



Added Value from Potato Fruit Juice

Martin Lotz, Emsland-Stärke GmbH, Forschungslabor, D-49824 Emlichheim, drlotz@emsland-staerke.de



55th Starch Convention

BAGKF Detmold, April 22nd, 2004

Possibilities for Added Value from PFJ



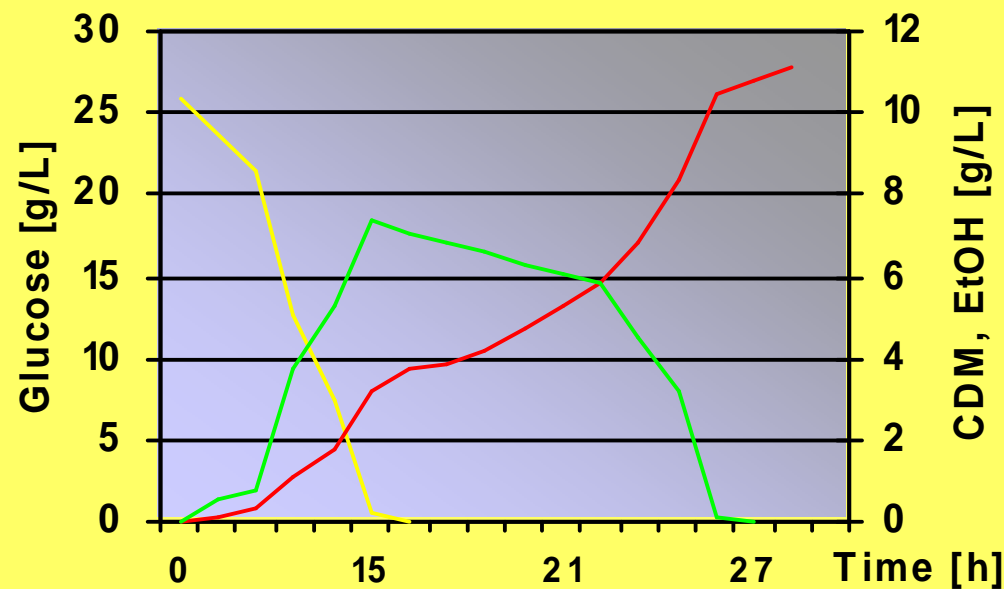
- Ø Fermentation to get Single Cell Protein (SCP)
- Ø Fermentation to get bio alcohol (ethanol)
- Ø Fermentation to get β -1,3-glucan
- Ø Recovering of potato protein in food grade quality and high yield

Batch wise SCP-Production



Airlift reactor with inner loop

Gross vol.	4,000 L
Net vol.	2,500 L
Aeration	1.2 vvm
Temperature	30 °C
pH	4.0
PPL	10 %
Sacch. cerevisiae	



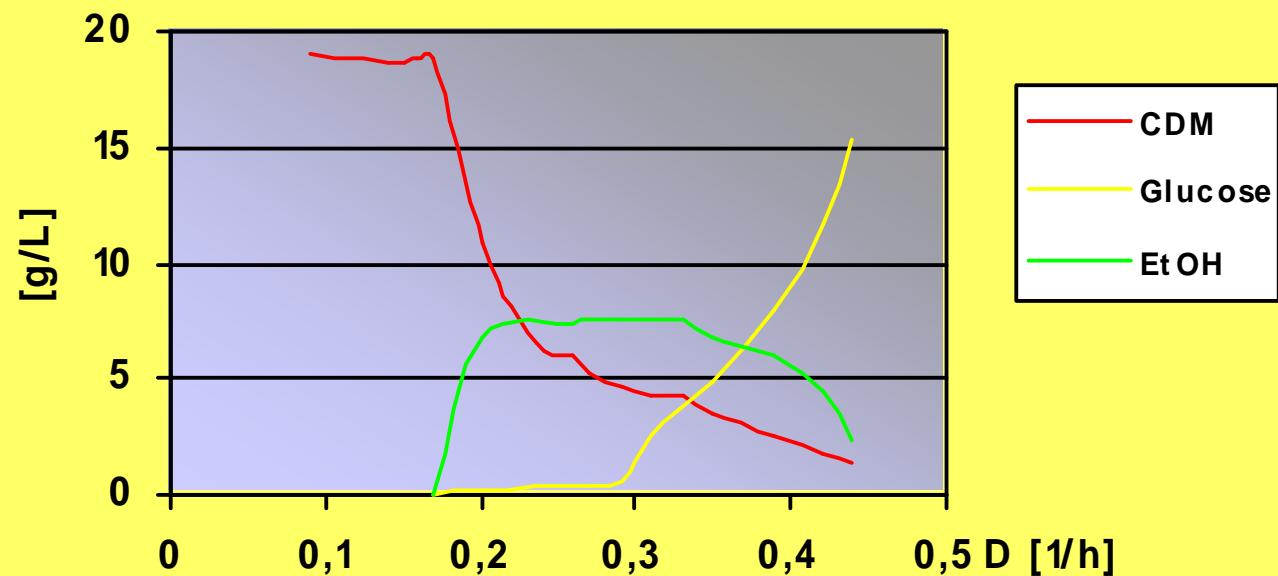
- Ø First growth on glucose, then 2nd growth phase on ethanol
- Ø Maximal CDM 11 kg/m³ after 28 h
- Ø Productivity 0.9 kg/m³h
- Ø COD degradation from 60,000 to 20,000 mg O₂/L
- Ø Compared to it: domestic waste water: ca. 2,000 to 2,500 mg O₂/L

