

# Pilot plant for the utilization of agricultural starchy raw materials

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**Biorefinica 2009**

**International Symposium Biobased Products and Biorefineries**

January 27 and 28, 2009, Osnabrück

# ➤ Bioconversion technologies for the production of industrial raw materials

## Biorefineries: factories of the future

Faced by global warming and limited fossil resources, and thanks to the development of new biological processes, the use of renewable materials becomes an attractive alternative as feedstock for producing fuels, materials and chemicals.

## Renewable resources and bioprocesses ...

... for a sustainable industrial production



# Top Value Added Chemicals from Biomass

## Volume I — Results of Screening for Potential Candidates from Sugars and Synthesis Gas

August 2004

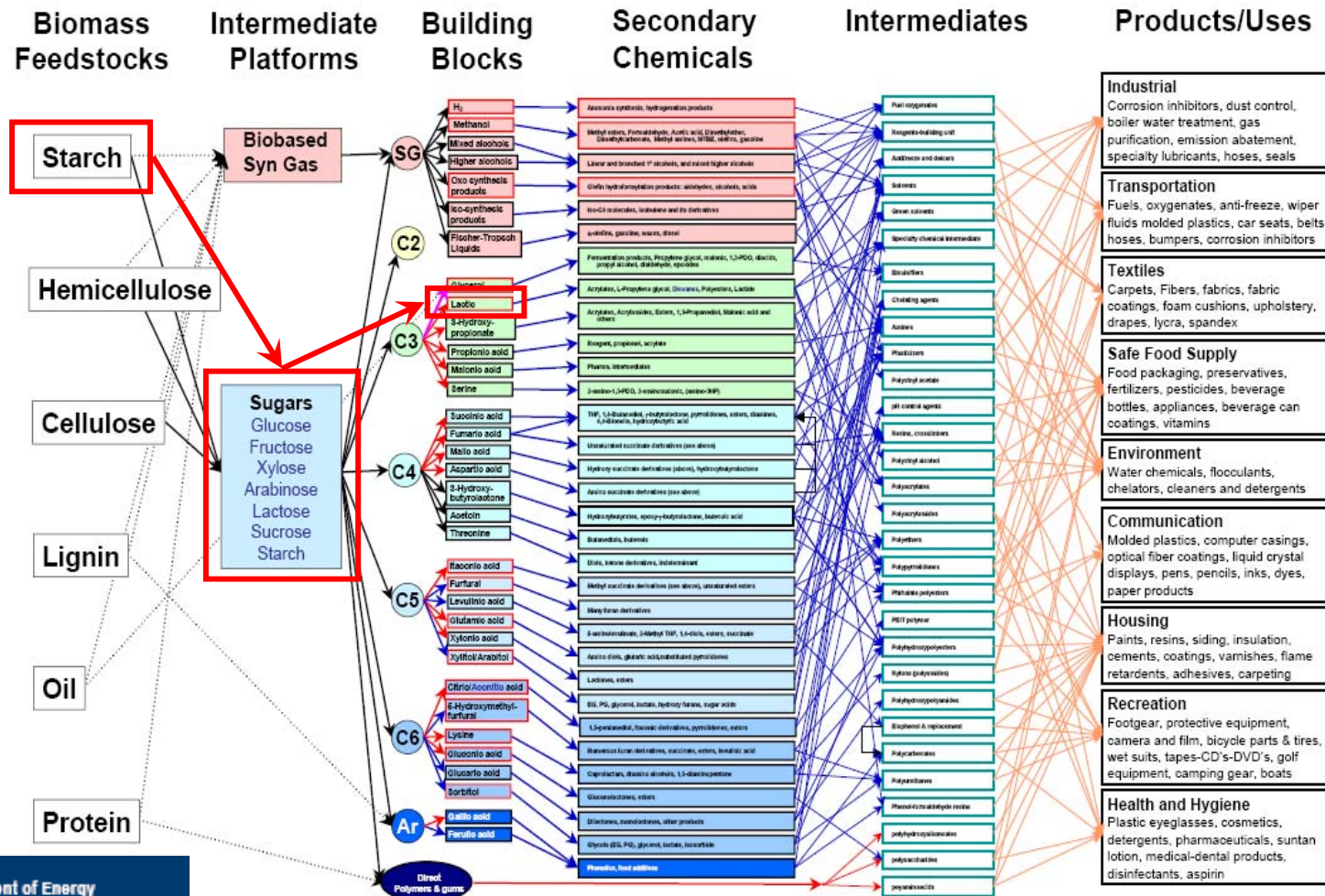
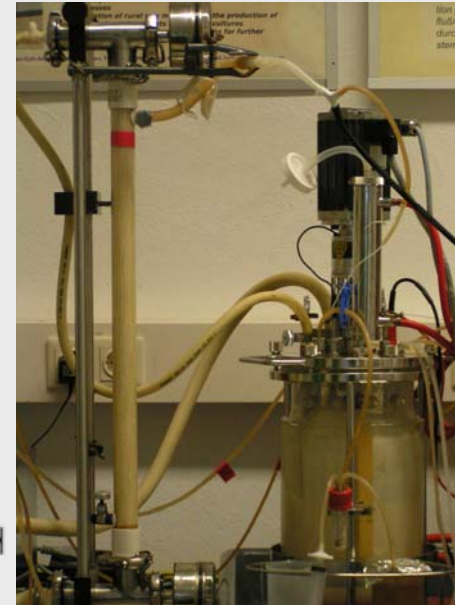
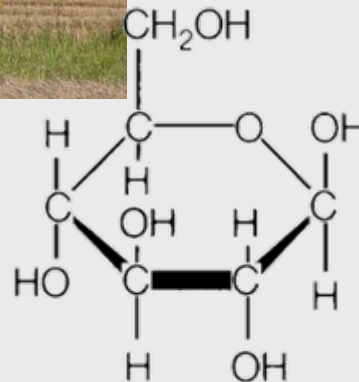


