Storage and pre-treatment of energy crops

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CROPGEN - WP3:

Pre-treatments to enhance methane production from energy crops

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Research at IFA-Tulln:

- **Silage preparation**
  - ensiling as pre-treatment
  - storage (reduction of losses)
- **Mechanical, chemical & thermal pre-treatments**

Ensiling of energy crops

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- **Effects of silage inoculants on whole crop maize silage**
  - Differences in silage quality
    but no significant differences in methane formation
  - Effect of spoilage bacterium (*Clostridium tyrobutyricum*)
    - not recommended for practical use
    - mechanism/effect is unclear
- **Effect of ensiling and silage quality on other energy crops than maize**

Ensiling of energy crops

Strategies

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- **Development of silage additives to improve methane formation**
  - without the disadvantages of *C. tyrobutyricum*
- **Minimisation of storage losses**
  - Animal feeding and anaerobic digestion - differences:
    - size of silo
    - unloading
    - handling

Ensiling of energy crops

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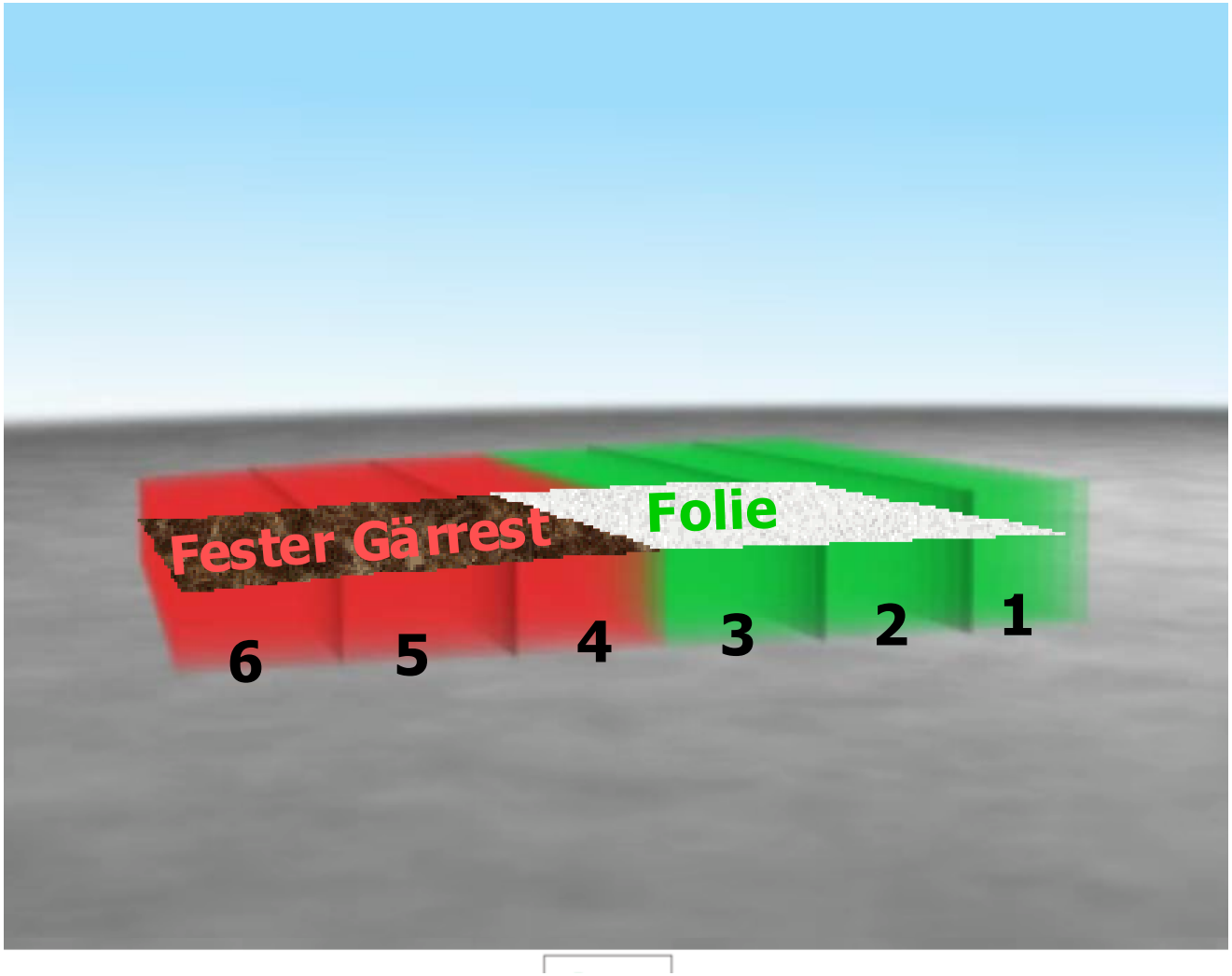
How high are the actual losses in a silo used for storage at a biogas plant?

Is there a need for special measures (e.g. additives) to reduce losses?