Continuous SCP-Produktion



Airlift reactor with inner loop

Gross vol.	4,000 L
Net vol.	2,500 L
Aeration	1.2 vvm
Temperature	30 °C
pH	4.0
PPL	10 %
Sacch. cerevisiae	



- Ø Critical diluting rate $D_c = 0.19$ 1/h (starting of Glucose repression)
- Ø Point of washing out = μ_{max} 0.47 1/h
- Ø Maximal CDM 19 kg/m³
- Ø Productivity 3.5 kg/m³h, in laboratory scale 3.9 kg/m³h
- Ø Degradation of COD from 60,000 to 18,000 mg O₂/L

Batch wise Ethanol-Production



Lab scale fermenter

Gross volume 12 L

Net volume 10 L

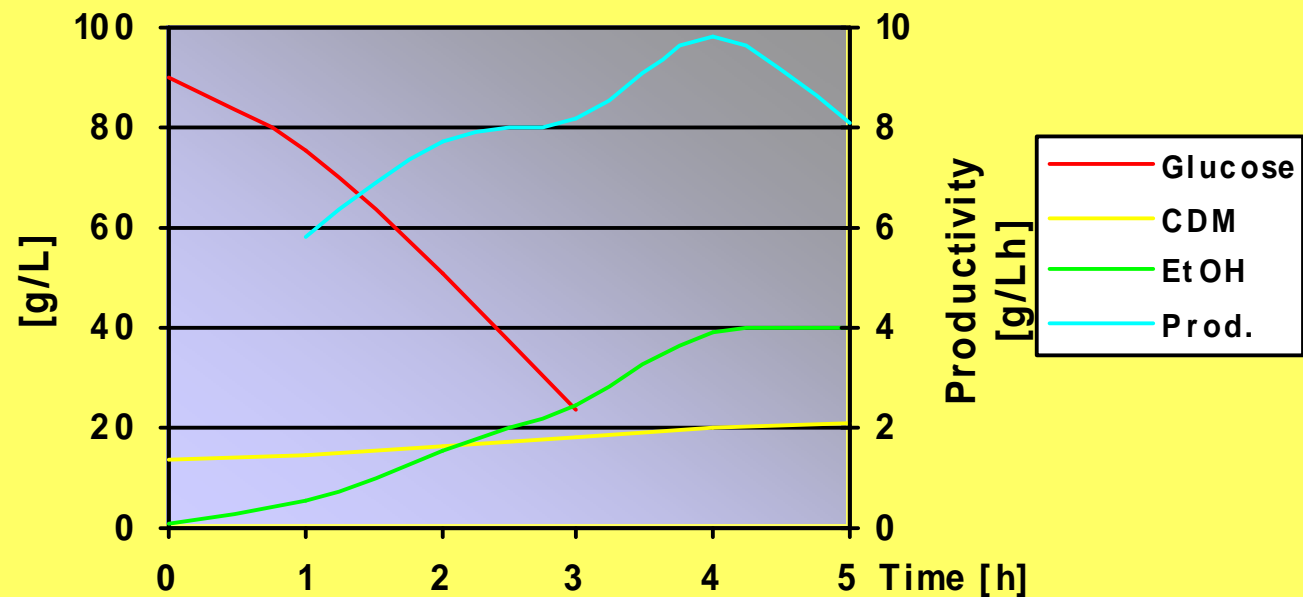
Temperature 30 °C

pH 4.0

Glucose 90 kg/m³

PPL 5 %

Sacch. uvarum



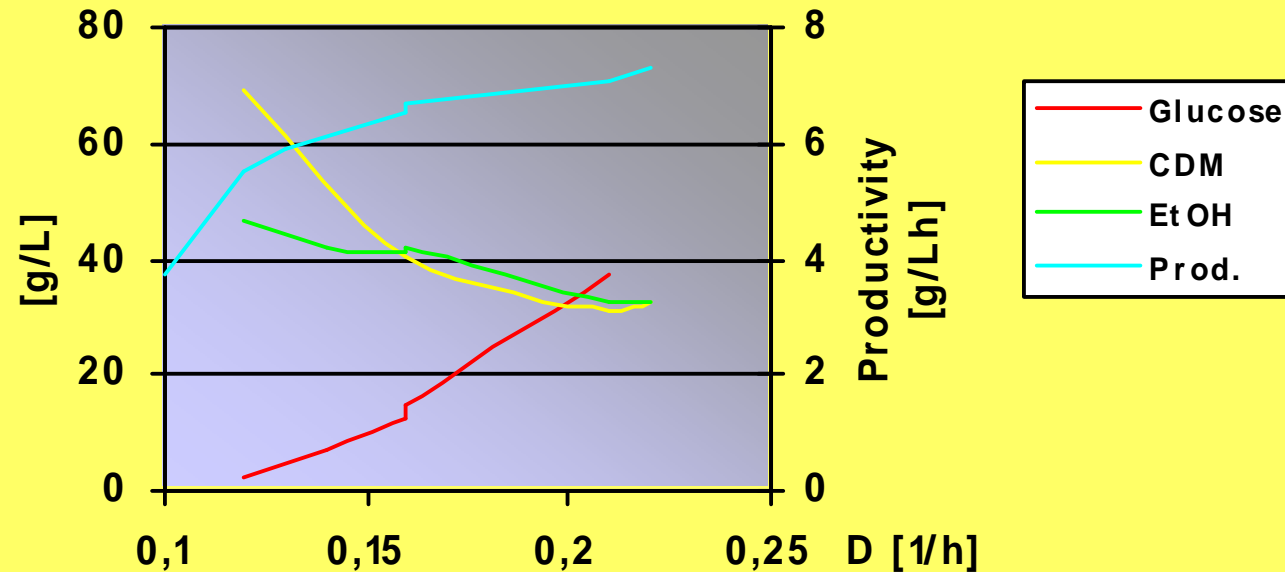
- ∅ Aerobe fermentation for a high CDM before the anaerobe fermentation
- ∅ Maximal CDM 20 kg/m³, max. EtOH concentration 40 kg/m³
- ∅ Productivity 9.8 kg/m³h
- ∅ No inhibition through PPL/PFJ can be detected
- ∅ Only little degradation of COD