Figure 3 – Analogous Model of a Biobased Product Flow-chart for Biomass Feedstocks

# New biorefinery-concept for starch-containing crops and green biomass

## - BIOCONVERSION -



# Production figures and prices for fermentation products



Royal Belgian Academy Council  
of Applied Science

INDUSTRIAL BIOTECHNOLOGY AND  
SUSTAINABLE CHEMISTRY

January 2004



Koninklijke Vlaamse Academie van België  
voor Wetenschappen en Kunsten  
Paleis der Academiën  
Hertogsstraat 1, 1000 Brussel



Académie royale des Sciences, des Lettres et des  
Beaux-Arts de Belgique  
Palais des Académies  
Rue Ducale 1, 1000 Bruxelles

	World production (ton/year)	World market price (€/kg)
Bio-ethanol	26.000.000	0,40
L-Glutamic acid (MSG)	1.000.000	1,50
Citric acid	1.000.000	0,80
L-Lysine	350.000	2,00
<b>Lactic acid</b>	<b>250.000</b>	<b>2,00</b>
Vitamin C	80.000	8,00
Gluconic acid	50.000	1,50
Antibiotics (bulk products)	30.000	150,00
Xanthan	20.000	8,00
L-Hydroxyphenylalanine	10.000	10,00
Antibiotics (specialities)	5.000	1.500,00
Dextran	200	80,00
Vitamin B12	10	25.000,00

