MANAGEMENT CENTER INNSBRUCK

bioethanol from lignocellulosic feedstock

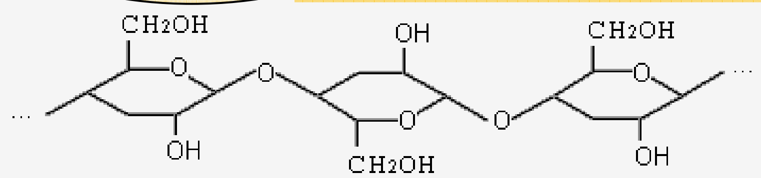
bioethanol and biogas co-generation

fermentation of polysaccharide solutions out of hot-water pre-treatment procedure

IEA Workshop
9.09.2008
Vienna / Austria

Composition of lignocellulosic biomass

- **Celluloses**
  structure based on glucose
  water-insoluble, hydrolysable



potential sugar sources for EtOH-Production

- **Hemicelluloses**
  branched-chain structure (based on 5-carbon sugar, mainly xylose), water-soluble, hydrolysable
- **Lignin**
  no repeating structures, water-insoluble, difficultly hydrolysable

well-known basic steps

- **Saccharification of cellulose**

  using commercial avialable enzyme-mixtures saccharification procedure leads to sugar yields more than 90% (weight)

- **Fermentation of glucose out of cellulose saccharification with help of yeasts leads to yields up to about 50% (weight)**

- **Destillation**

  economic practicability depends on ethanol concentration

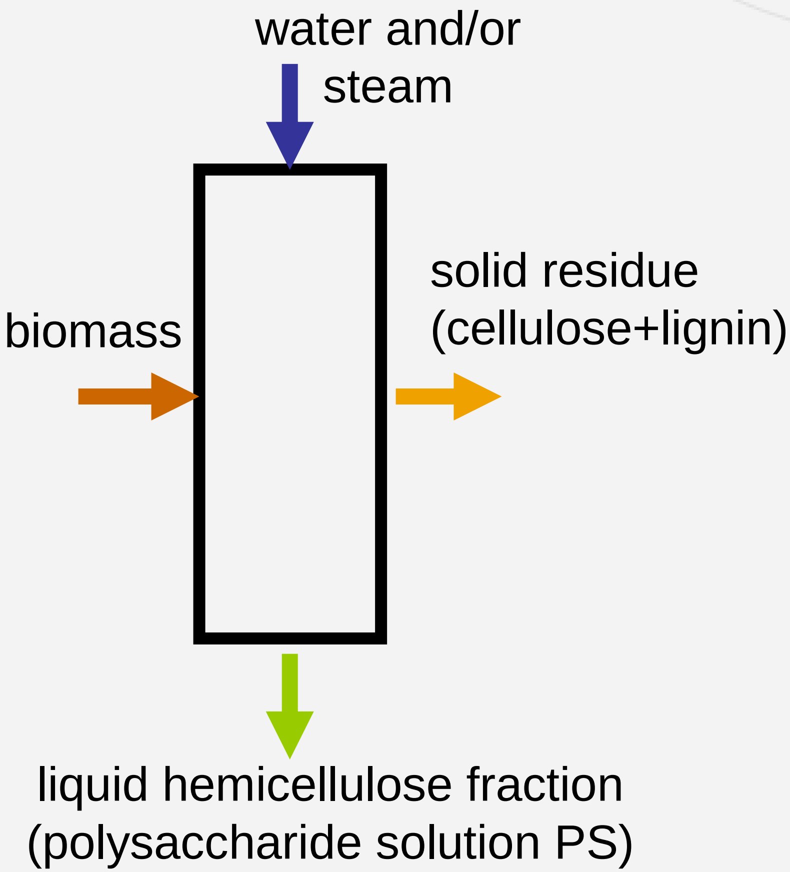
How can the enzymes get access to the cellulose coverded by lignin and hemicellulose inside the plant structure ?