Continuous Ethanol-Production



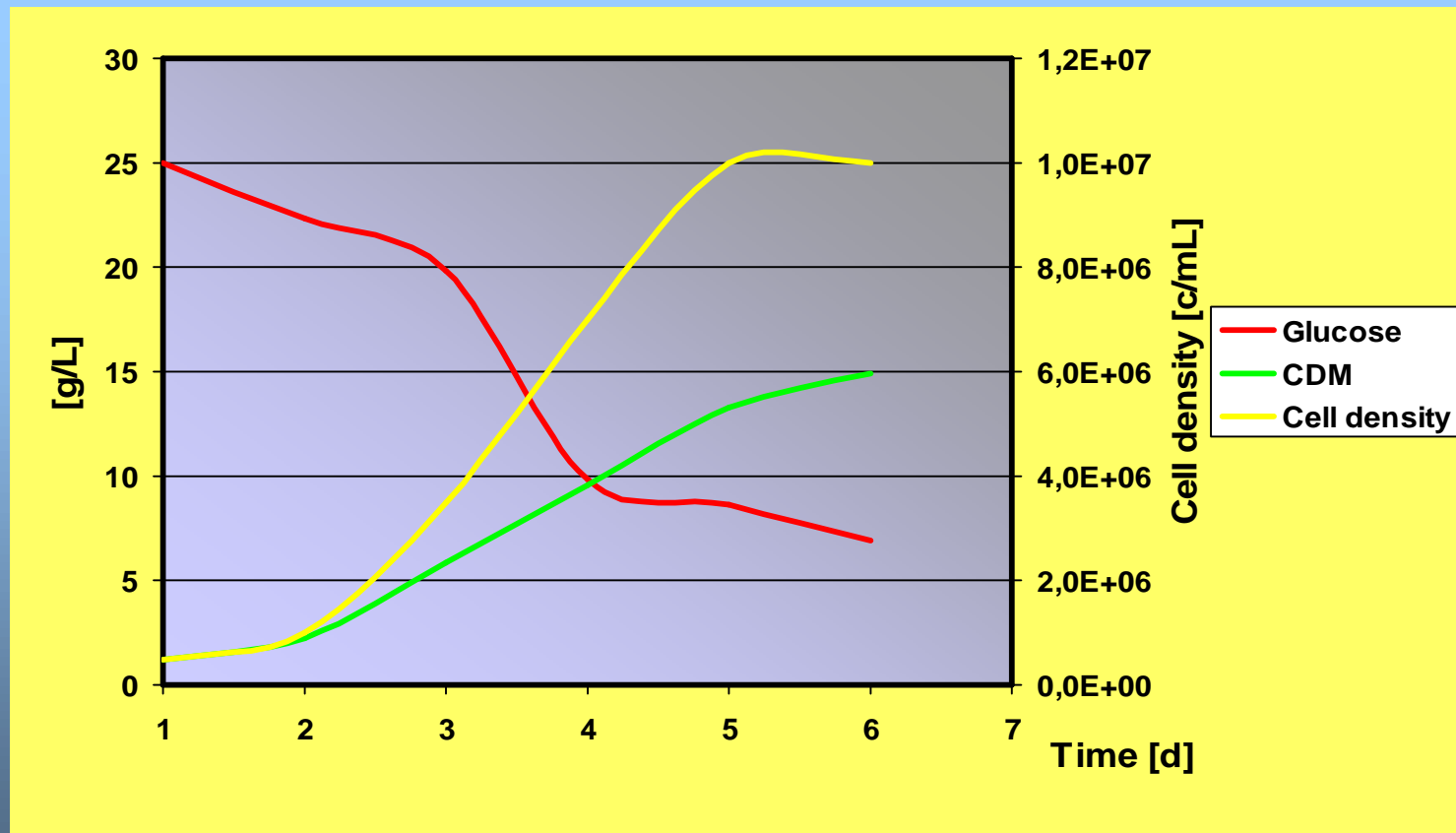
Bubble column with outer loop

Gross vol. 4,500 L
Net vol. 3,000 L
Temperature 30 °C
pH 4,0
Glucose 100 kg/m³
PPL 5 %
Sacch. uvarum



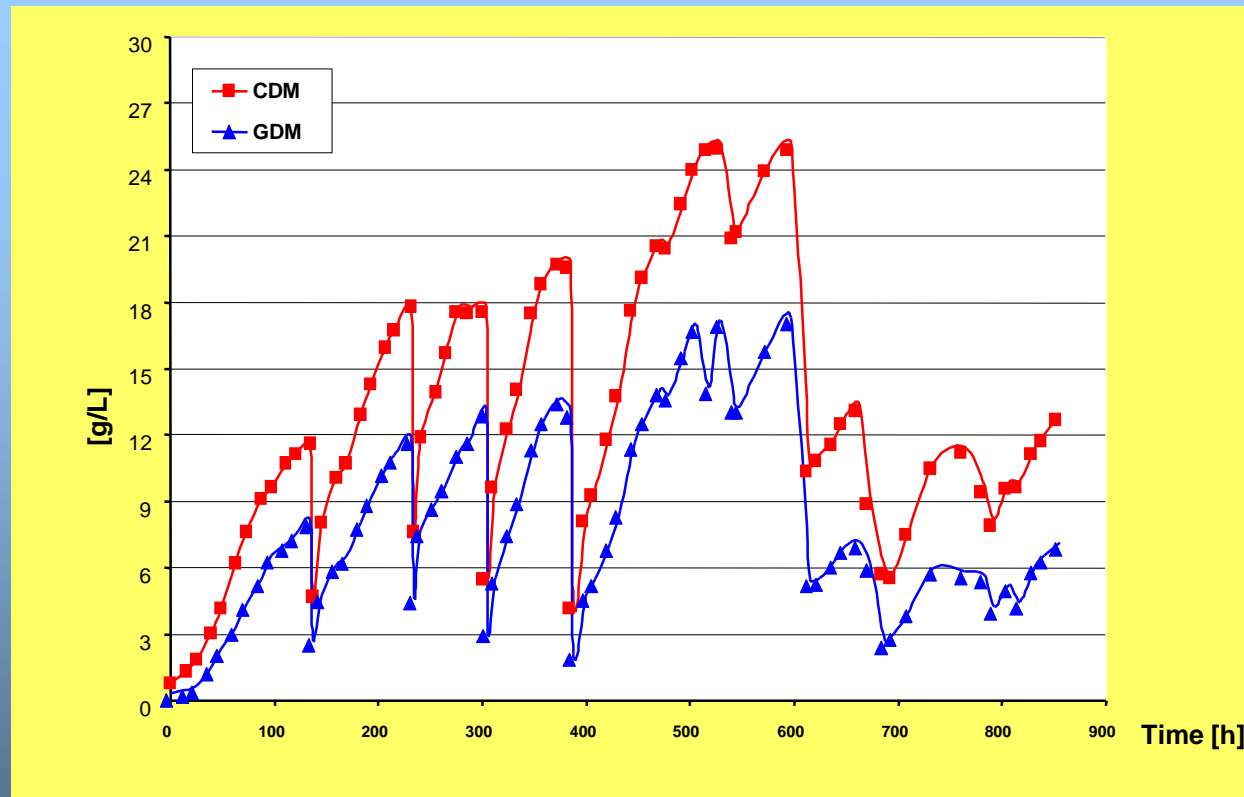
- Ø Maximal CDM 70 kg/m³
- Ø Maximal ethanol concentration 46 kg/m³
- Ø Maximal productivity at diluting rate $D_c = 0.22$ 1/h
- Ø Productivity without flocculating agent for sedimentation 4 kg/m³h
- Ø Productivity with flocculating agent 7.3 kg/m³h, (laboratory 15.6 kg/m³h)