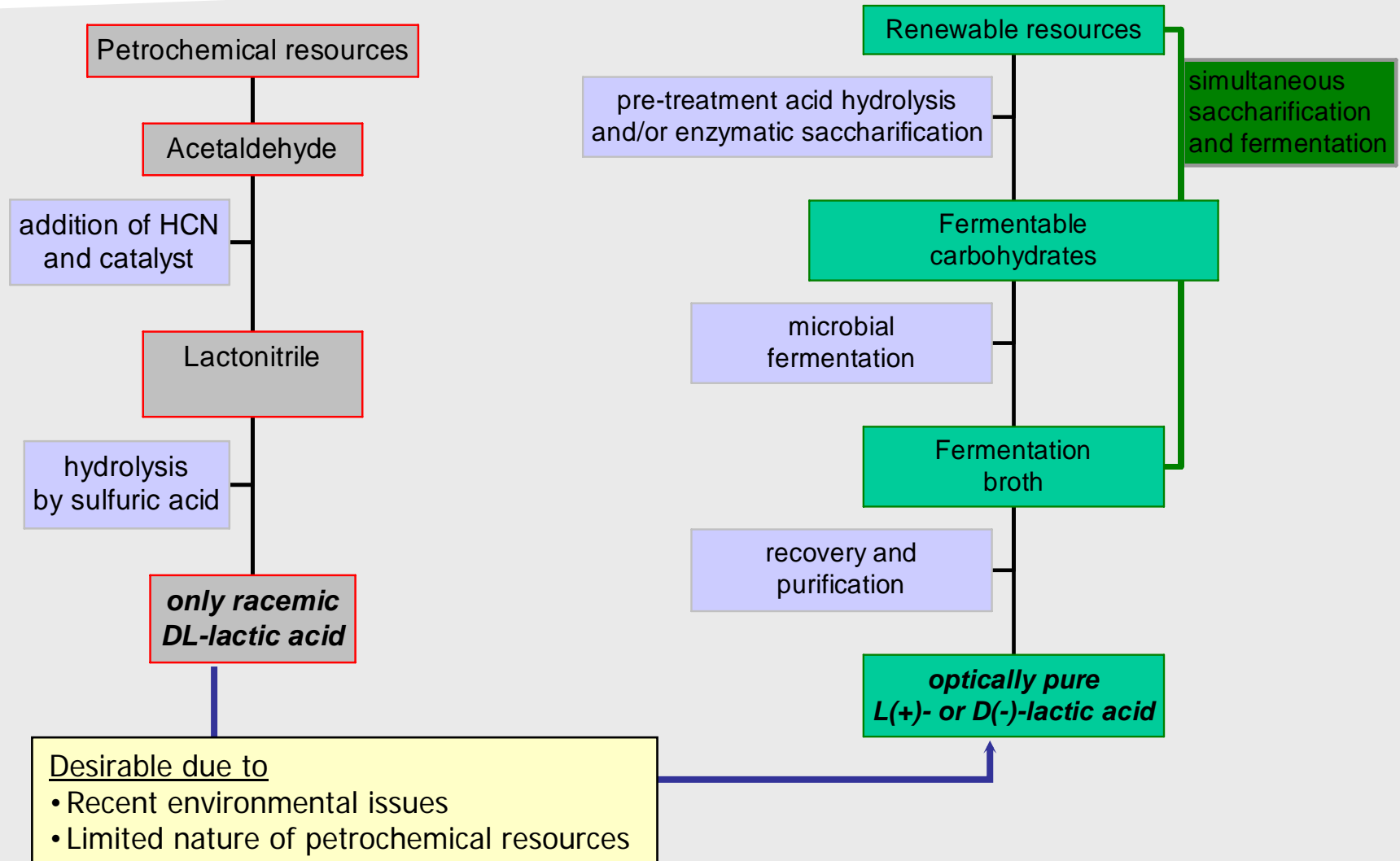
# Occurrence and application of lactic acid

Lactic acid (2-hydroxypropanoic acid),  $\text{CH}_3\text{-CHOH-COOH}$  [CAS 50-21-5], is the most widely occurring hydroxycarboxylic acid present in many foods both naturally or as a product of microbial fermentation (e.g. sauerkraut, yogurt, buttermilk, sourdough breads) and many other fermented foods

## Main fields of application

- Traditionally, food and food-related applications: acidulant, flavoring, pH buffering agent, inhibitor of bacterial spoilage, emulsifying agents particularly for bakery goods...
- **Non-food:**
  - **textile and leather auxiliary, mordant, cleaning agent, disinfectant, pH adjustment of hardening baths...**
  - **Lactic acid and ethyl lactate [CAS 97-64-3] have long been used in pharmaceutical and cosmetic applications and formulations (topical ointments, lotions, anti acne solutions, humectants, parenteral solutions and dialysis applications, anti carries agent...)**
  - **chemical industry (raw material for the production of lactate ester, propylene glycol, 2,3-pentanedione, propanoic acid, acrylic acid, acetaldehyde, dilactide, biodegradable polymers...)**

# Overview of the two manufacturing methods of lactic acid



[WEE et al., 2006]

# COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

on the mid term review of the Strategy on Life Sciences and Biotechnology

## Summary of recommendations from the contact network

- ...
- Support the setting up of **demonstration/pilot projects** and **integrated bio-refineries**, which are flexible installations **at pilot** or industrial **scale** for the production of biofuels and other biomaterials, based on a variety of feedstock. Giving support to demonstration projects is important since **SMEs** active in this area do not have the resources to set up a real proof-of-concept. It would also help to test logistical solutions and form value chain coalitions between actors
- ...