- **Silo at the biogas plant in Strem**
  - Determination of mass losses
  - Influence of coverage (plastic film vs. digestate)
  - Monitoring of silage quality (chemical and microbiological analysis)



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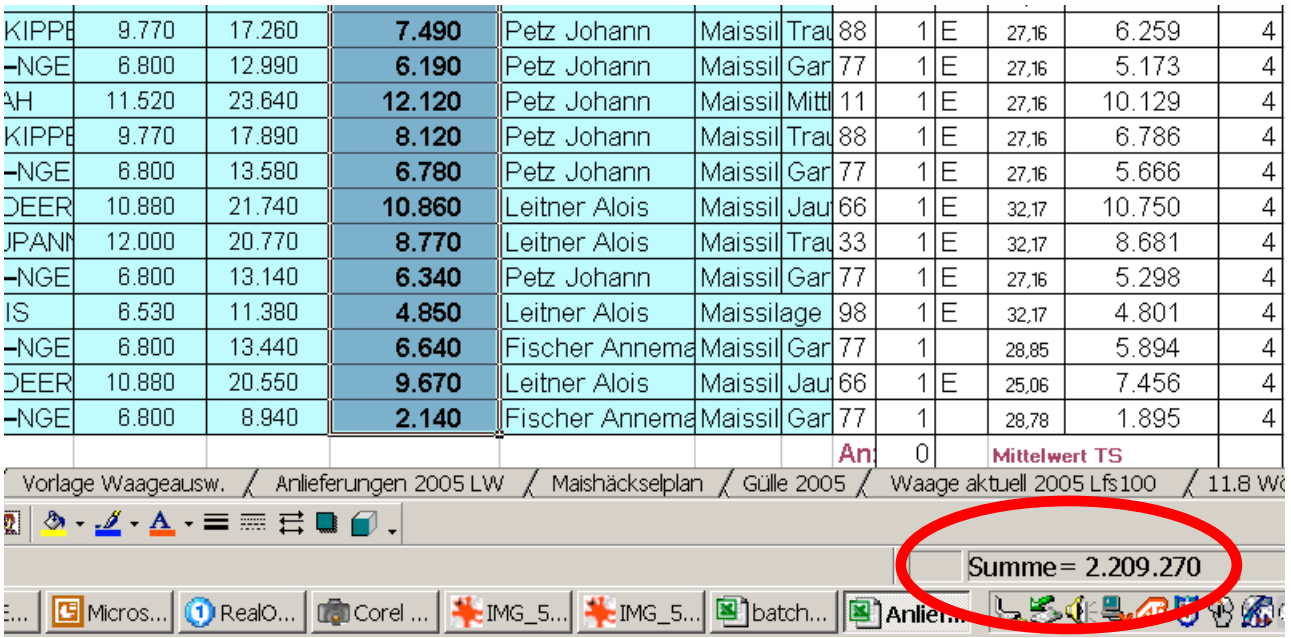
3 2
2 1
1 2



KIPPE	9.770	17.260	**7.490**	Petz Johann	Maissil	Trau	88	1	E	27,16	6.259	4
-NGE	6.800	12.990	**6.190**	Petz Johann	Maissil	Gar	77	1	E	27,16	5.173	4
AH	11.520	23.640	**12.120**	Petz Johann	Maissil	Mittl	11	1	E	27,16	10.129	4
KIPPE	9.770	17.890	**8.120**	Petz Johann	Maissil	Trau	88	1	E	27,16	6.786	4
-NGE	6.800	13.580	**6.780**	Petz Johann	Maissil	Gar	77	1	E	27,16	5.666	4
DEER	10.880	21.740	**10.860**	Leitner Alois	Maissil	Jau	66	1	E	32,17	10.750	4
JPANN	12.000	20.770	**8.770**	Leitner Alois	Maissil	Trau	33	1	E	32,17	8.681	4
-NGE	6.800	13.140	**6.340**	Petz Johann	Maissil	Gar	77	1	E	27,16	5.298	4
IS	6.530	11.380	**4.850**	Leitner Alois	Maissilage		98	1	E	32,17	4.801	4
-NGE	6.800	13.440	**6.640**	Fischer Annema	Maissil	Gar	77	1		28,85	5.894	4
DEER	10.880	20.550	**9.670**	Leitner Alois	Maissil	Jau	66	1	E	25,06	7.456	4
-NGE	6.800	8.940	**2.140**	Fischer Annema	Maissil	Gar	77	1		28,78	1.895	4
							An:	0		Mittelwert TS		

Vorlage Waageausw. / Anlieferungen 2005 LW / Maishäckselplan / Gülle 2005 / Waage aktuell 2005 Lfs100 / 11.8 W

Summe= 2.209.270

E... Micros... RealO... Corel ... IMG_5... IMG_5... batch... Anlieferungen...