→ Biomass pre-treatment

Examples for common procedures:

- **acid pre-treatment**
- **combined steam explosion and acid pre-treatment**
- **steam or hot-water pre-treatment**

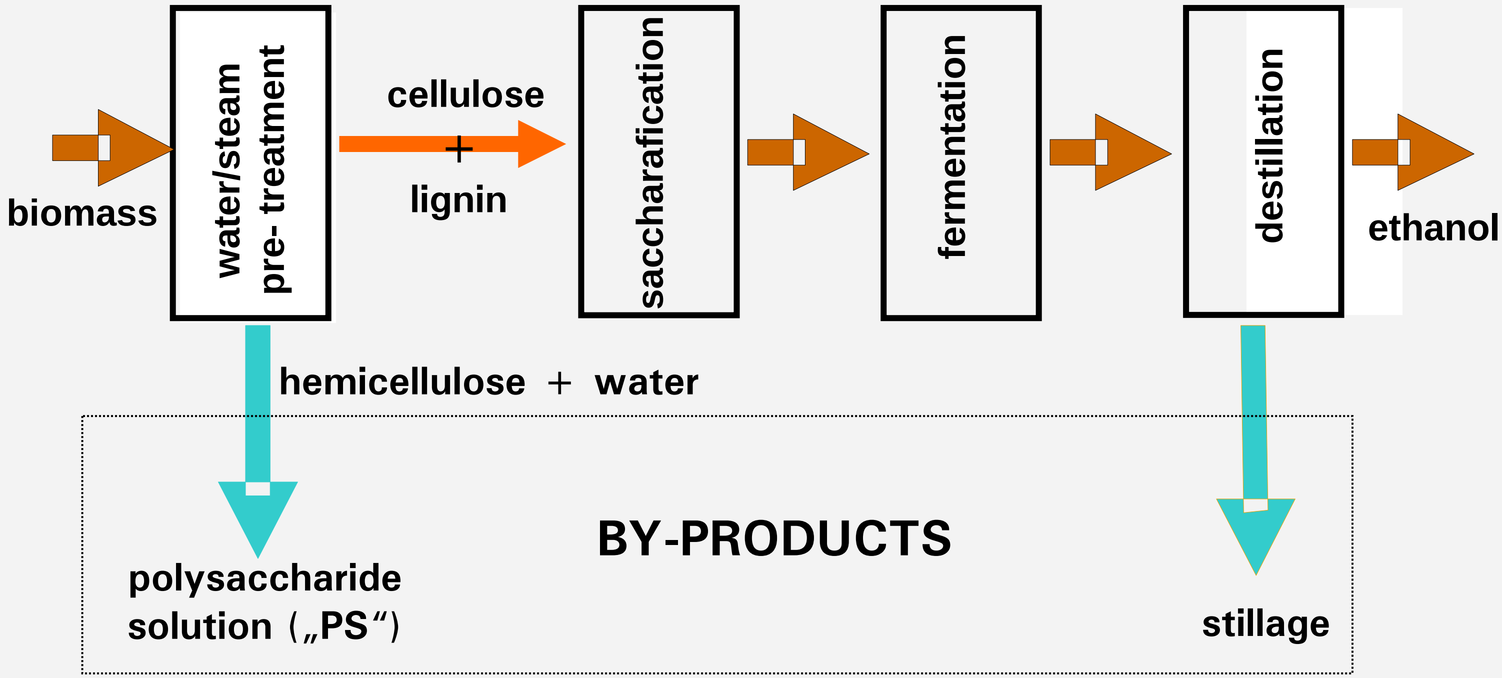
water and/or steam pre-treatment



some reasons for realizing water/steam pre-treatment:

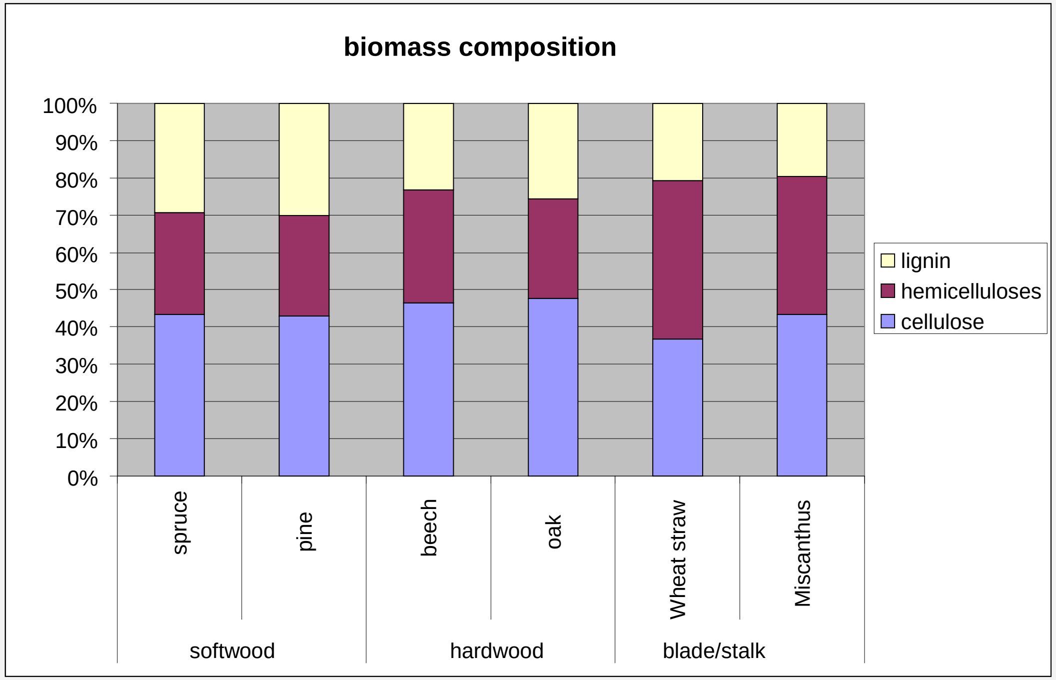
- no chemicals required → no further problems with recycling and disposal
- glucose losses nearly neglectable → high saccharification yields (up to 80% weight) are possible
- low amount of enzyme inhibition by-products in solid residue → inhibition nearly neglectable
- easy by-product utilization is possible

example for a *Lignoethanolprocess* with water/steam pre-treatment



DISADVANTAGES

- only the sugars out of cellulose are utilized



- basic one stage saccharification and fermentation processes are leading to low ethanol concentrations → energy consuming distillation

Possible solution investigated by the MCI

Fermentation of the polysaccharide solution (out of hemicelluloses) together with the stillage to biogas

ADVANTAGES

➡ **Utilization of all plant sugars**

➡ **(heat) Energy supply for distillation**

Properties of the polysaccharide solution

feedstock investigated: spruce wood

typical PS sample data:

dry matter dm	about 2 – 3%
PS	about 90% from dm

Total sugar content:

Glucose	50%
Xylose	22,5%

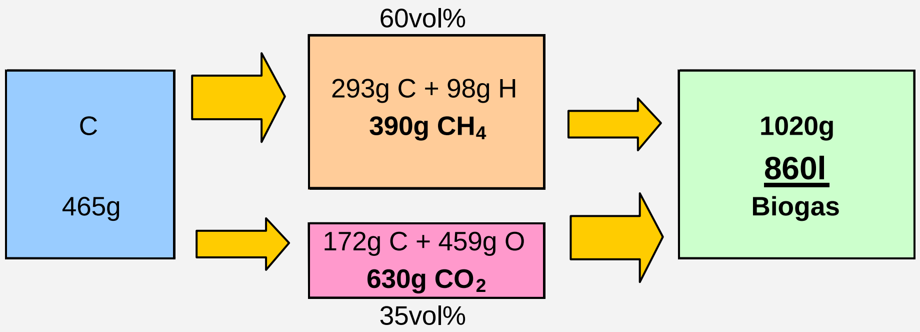
Degradation products from pre-treatment:

HMF	0,04%
glucose	0,04%
furfural	0,08%
acetic acid	0,09%
Xylose	0,29%

biogas-fermentation of the polysaccharid solution out of spruce wood

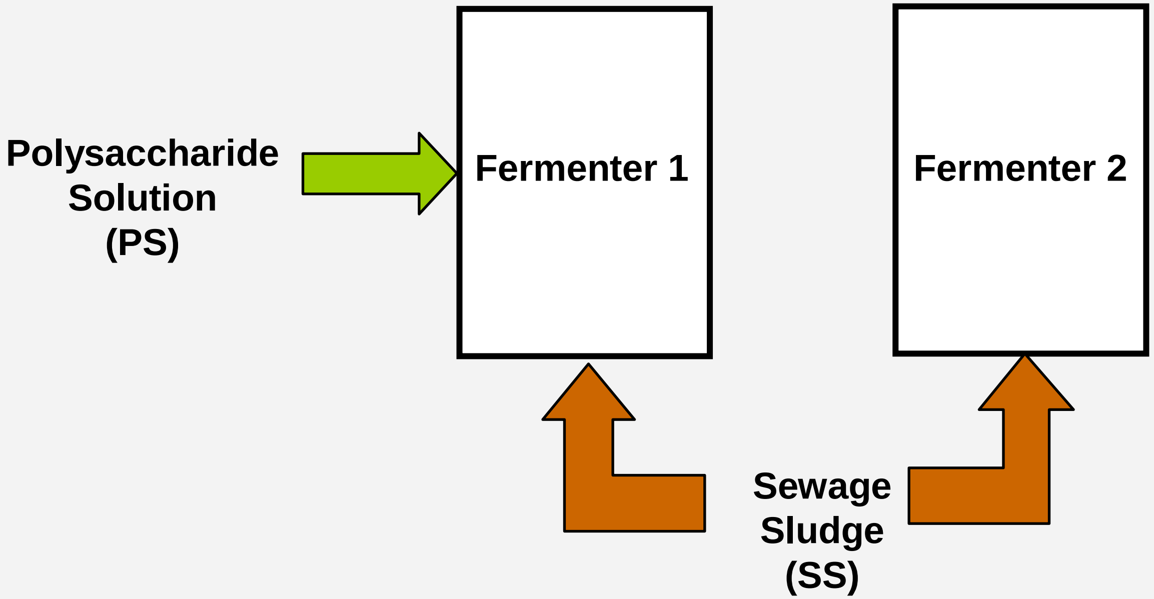
from elemental analysis → about 465g carbon per kg organic dry mass

in theory – assuming 60% CH_4, 35% CO_2, 5% others
(good agreement with experimental data) – a biogas potential of about 860 litres per kg organic dry mass (odm) can be supposed



Co-Fermentation with sewage sludge

Experimental:

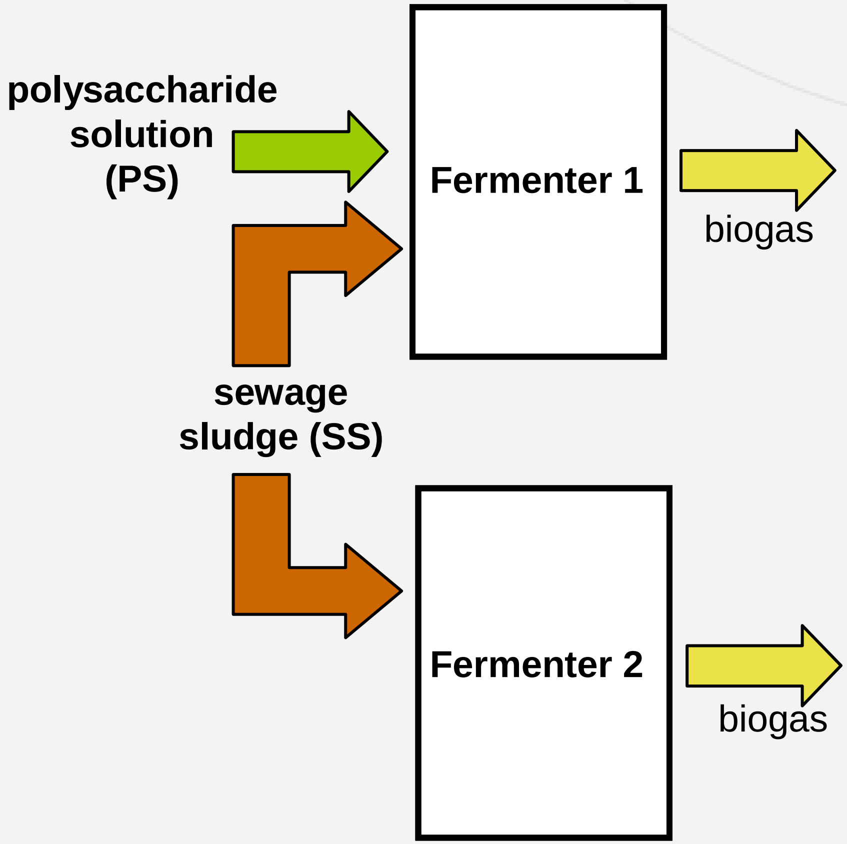


process parameters:

residence time: 25 days
av. temperature: 35℃

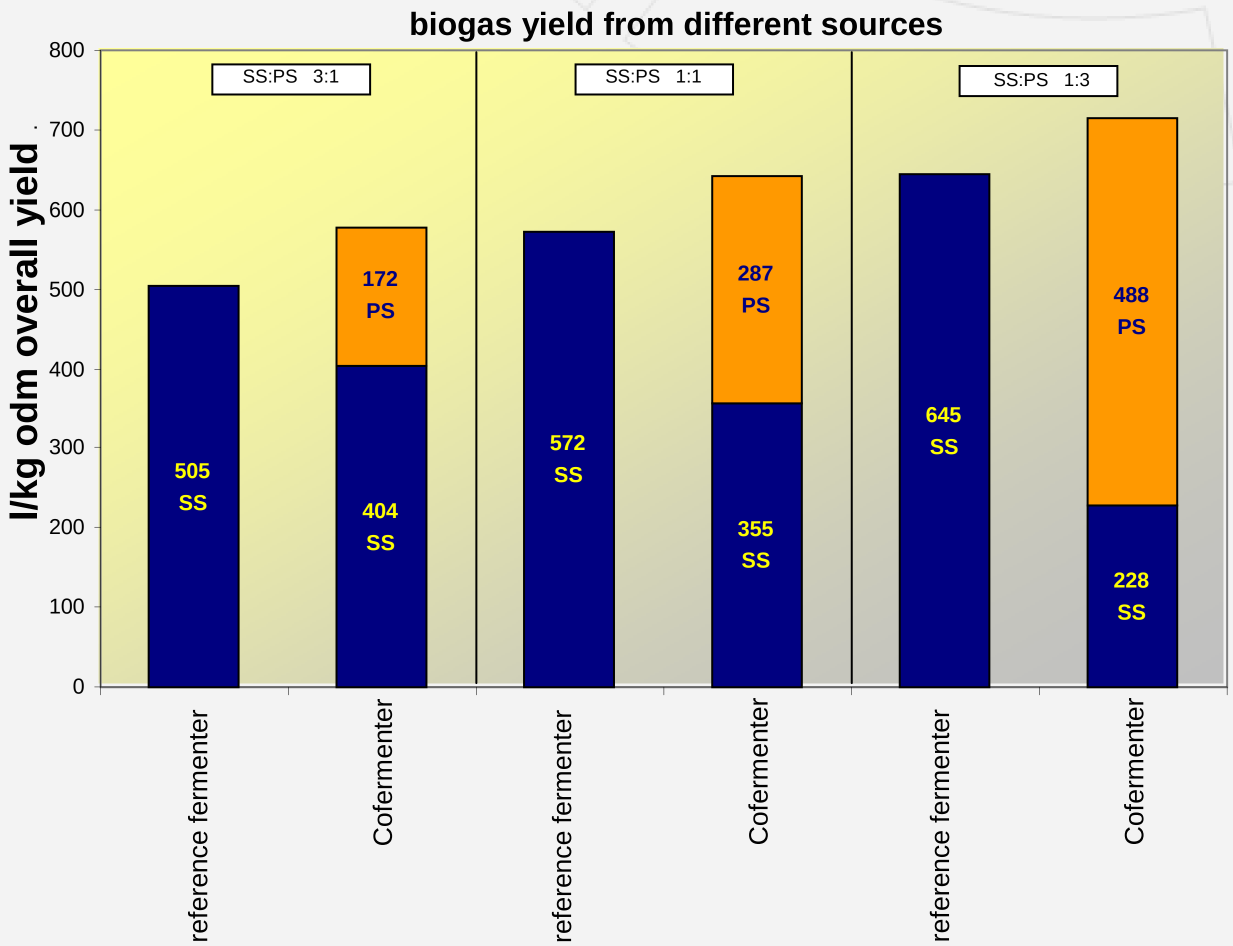
additional measured:
•biogas composition
•pH-value
•dm, odm input/output