Universities, Research Institutes, SMEs  
Applied & basic research

Industry  
Industrial application  
Large-scale production

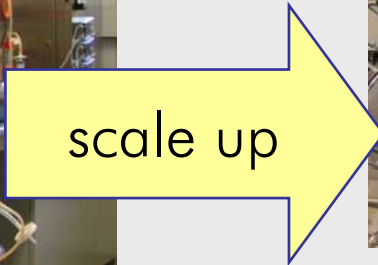


# Pilot plant facility

- swift transfer of new biotechnological processes into practice often fails due to the lack of a reference facility that can be used for multiple applications
- pilot facility for production of lactic acid at the ATB consequently fills a gap in the various phases of bioprocess engineering
- provision of product samples is intended to open up the possibility of interesting partners in industry with specific product requirements in the various applications



BIOSTAT® Bplus (Sartorius BBI Systems GmbH, Germany) equipped with a digital control unit DCU for the continuous fermentation with cell recycling

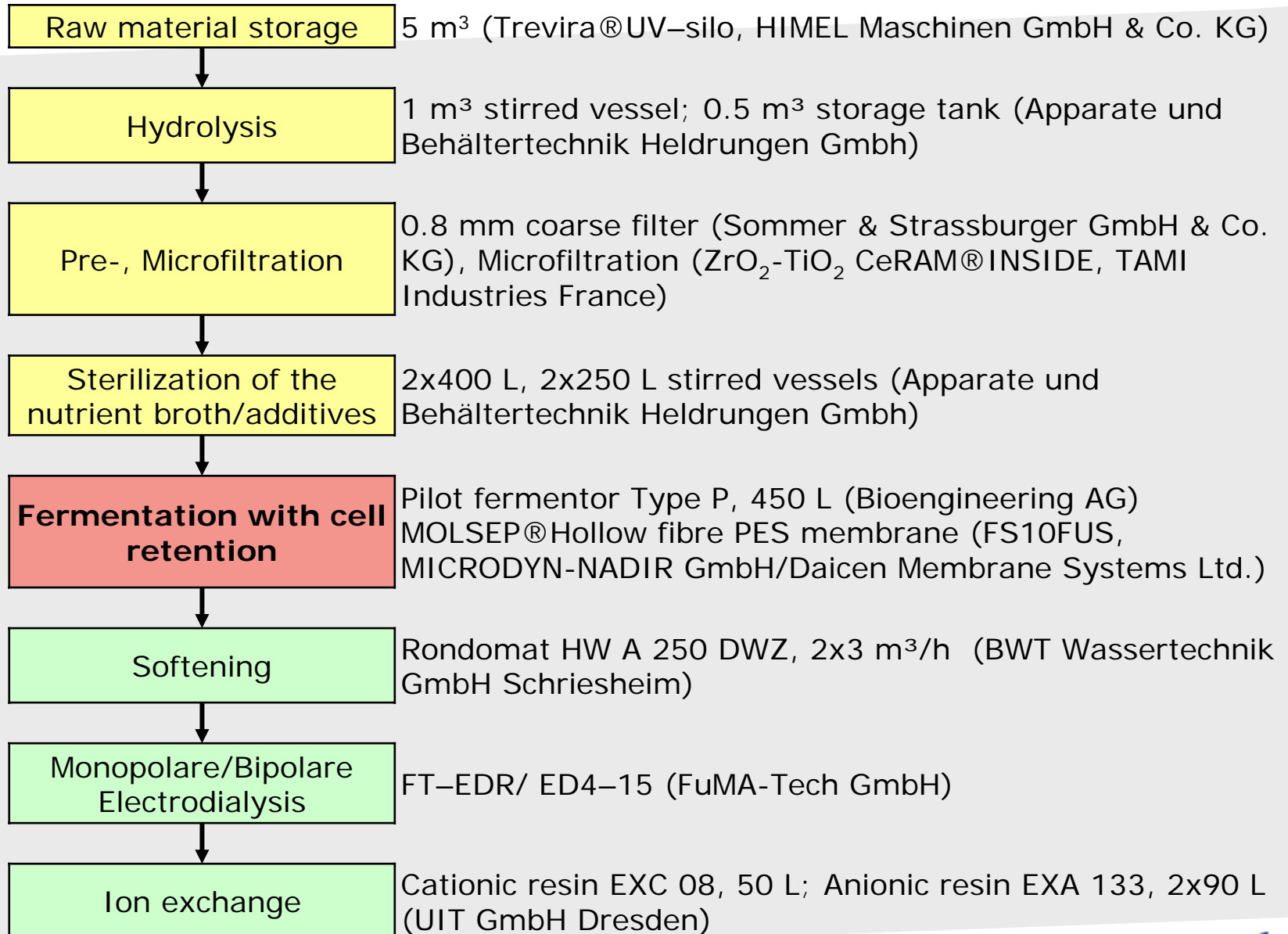


Pilot fermentor Type P, 450 L (Bioengineering AG)