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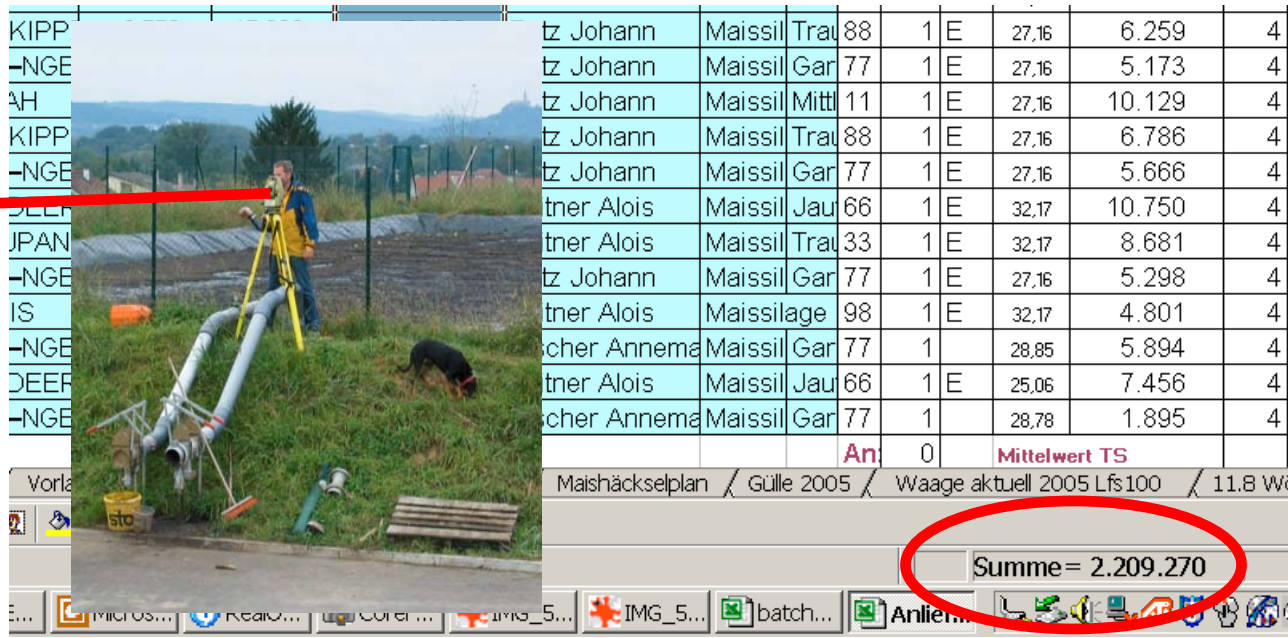
Maissil Trau 88 1 E 27,16 6.259 4
Maissil Gar 77 1 E 27,16 5.173 4
Maissil Mittl 11 1 E 27,16 10.129 4
Maissil Trau 88 1 E 27,16 6.786 4
Maissil Gar 77 1 E 27,16 5.666 4
Maissil Jau 66 1 E 32,17 10.750 4
Maissil Trau 33 1 E 32,17 8.681 4
Maissil Gar 77 1 E 27,16 5.298 4
Maissilage 98 1 E 32,17 4.801 4
Maissil Gar 77 1 28,85 5.894 4
Maissil Jau 66 1 E 25,06 7.456 4
Maissil Gar 77 1 28,78 1.895 4
An: 0 Mittelwert TS
Maishäckselplan
Gülle 2005
Waage aktuell 2005 Lfs100
Summe= 2.209.270
IMG_5...
batch...