results



Mixing Relation (SS:PS)	biogas litre/kg odm	av. pH
3:1	576	7.3
1:1	643	7.2
1:3	716	7.1

Reference for Mixing Realtion in Fermenter 1 (SS:PS)	biogas litre/kg odm	av. pH
3:1	505	7.4
1:1	572	7.4
1:3	645	7.4



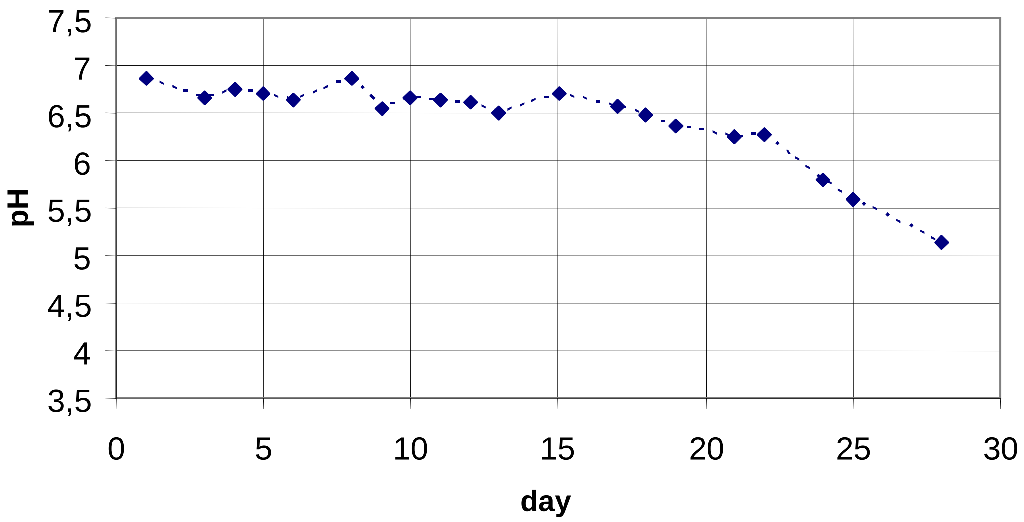
together with the data from the reference fermenter, the biogas potential of the polysaccharide solution can be calculated:

Mixing relation	biogas potential (l/kg odm)
3:1	863
1:1	759
1:3	755

Further experiments with mixing relations down to 1:10 have been shown, that an average biogas potential between **700 – 800 litres/kg odm** can be assumed.

