Zea mays*, cv Ronaldino
- 15-20 tn / ha /a
- Requires strong weeding, frost sensitive
- 120 kg N /ha
- DM = 17%

Water soluble	Cellulose	Arabino xylans	Lignin
14-20%	24%	17%	14%

Hemp

- *Cannabis sativa*, cv Uso
- 14 tn / ha /a
- No weeding required
- 60 kg N /ha
- DM = 33% or 63% after two days pre-wilting

Water soluble	Cellulose	Arabino xylans	Lignin
6%	37%	12%	17%

Methods – ensiling and alkaline preservation

Ensiling: Anaerobic conditions+ bacteria + carbohydrates

→ acid formation

Mainly lactic- and acetic acids formed

Additives enhance ensiling in different ways

- Lactic acid bacteria
- Molasses, other sugars
- Enzymes
- Acids, mainly formic acid
  - A.I.V silage for feed

Preservation with alkaline additives, mainly urea

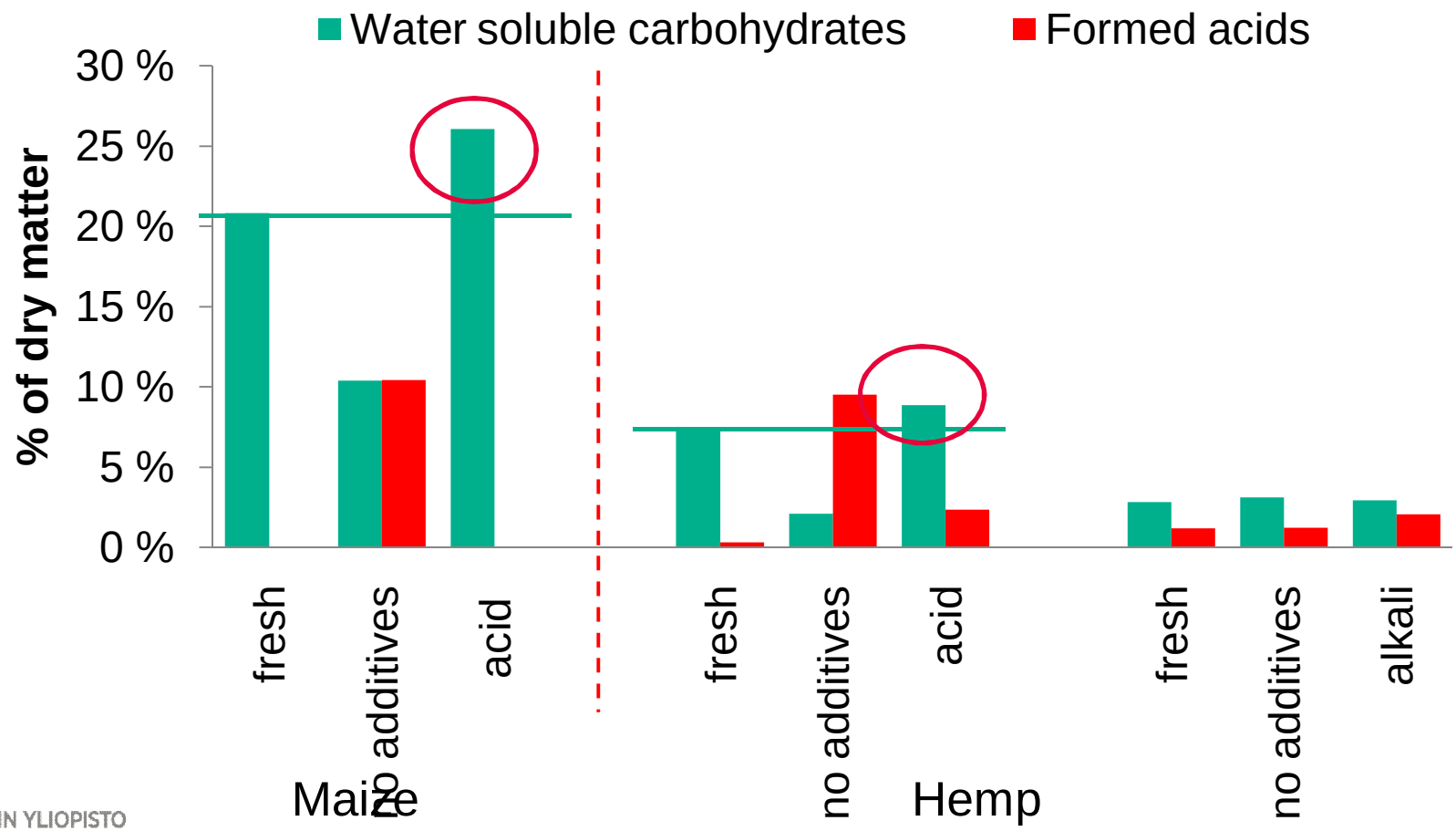
4 M

8 M

Ensiling and alkaline preservation

- Are the valuable carbohydrates preserved?
- What is formed and lost during ensiling / preservation?
- Does anaerobic preservation enhance methane productivity?
- Does anaerobic preservation enhance enzymatic hydrolysability?