$$\rho = m / V$$

Thermal pre-treatment

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- **Substrate: maize silage**
- **Objective: to enhance the digestibility of the substrate**
- **Experimental design:**

Temperature	Time
140°C	5 min
140°C	20 min
180°C	5 min
180°C	20 min
162°C	12.5 min

20 L hydrolysis reactor

- 2 kg maize whole crop silage (TS: 32.64)
- 3 L water

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Thermal pre-treatment

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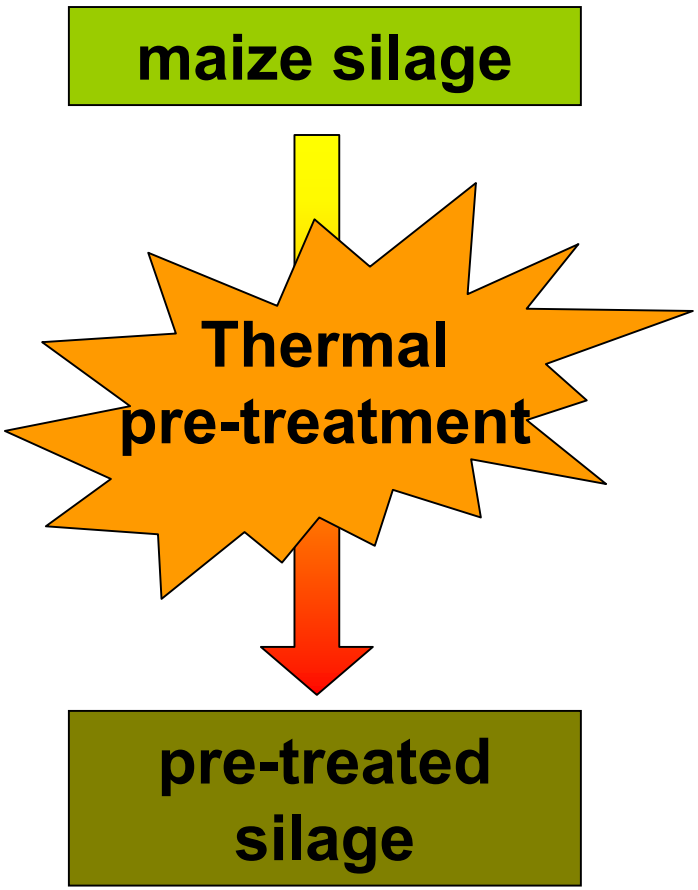
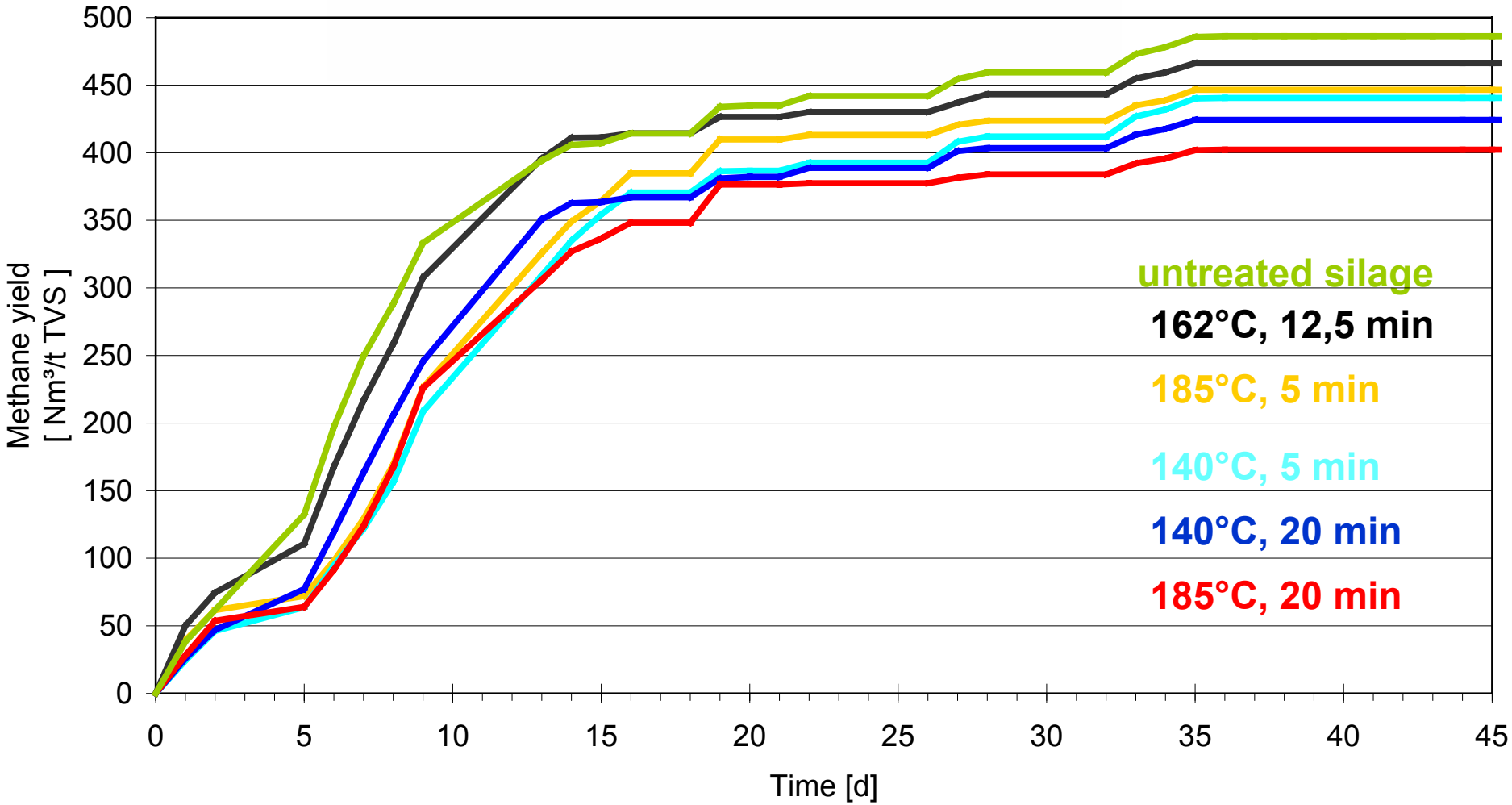