Nevertheless, **one staged fermentation of pure polysaccharide solution** out of spruce pre-treatment is **not stable**:

pH-progress during fermentation of pure PS out of spruce wood:

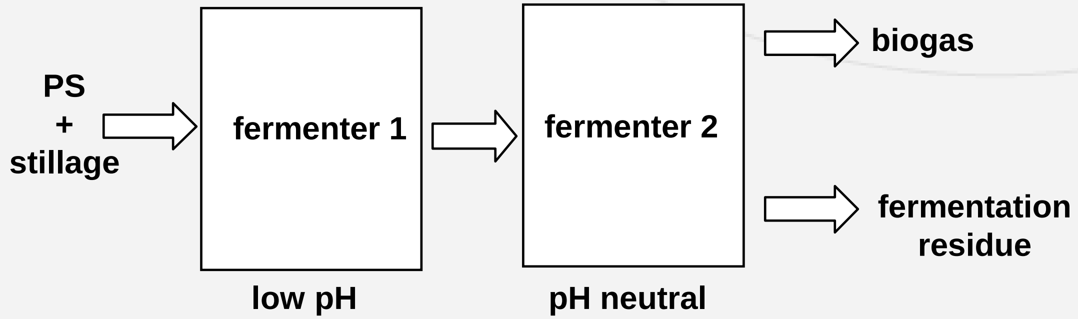


possible reasons:

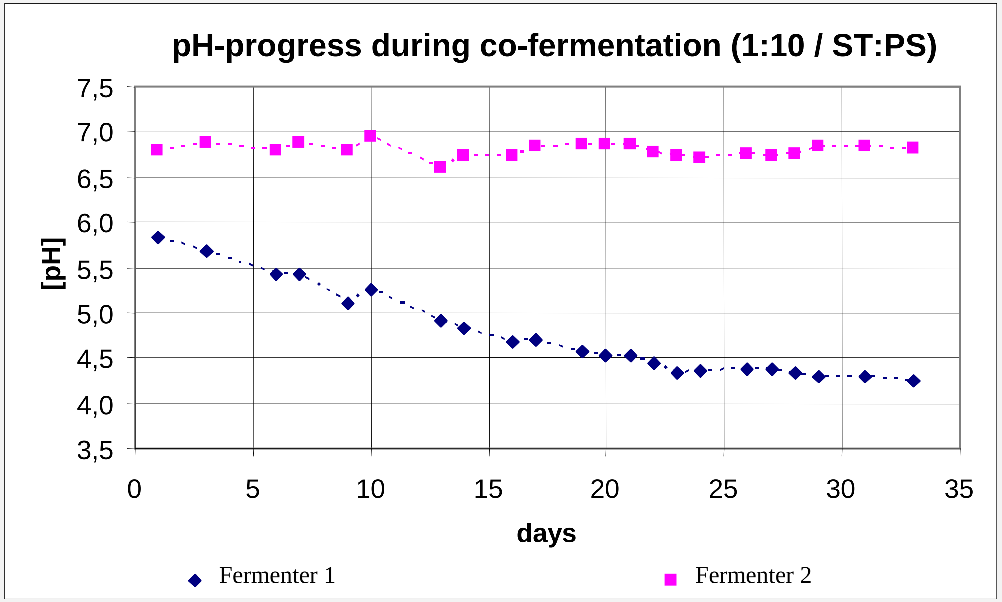
- **PS conversion into acids much faster than methane generation**