Venus, J.; Richter, K.: Eng. Life Sci. 2007, 7, No. 4, 395-402

# Process steps for the manufacture of lactic acid



# Bioconversion of renewables

## feedstock

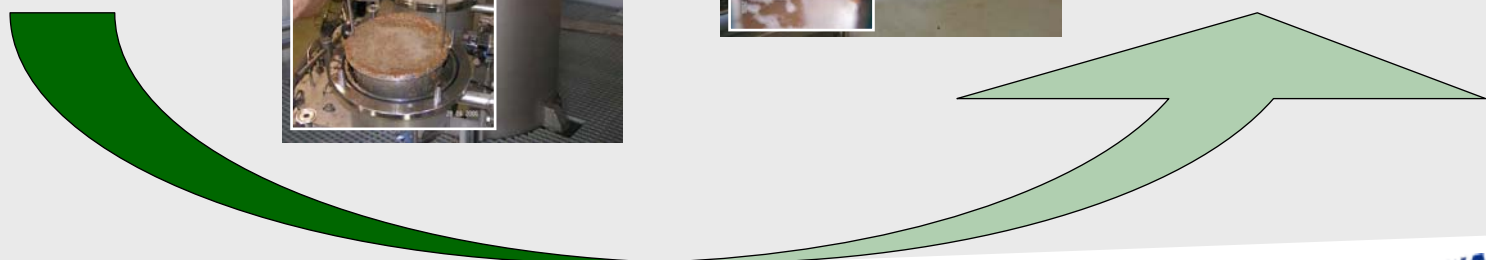
cereals (e.g. rye),  
wholemeal  
green biomass

## pretreatment bioconversion

cereal's hydrolyzate  
press juice  
fermentation, down-stream

## products

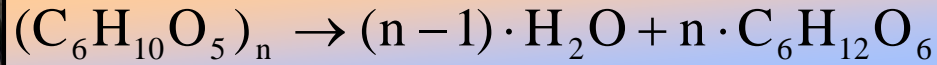
(raw)lactate, lactic acid,  
biomass...  
...bioplastics