β -1,3-Glucan Fermentation with PFJ



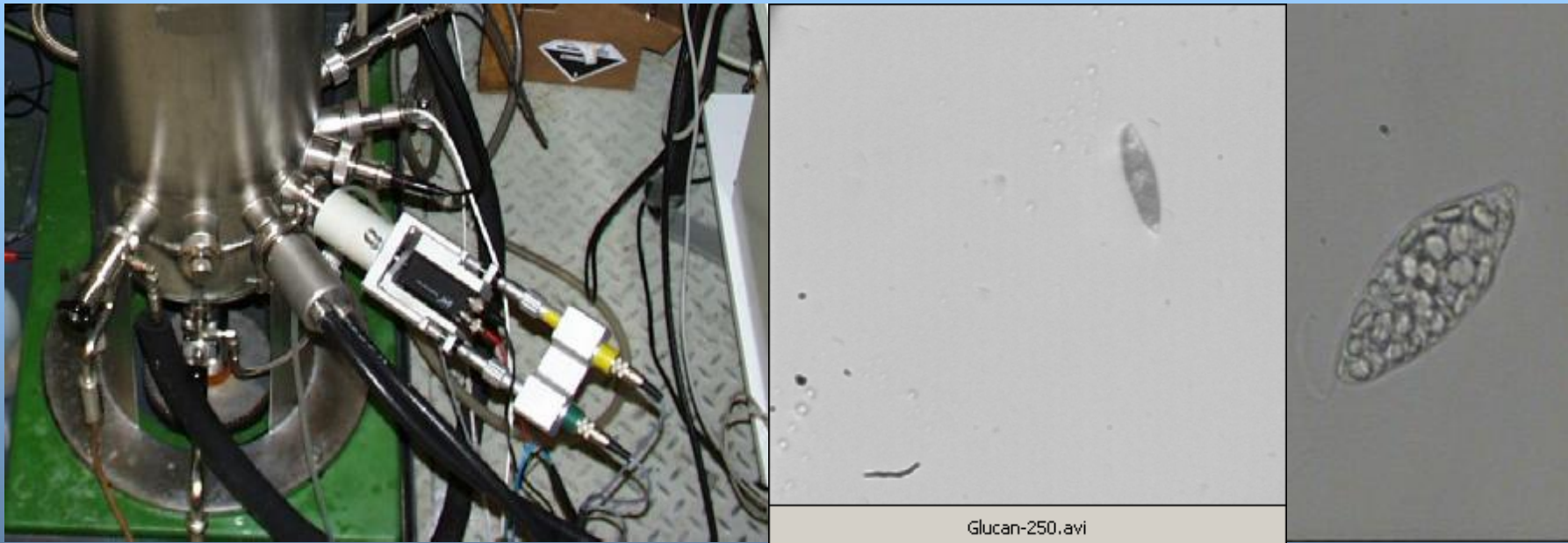
Compared to growth in synthetic culture medium in PFJ fermentation needs more time. But the resulting cell masses are nearly equal.