- **less nutrients**

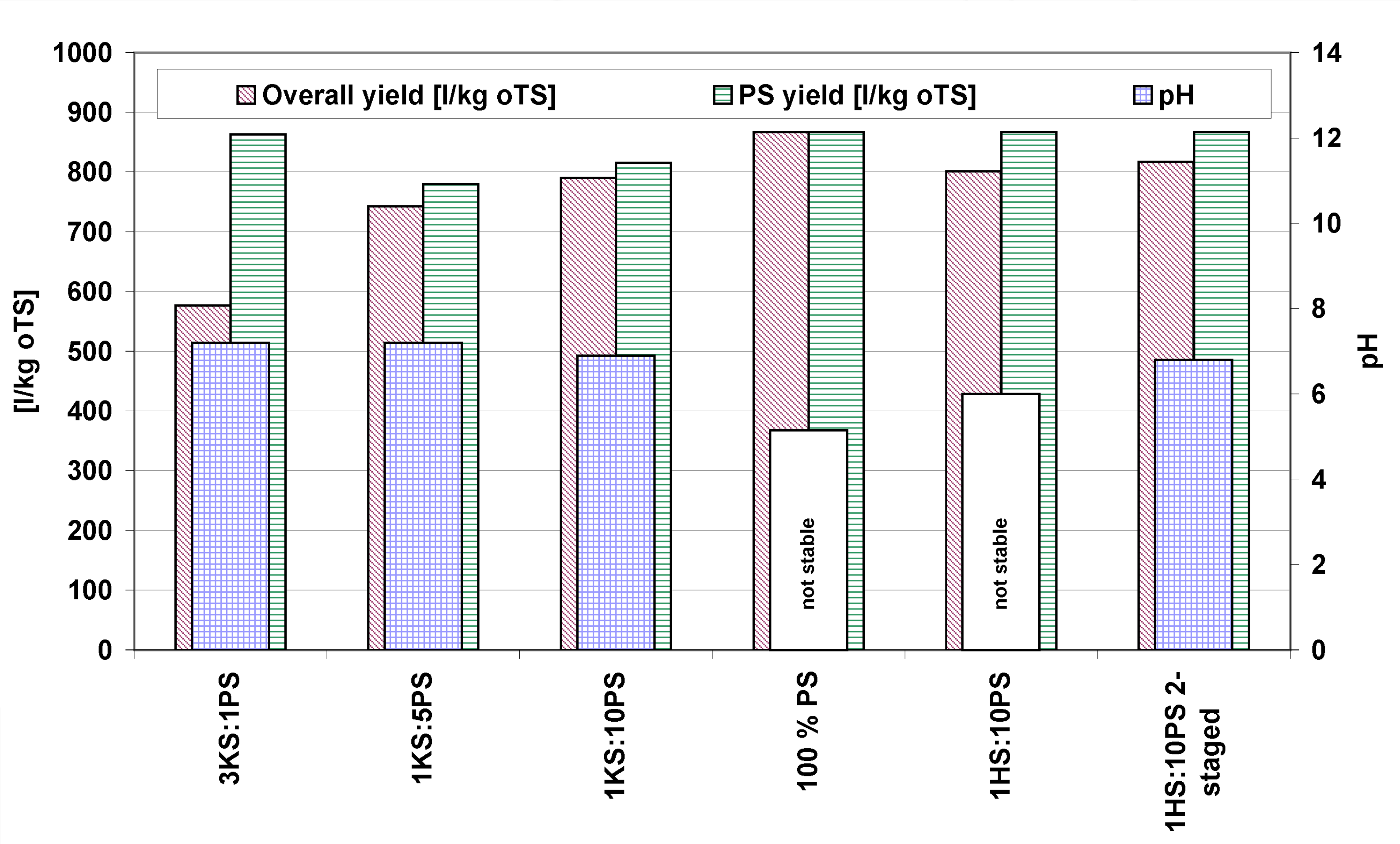
2-staged Co-fermentation with stillage



Parameters:
- fixed temperature: 35°C
- residence time: 35 days
- mixing relations (ST : PS): 1:10, 1:100



Summary of results



possible application in bioethanol production

numbers for spruce wood