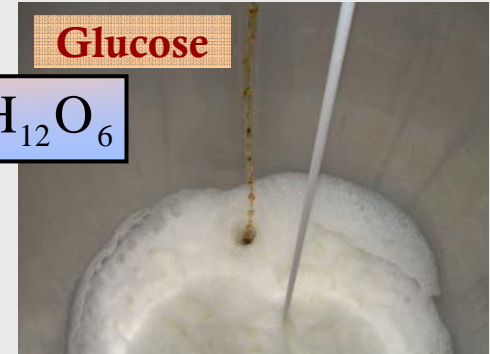
# Enzymatic grain/starch hydrolysis



**Hydrolysis (1 m<sup>3</sup>)**



**Separation of wholemeal particles**



**Glucose**

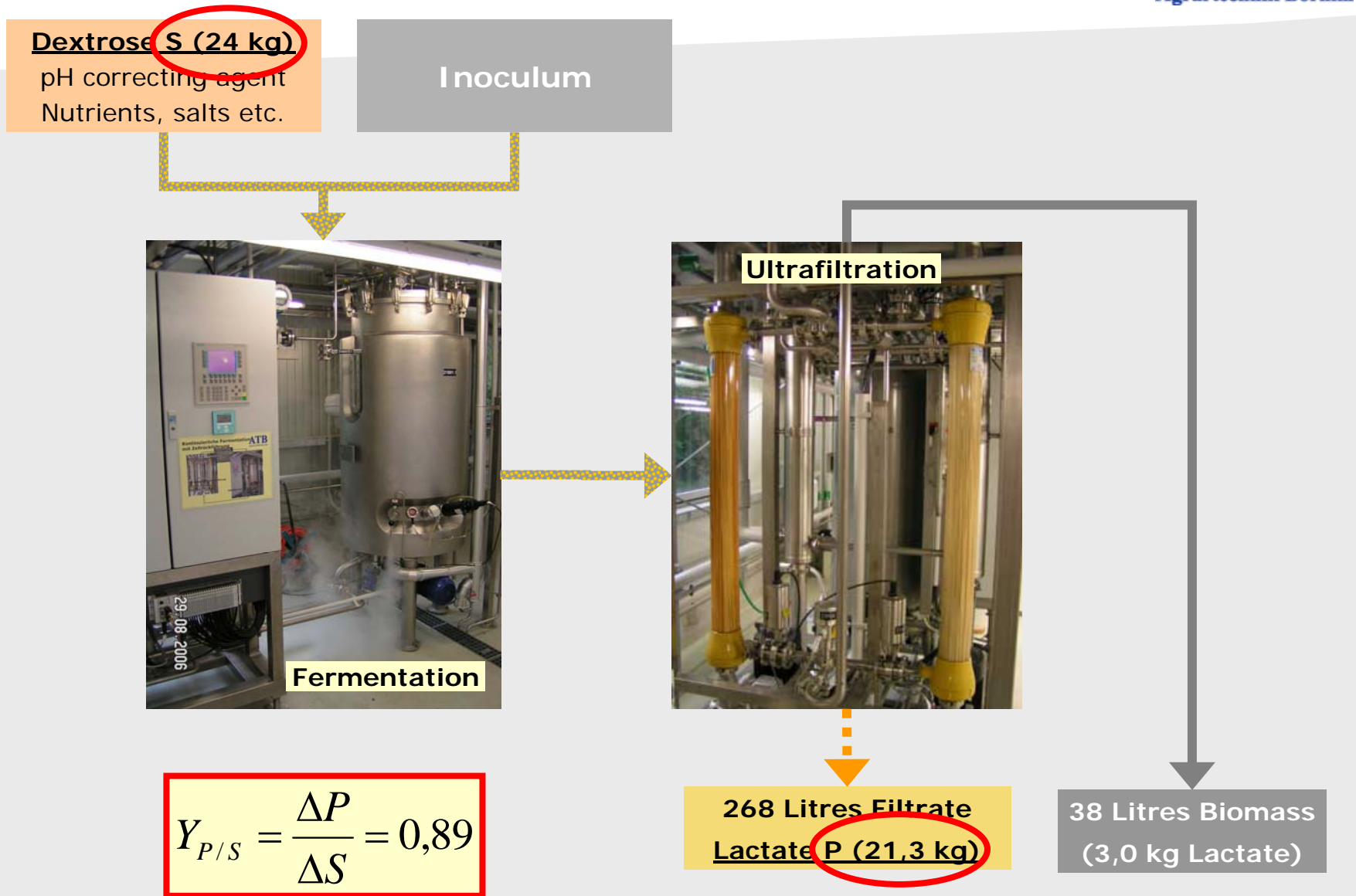


**Membrane filtration**

Hydrolyzate of Rye (081104)	DM [%]	NH <sub>4</sub> -N [mg/L]	N <sub>ges</sub> [g/L]	P <sub>ges</sub> [mg/L]	Glucose [g/L]
End of hydrolysis	16,5	22,9	3,103	711	103,9
After filtration <sup>#</sup>	13,5	29,3	1,547	589	101,2