Repeated Batch Fermentation



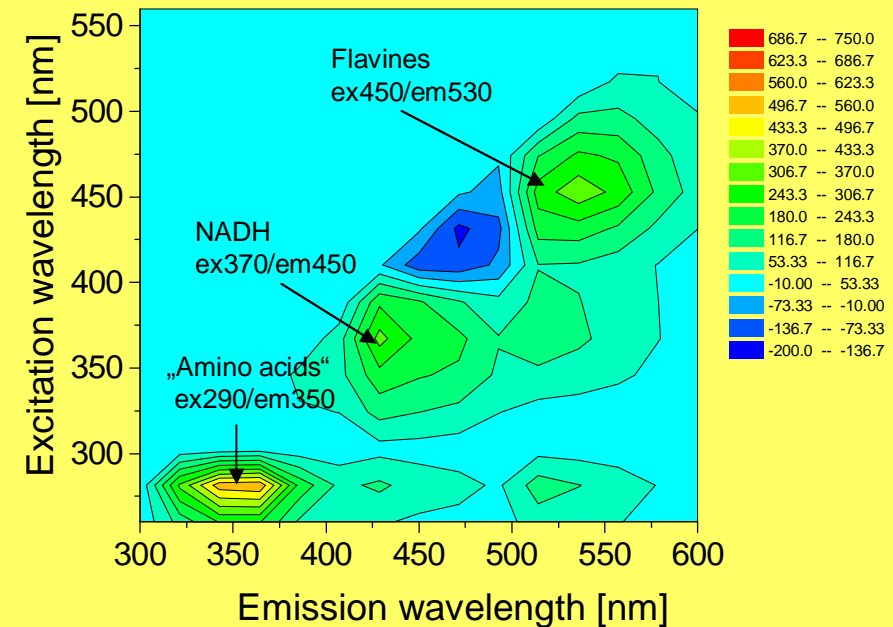
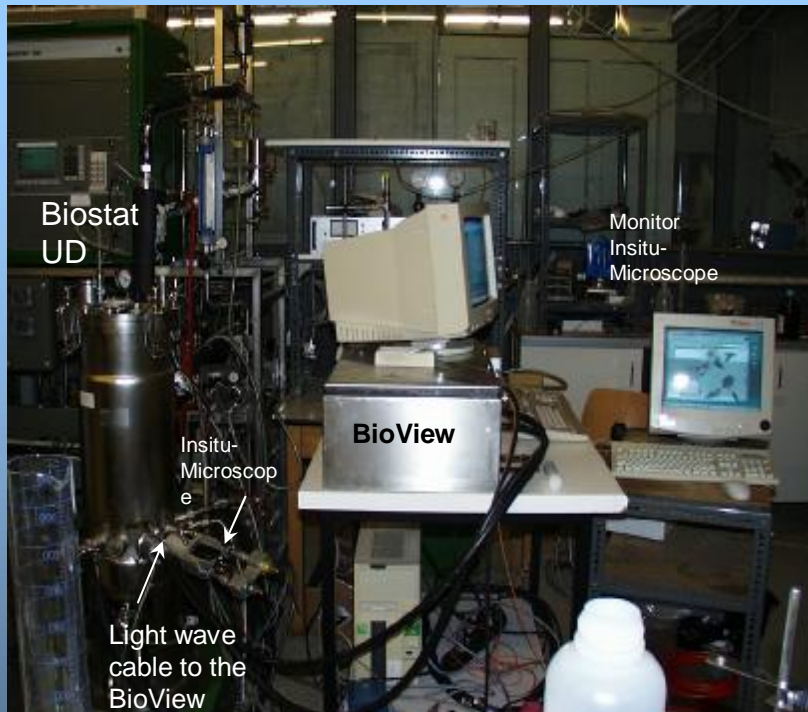
Repeated batch culture was tested in a 30 L scale as an intermediate step from batch culture to continuous fermentation. During a fermentation time of more than 4 weeks β -1,3-glucan could be harvested with a productivity of 4 kg/m³d.