Water soluble carbohydrates – formed acids



Carbohydrates

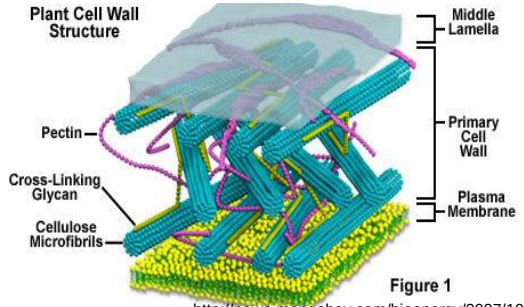
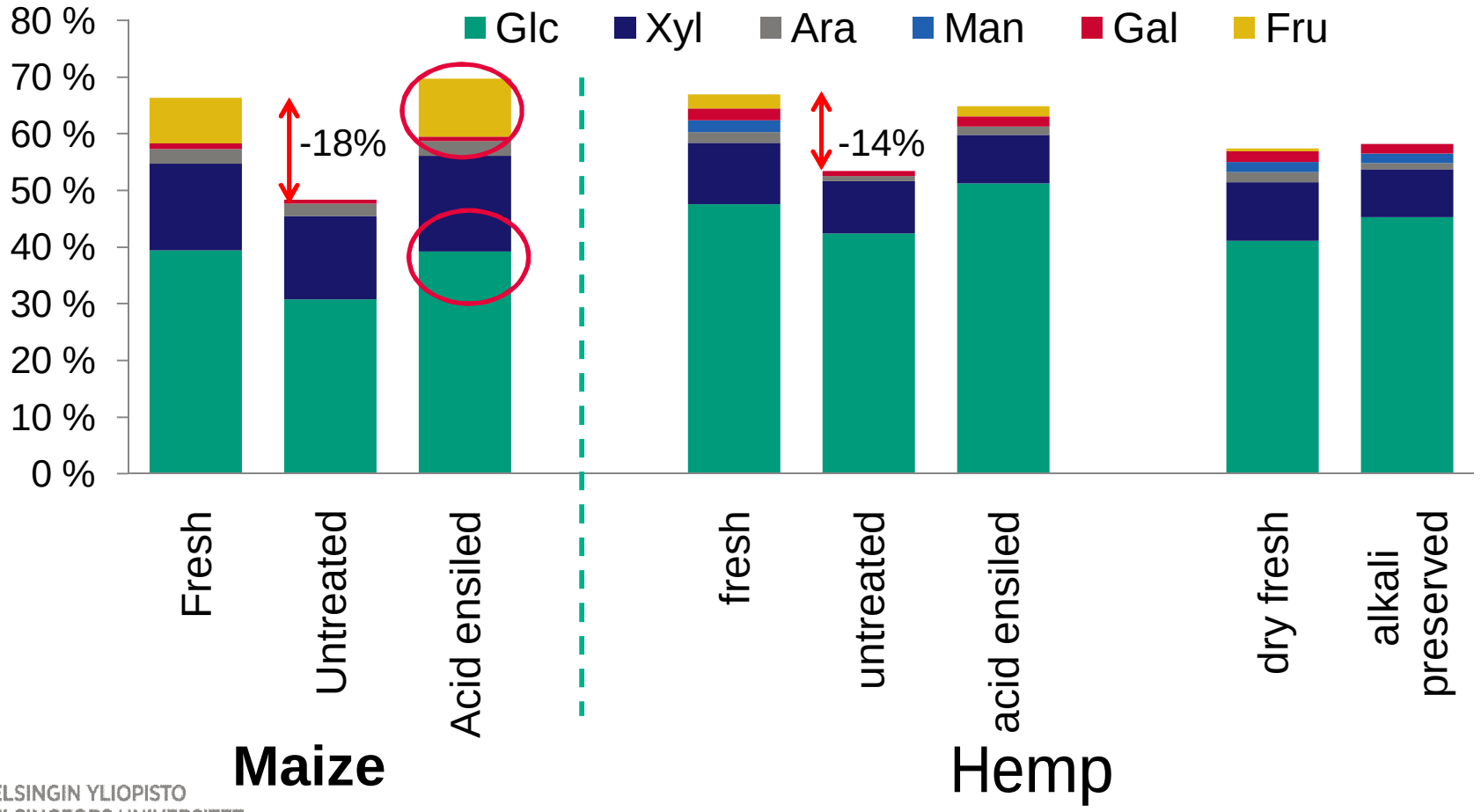
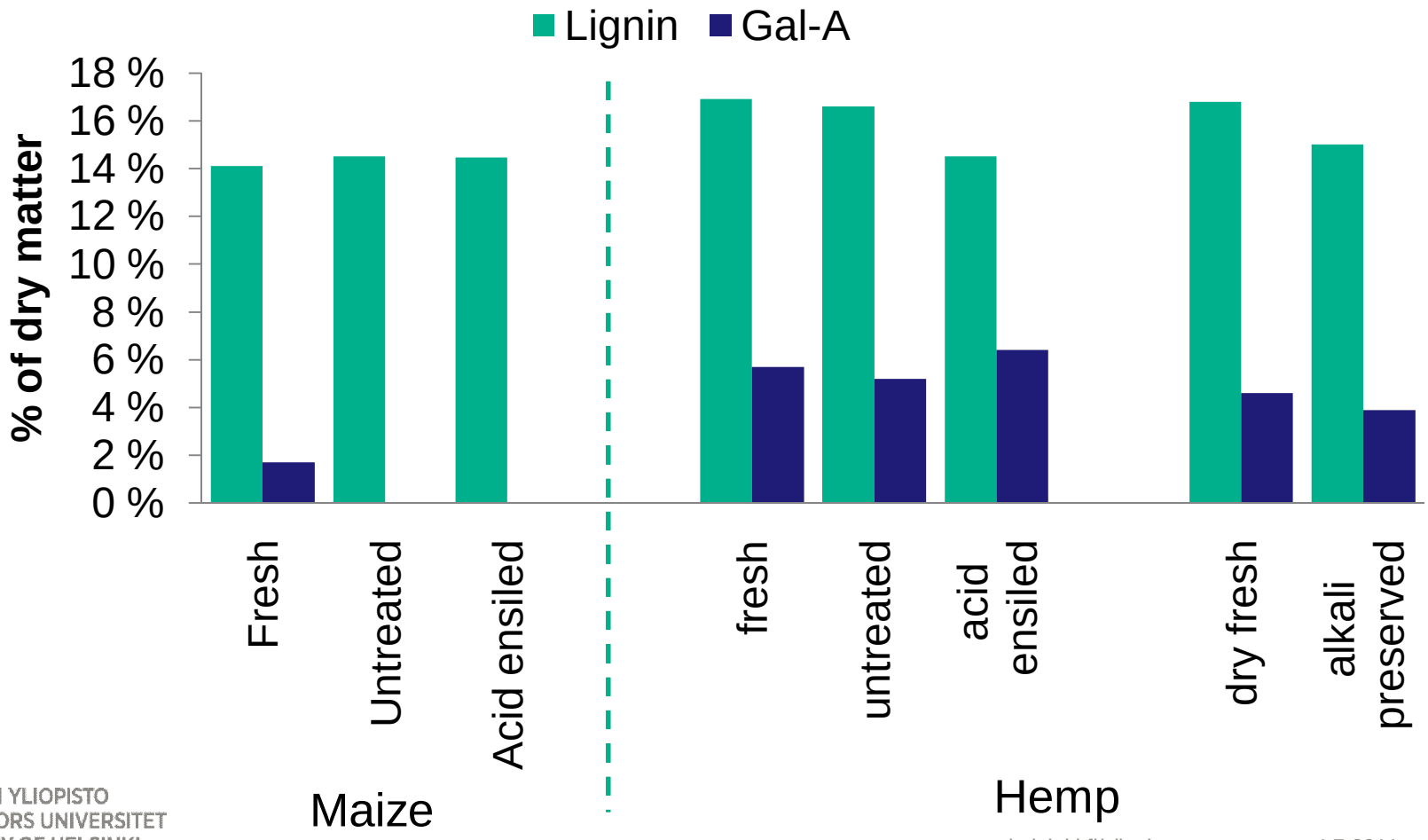