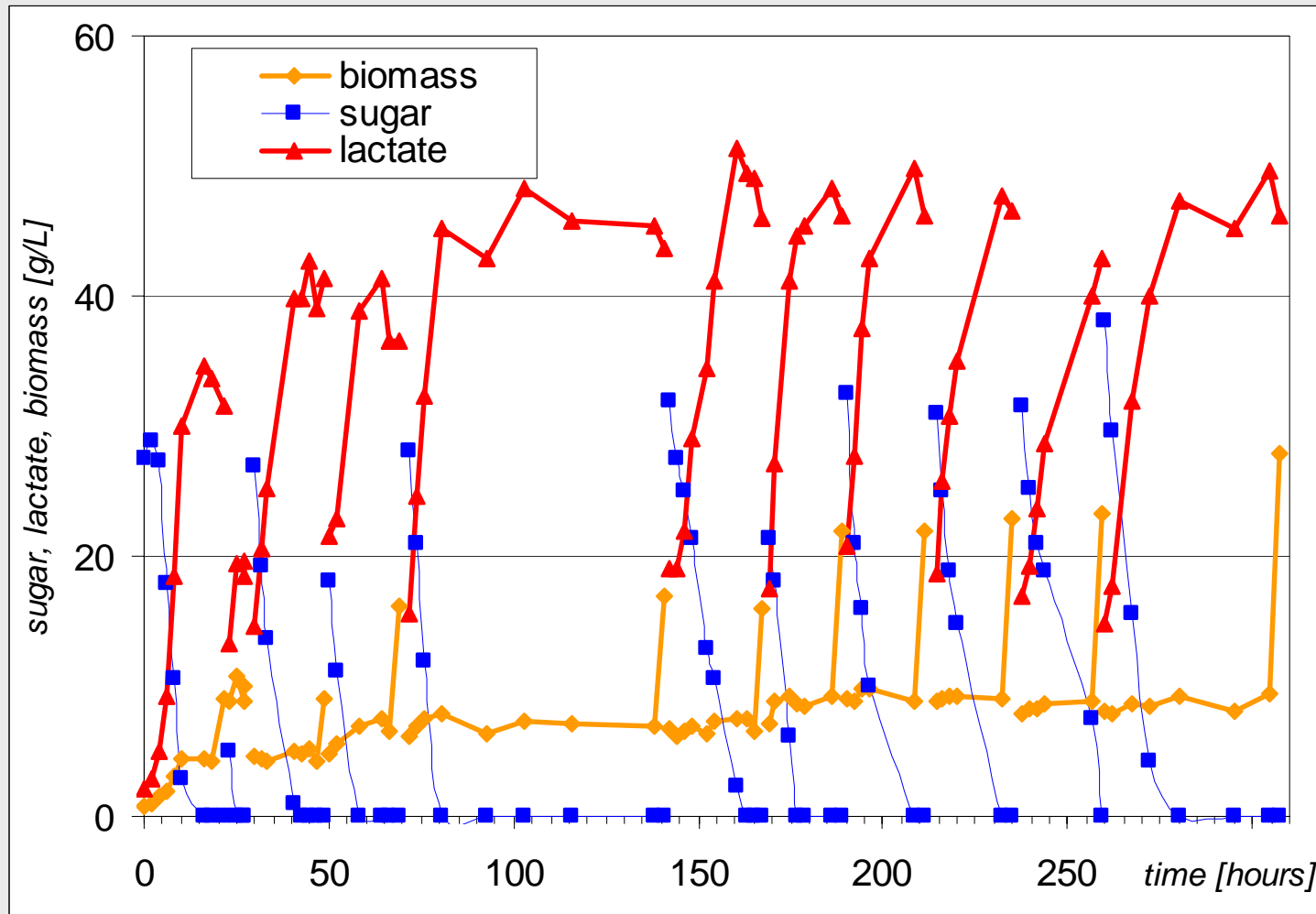
<sup>#</sup> Enrichment & purification of the hydrolyzate by coarse filtration & membrane separation processes

# Mass flow „fermentation unit“ (batch)



# Repeated batch cultivation

- *Lactobacillus paracasei*
- 40,5°C; pH 6,0
- Rye hydrolyzate with added nutrients