- Chemical analysis:
  - TS, TVS
  - sulfuric acid hydrolysis
    → Klason lignin, carbohydrates
- Batch tests
  (Methane formation)

Results batch fermentation tests



Characterisation of the liquid phase

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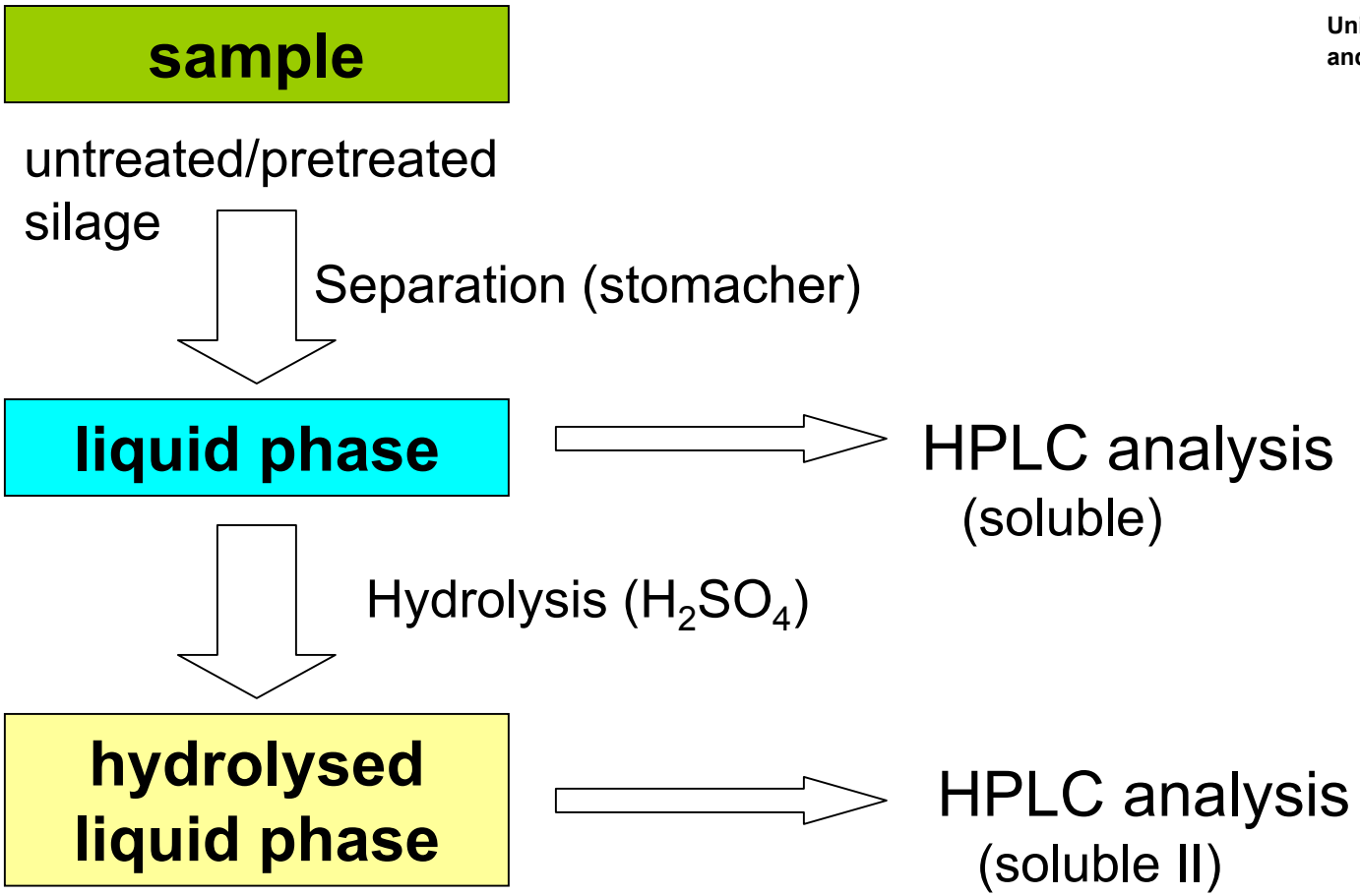