Online Monitoring: Insitu-Microscope



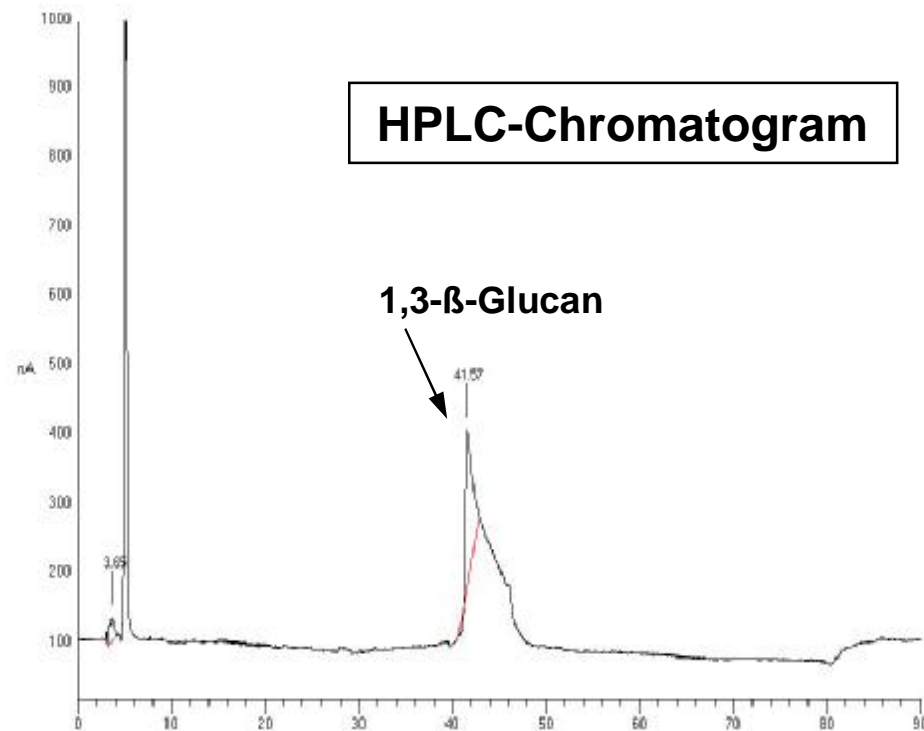
The curves of growth show that CDM and yield of glucan decrease when the fermentation time is too long. Therefore an optimal process needs an online monitoring. With the insitu-microscope cell density can be monitored safely. Also infections can be recognized online on a low level and at an early time

Online Monitoring: 2 D-Fluorescence



With the online recording of 2 dimensional fluorescence spectres with the **Bioview** the metabolism of the cell culture can be monitored. With the difference spectre the state of the culture can be judged and the optimal harvest time can be recognized.

Analysis of β -1,3-Glucan



β -1,3-Glucan

Moisture	14 %
N-content	0.01 %
P-content	n.d.
Ashes	0.10 %
Fat	0.03 %
Whiteness	95.8 %
pH-value	7.6
El. conductivity	50 μ S/cm
Bulk density	570 g/L
TVC	$2.8 \cdot 10^6$ g
Yeast + moulds	50/g

Principles of Getting Potato Protein from PFJ



- ∅ Heat treatment, e.g. steam injection at the i.e.p.
- ∅ Precipitation by setting the pH-value on an acid level
- ∅ Precipitation by solvents
- ∅ Precipitation by adding salts (salting out)
- ∅ Membrane techniques (MF, UF, NF, RO)
- ∅ Combinations of all these techniques

Heat Precipitated Potato Protein



Heat Precipitated Potato Protein	
Moisture	6 – 7 %
Protein (N*6.25)	> 85 %
Ashes	< 2 %
Fat	< 0.5 %
Whiteness	> 65 %
pH-value	5 - 6
Glycoalkaloids	< 1,000 ppm
TVC	< 50,000/g
Yeast + moulds	< 100/g
Water binding Capacity	> 1 : 4
Emulsifying Capacity	> 1 : 4 : 10



Heat precipitated potato protein is bright yellowish coloured, has a high water binding capacity and good emulsifying properties. Its nutritional value is very high due to its amino acid composition.