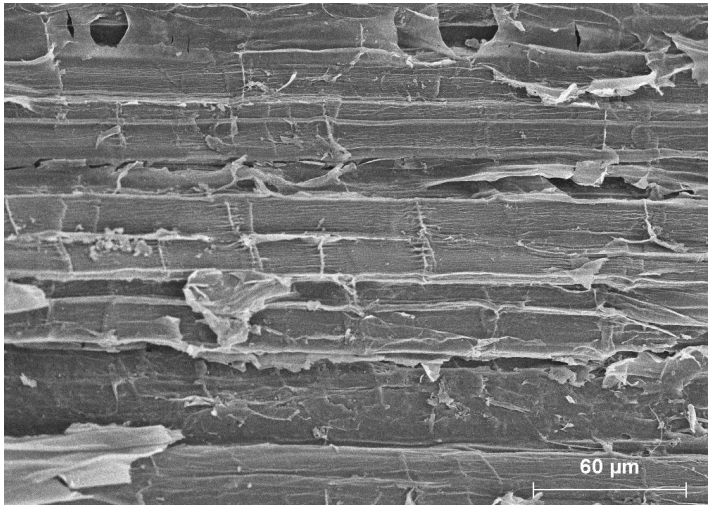
Figure 1
http://news.mongabay.com/bioenergy/2007/10/green-roads-engineers-investigate.html



Lignin and pectin

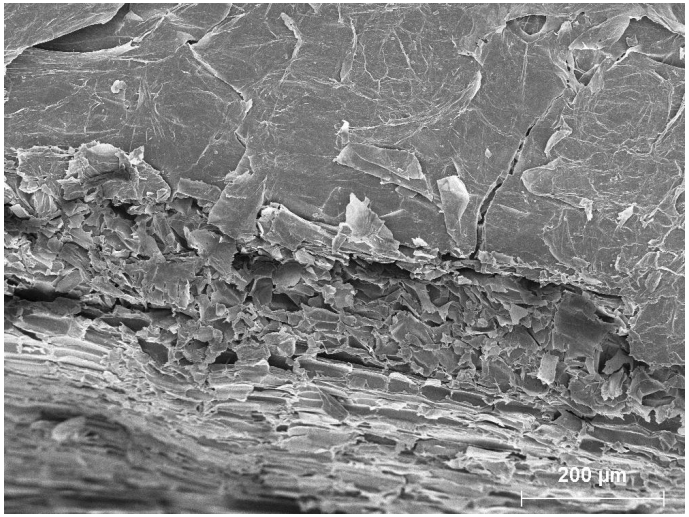


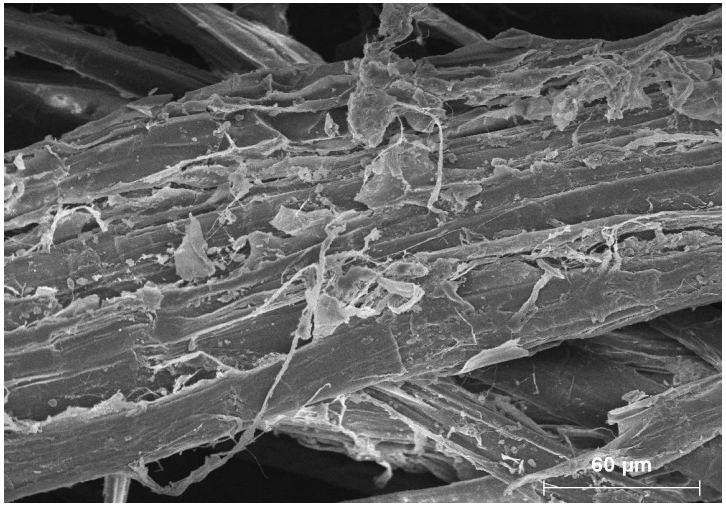
Stuctural changes in hemp - SEM



Hemp fresh:

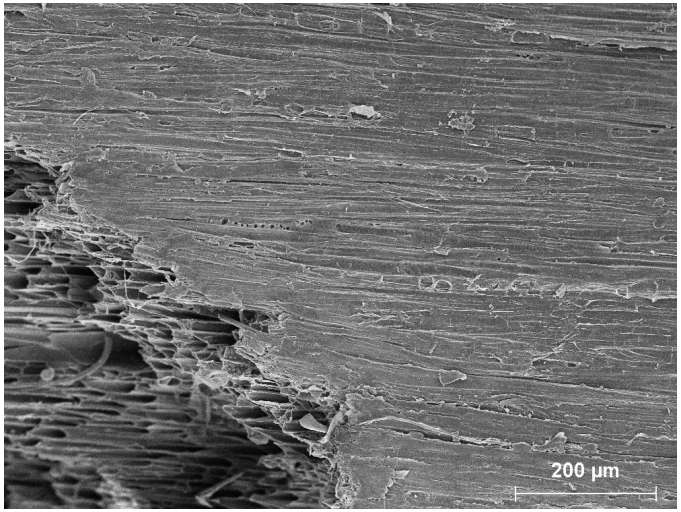
← Fibre
Stem →





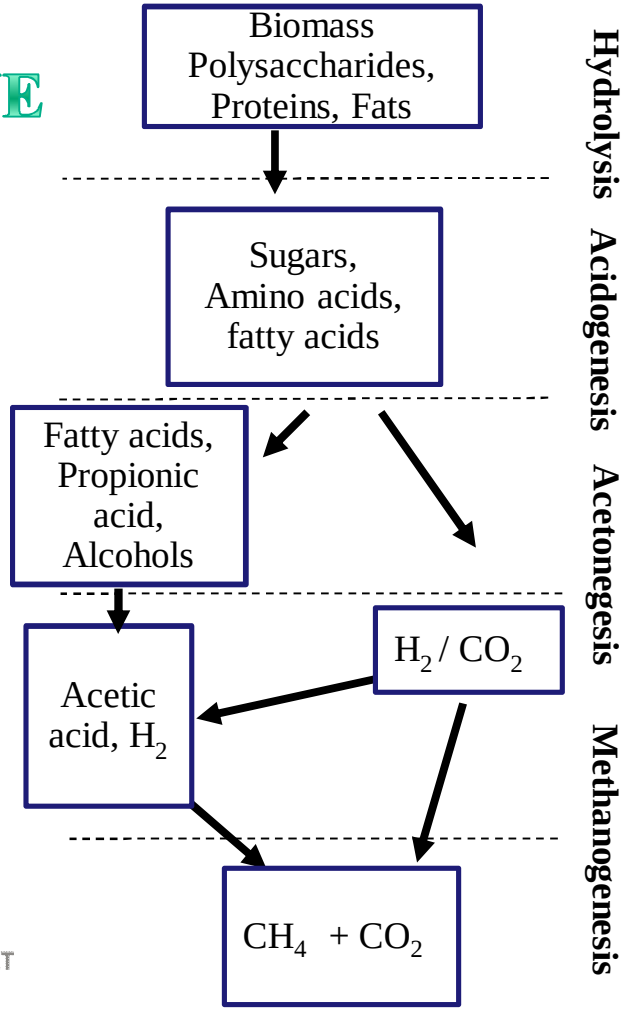
Hemp ensiled with formic acid:

← Fiber
Stem →

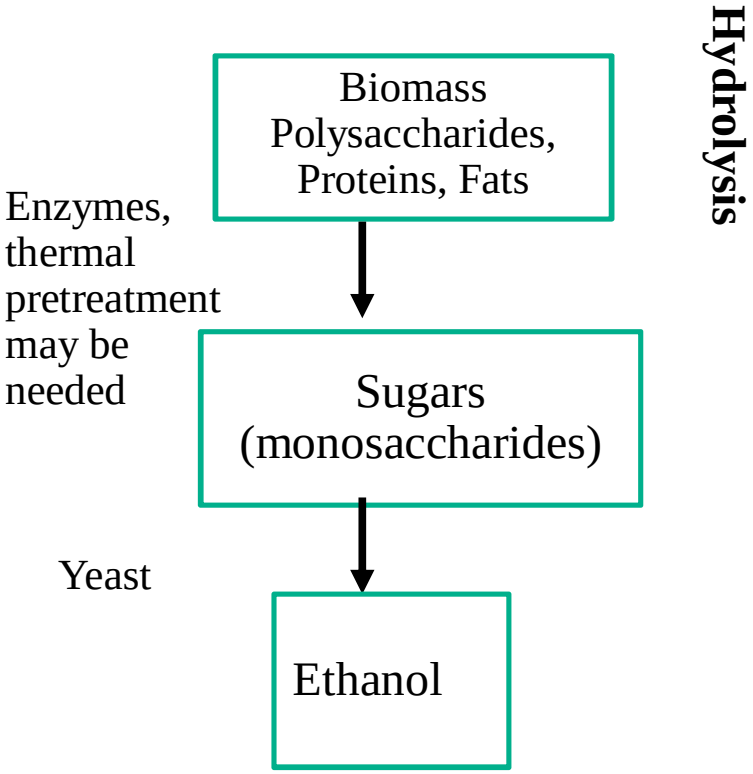


Methane vs. ethanol

METHANE

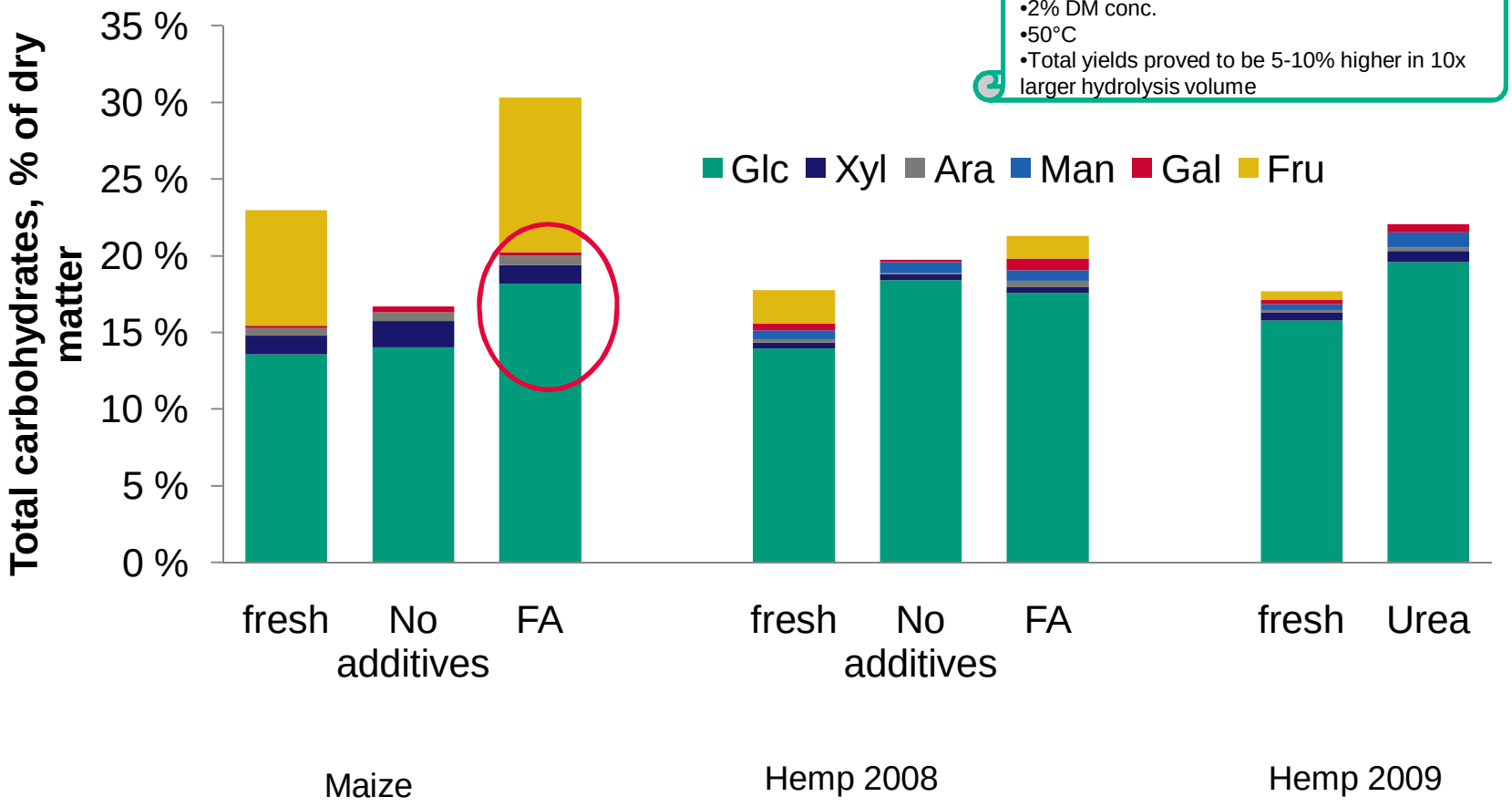


ETHANOL

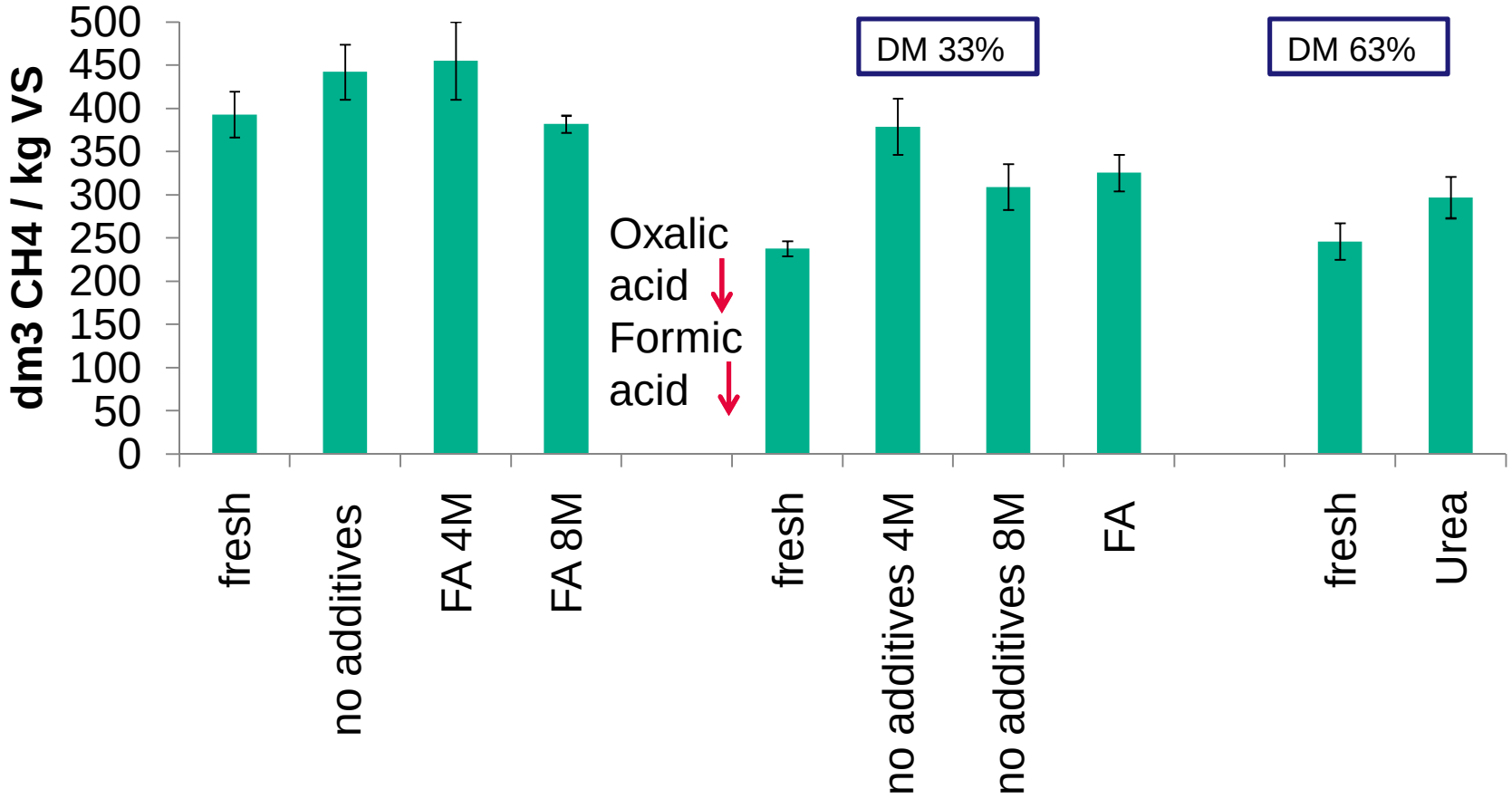


Hydrolyzability of fresh and ensiled crops

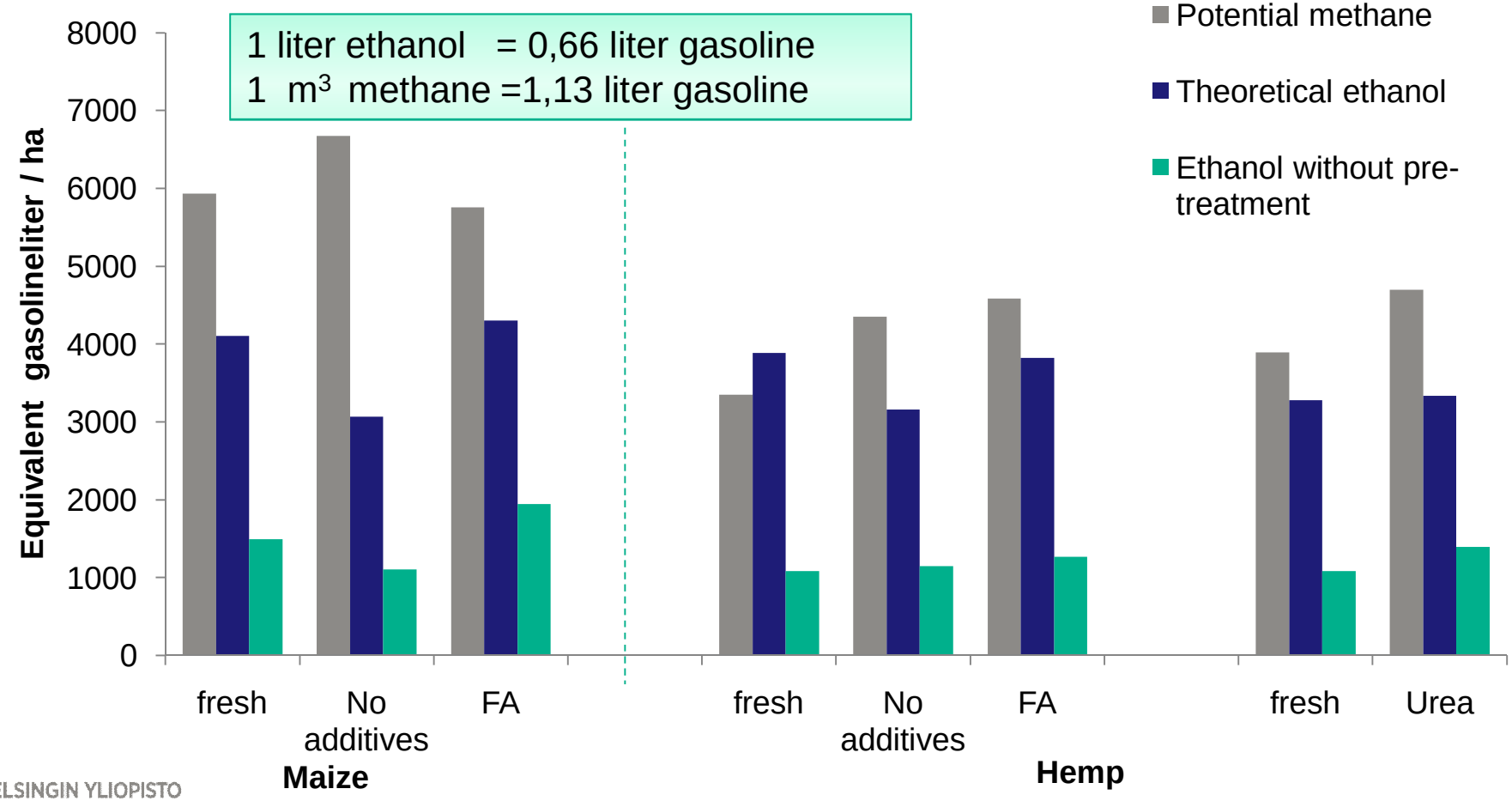
- Celluclast+ Novozyme 188
- Volume 5ml
- 2% DM conc.
- 50°C
- Total yields proved to be 5-10% higher in 10x larger hydrolysis volume



Methane yields from the fresh and ensiled hemp



Energy carriers to gasoline



Conclusions

Effects to ETHANOL

- ✓ Storing with additives increased the yield of sugars in enzymatic hydrolysis
  - ✓ Water soluble sugars well preserved
  - ✓ Some cellulose hydrolysed during ensiling
  - ✓ Storing altered the structure of the substrate?
- ✓ Suffered from acid formation when no additives were supplied.

Effects to METHANE

- ✓ Storing with or without additives increased methane yield
  - ✓ Formed acids were utilized, as well as the preserved water soluble sugars
- ✓ Prolonged storing seemed to decrease methane yields

Acknowledgements

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Tack så mycket
Thank you!