HPLC-Chromatograms

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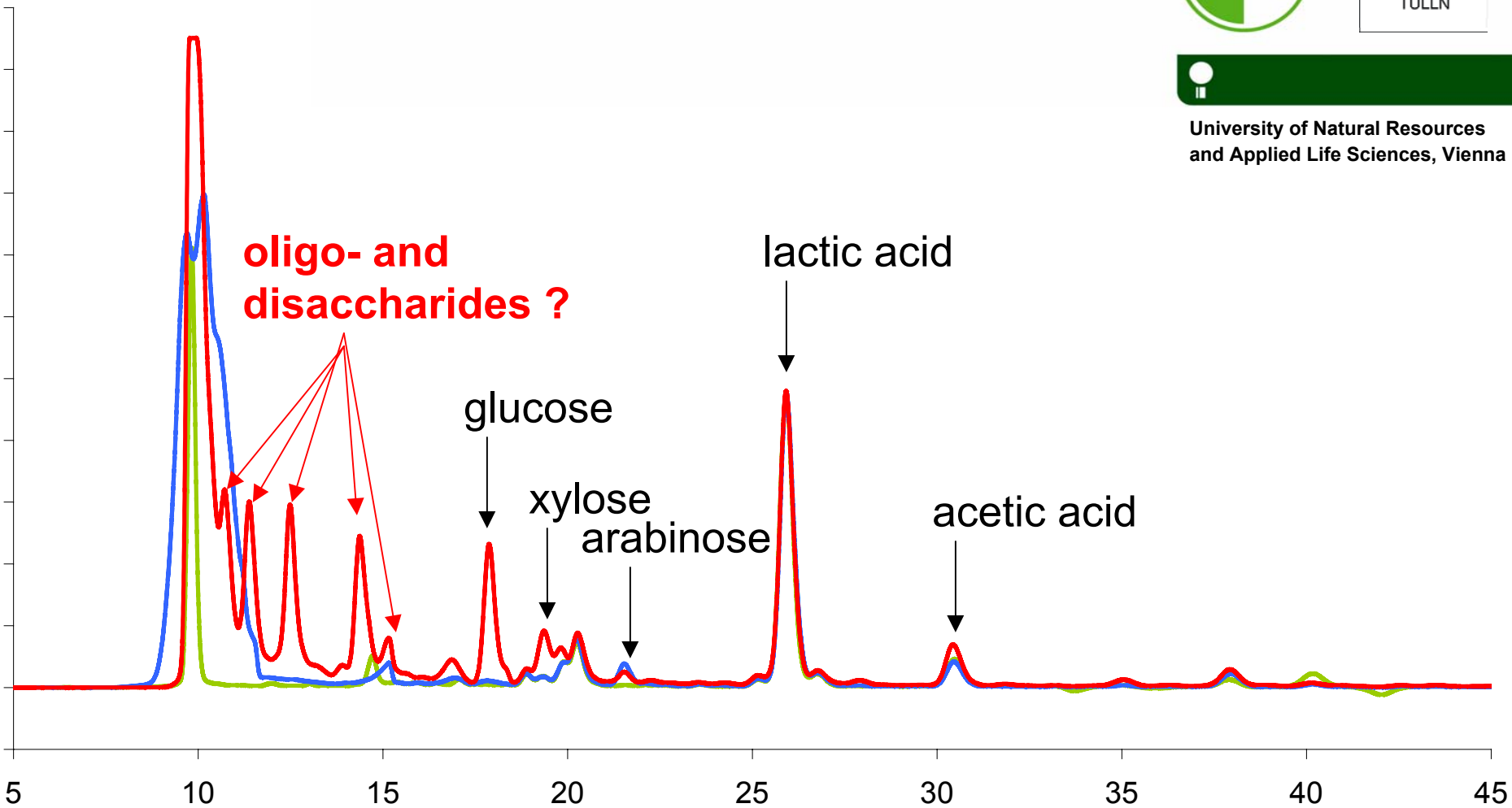
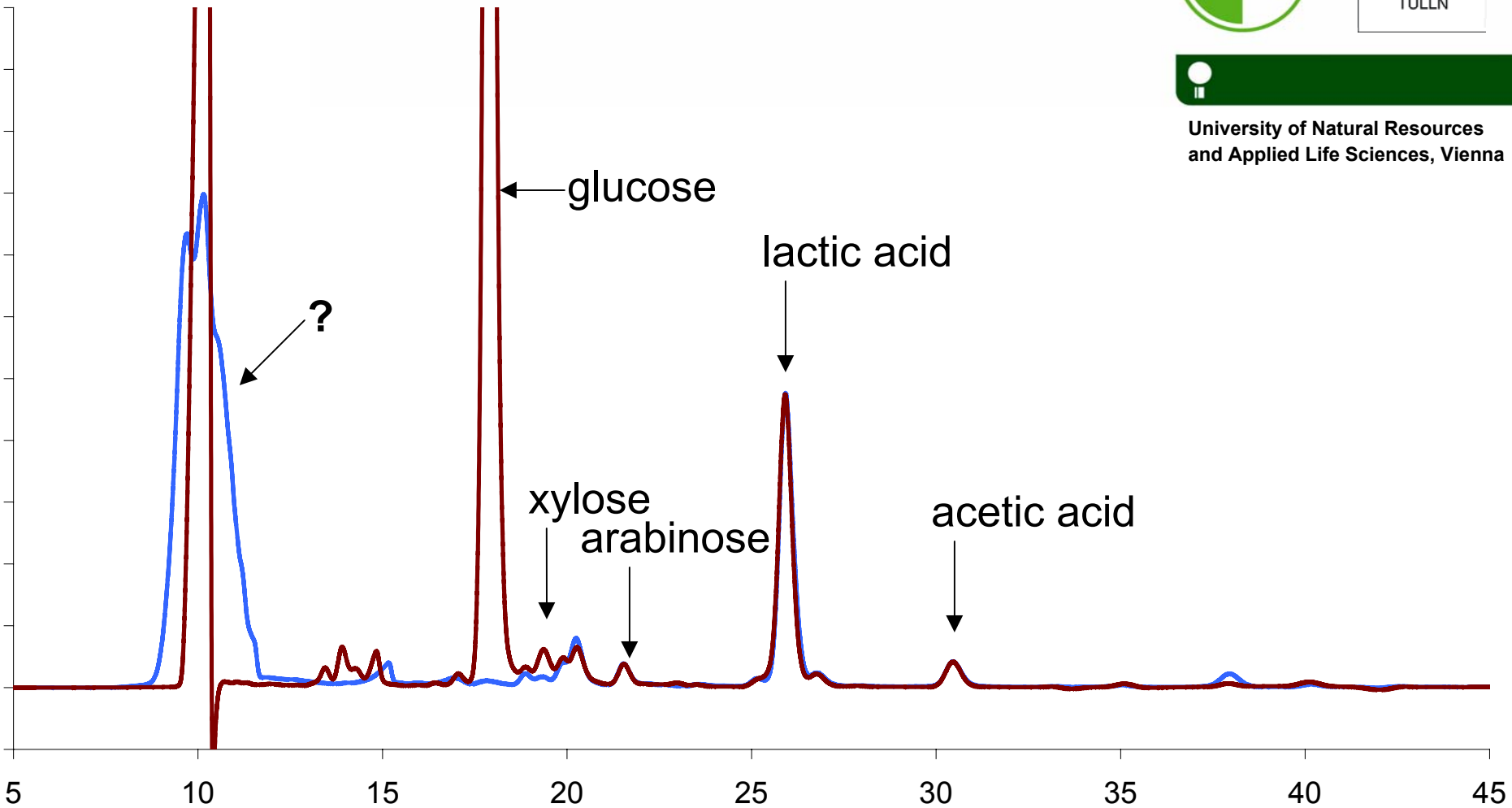