Membrane Filtration of PFJ for Protein



Experimental figures

Ultrafiltration membrane

50 kDa Cut off

Temperature 30 °C

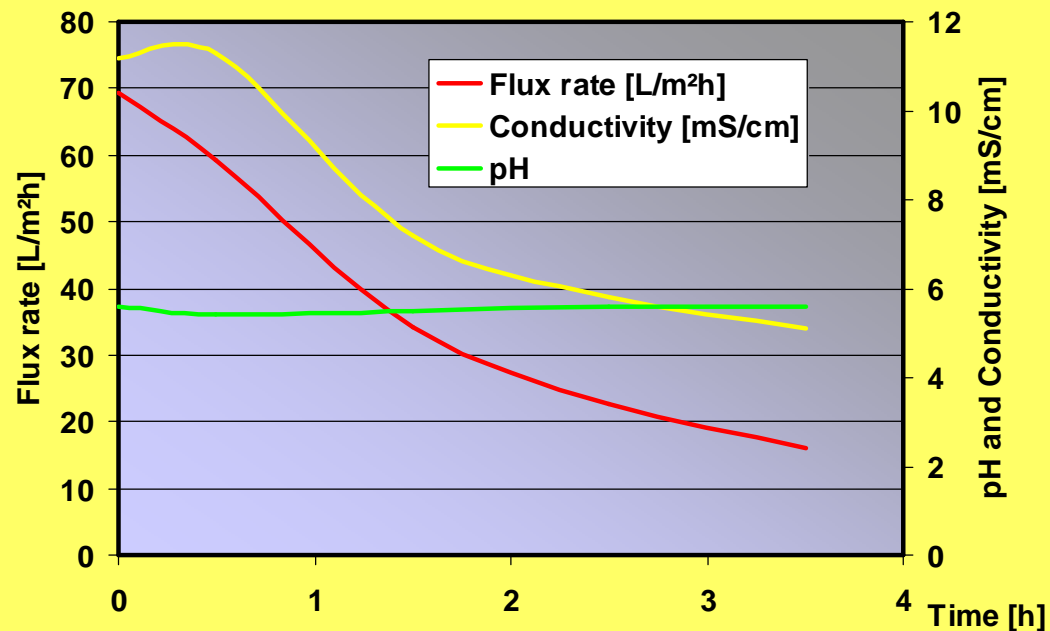
Pressure 6 bar

Diafiltration 1 : 1

Concentration 1 : 6

DM at start 4 %

DM at end 12 %

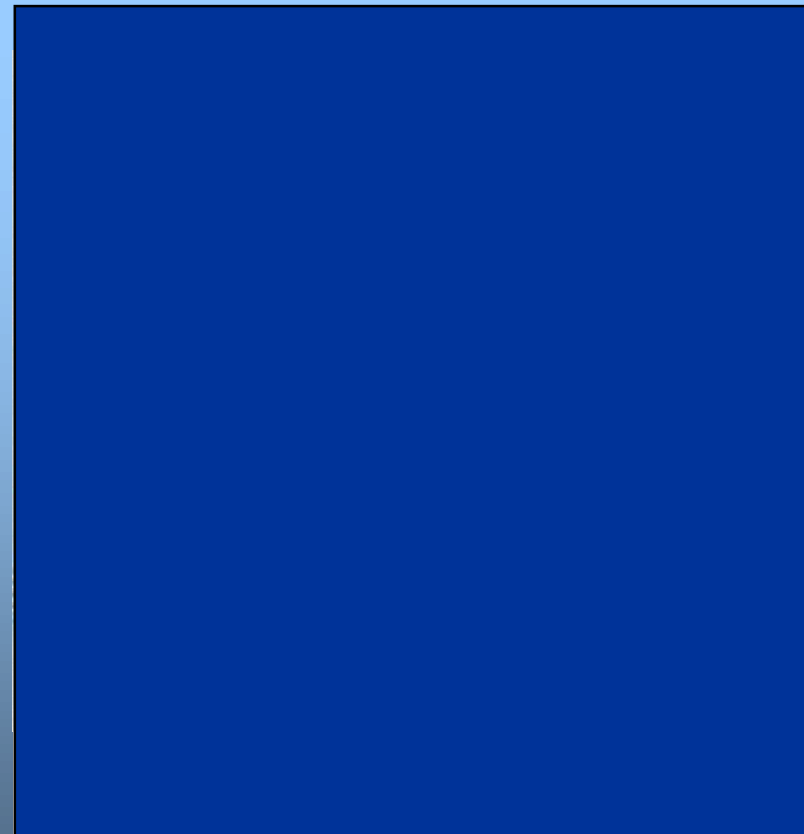


During ultrafiltration concentration and diafiltration were carried out simultaneously. Tap water was added in 3 portions. The flux rate decreases from 70 to 15 L/m²h. The resulted dry matter is too low for a commercial spray drying process.

Potato Protein from Membrane Filtration



Potato Protein from Ultrafiltration	
Moisture	6 – 7 %
Protein (N*6.25)	> 70 %
Ashes	< 7 %
Fat	< 0.5 %
Whiteness	> 58 %
pH-value	5 - 6
Glycoalkaloids	< 1,000 ppm
TVC	< 100,000/g
Yeast + moulds	< 200/g
Solubility	> 80 %
Emulsifying Capacity	> 400 mL oil/g
Foam activity	> 1,700 %
Foam stability	> 90 %



Despite the membrane-cut off of 50 kDa also low molecular proteins down to 6 kDa molecule size retain in the retentate and can be found in the protein. A possible explanation is that the secondary layer on the membrane determines the real cut off.

Further Investigations on Potato Protein



- ∅ Minimization of glycoalkaloids
- ∅ Test of the activity of the anti-nutritional components
- ∅ Stabilise the processes on bright coloured products
- ∅ Optimizing soluble potato proteins:
protein content, colour, neutral taste, micros
- ∅ Optimisation and long time tests of the membrane processes:
flux rate stability, diafiltration, cleaning procedure etc.
- ∅ Combination and scale up of the different protein processes for
an acceptable overall yield of protein in food grade quality