Silage
140°C/20 min
185°C/20 min

HPLC-Chromatograms



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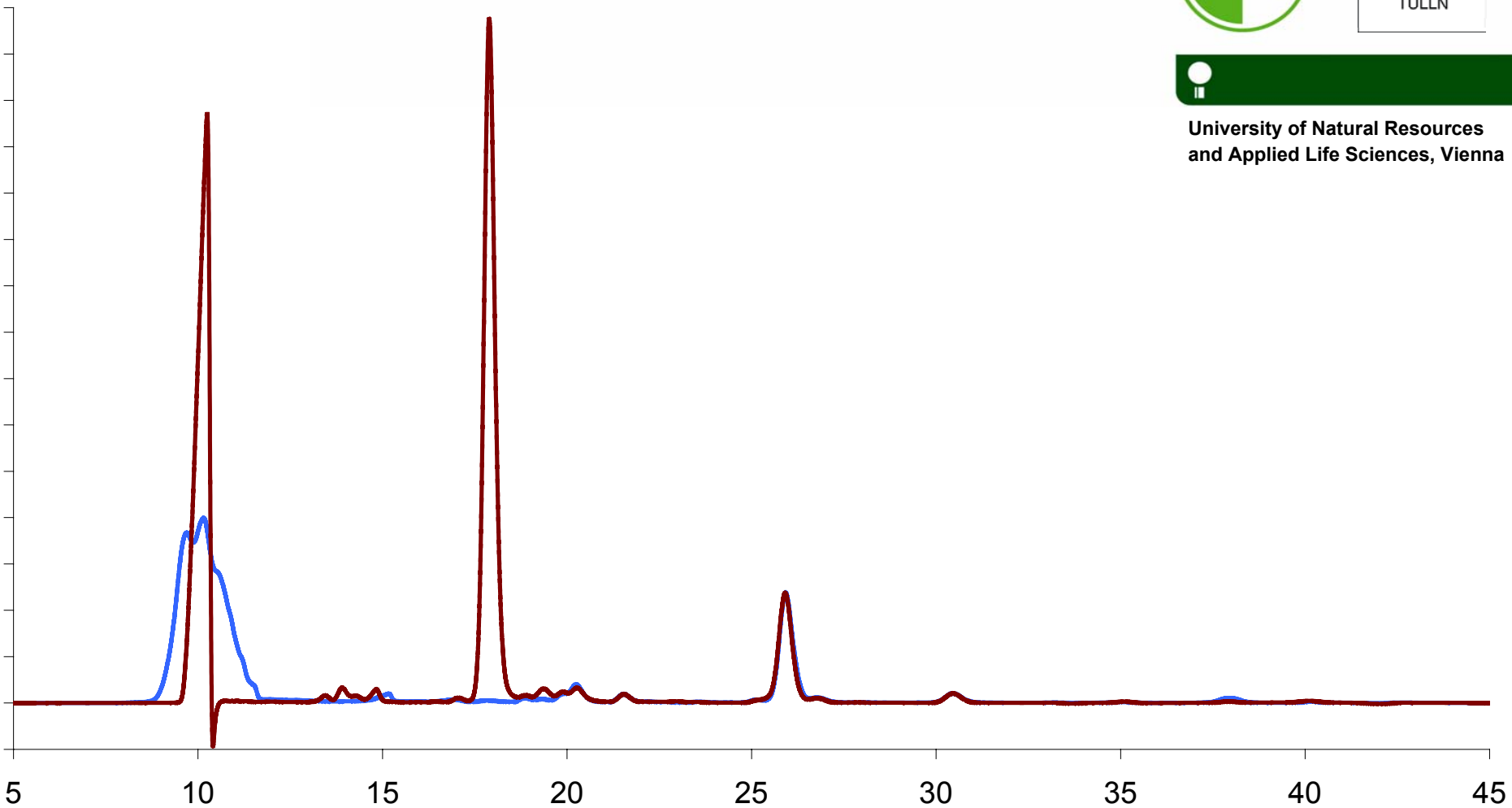
HPLC-Chromatograms



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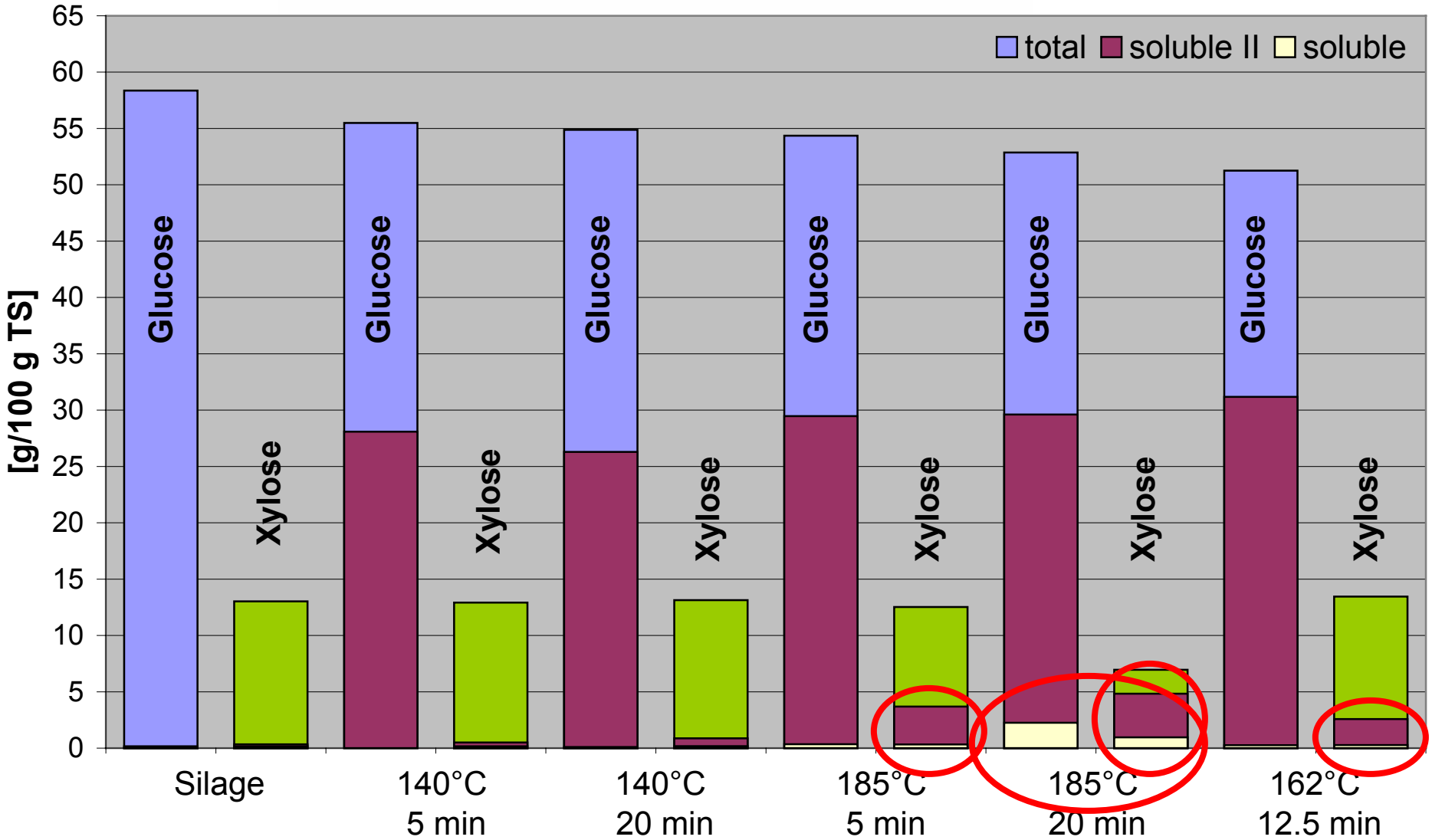
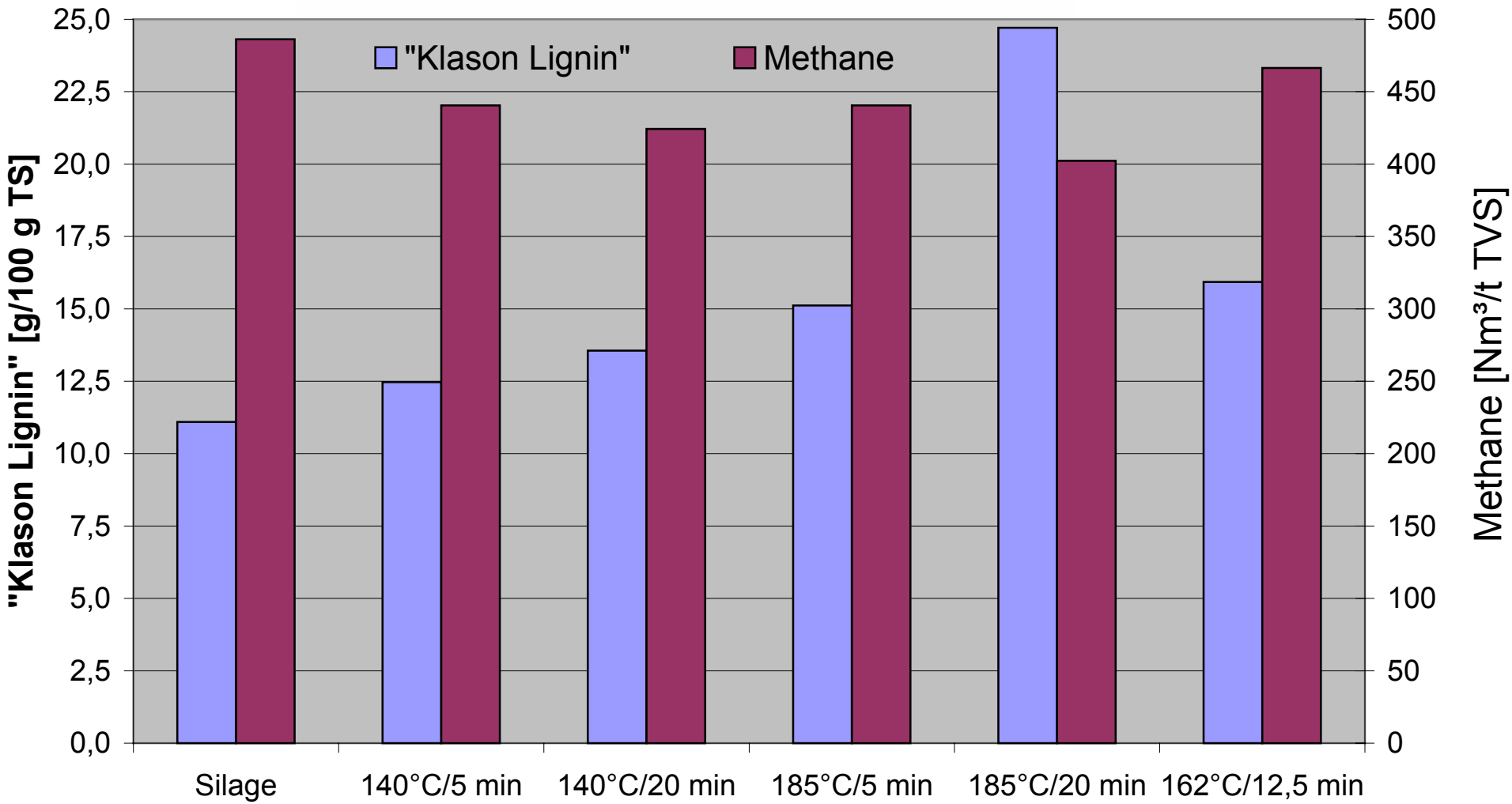

total
soluble II
soluble
[g/100 g TS]
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Glucose
Xylose
Silage
140°C
5 min
140°C
20 min
185°C
5 min
185°C
20 min
162°C
12.5 min


"Klason Lignin"
Methane
"Klason Lignin" [g/100 g TS]
Methane [Nm³/t TVS]
25,0
22,5
20,0
17,5
15,0
12,5
10,0
7,5
5,0
2,5
0,0
500
450
400
350
300
250
200
150
100
50
0
Silage
140°C/5 min
140°C/20 min
185°C/5 min
185°C/20 min
162°C/12,5 min

Conclusion

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- **Thermal pretreatment of maize silage increases the concentration of soluble carbohydrates**
  - The dissolved carbohydrates most probably result from starch
- **Disintegration of lignocellulose can only be expected at severe conditions** (high temperatures/long reaction times)
  - coupled with sugar degradation/losses
- **No improvement in methane formation was observed**
  - Lower methane production due to unwanted by-products and losses cover possible advantages from the disintegration of lignocellulose

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cropgen

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