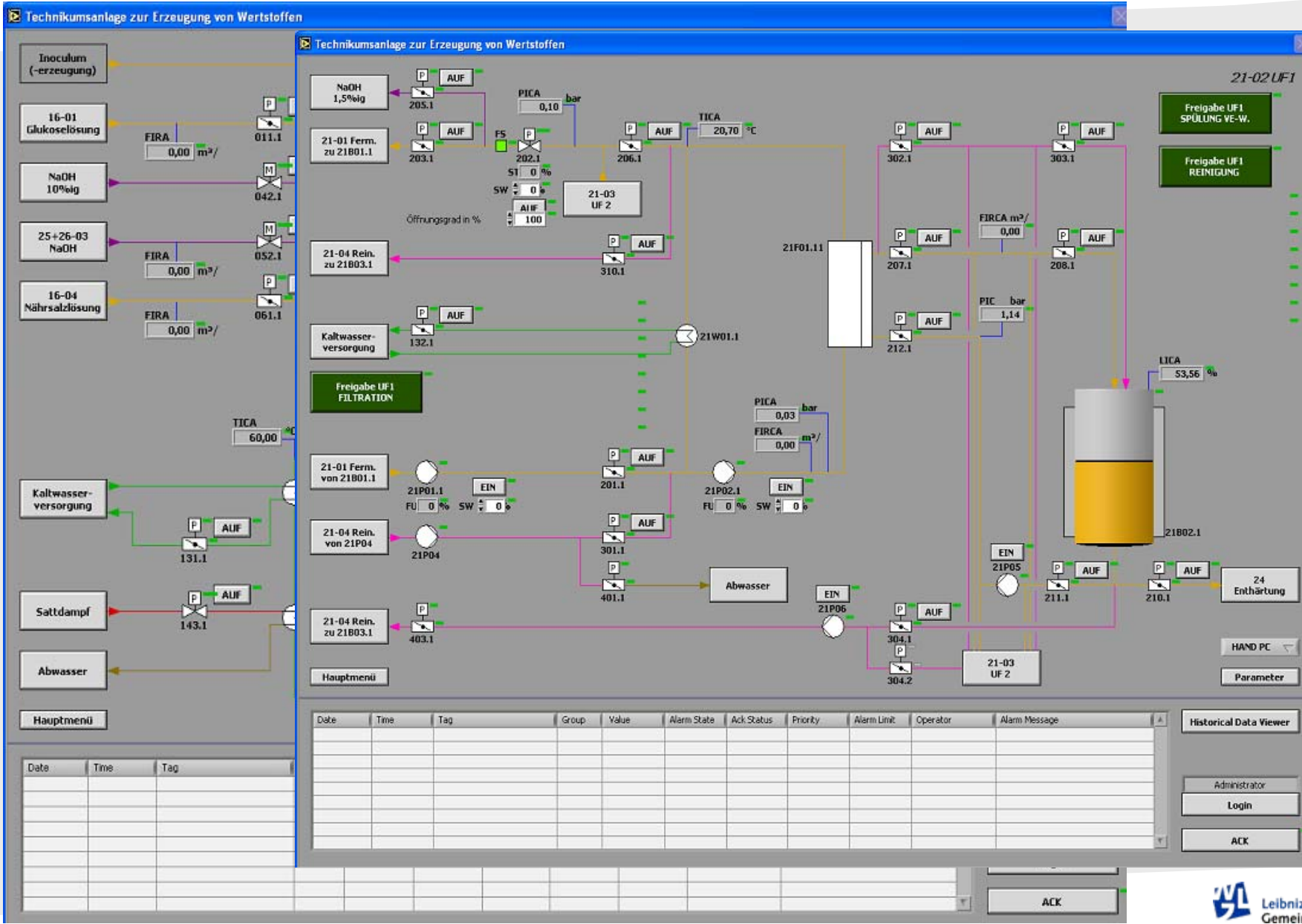


# New continuous fermentation process with cell retention



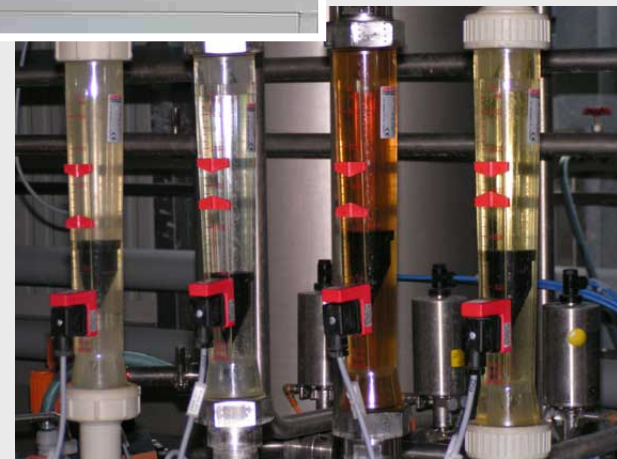
In the present case, a continuous operating mode is used, in which part of the biomass formed is retained in the system. The main portion of the fermented medium leaves the bioreactor as a cell-free filtrate through a membrane module, while a second process (containing biomass) is necessary to maintain a stable steady state. The principle of the fermentation mode is illustrated here.

# Screenshot of the flow chart „biomass separation“



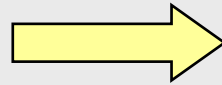


# Down-stream processing of raw lactates & lactic acid

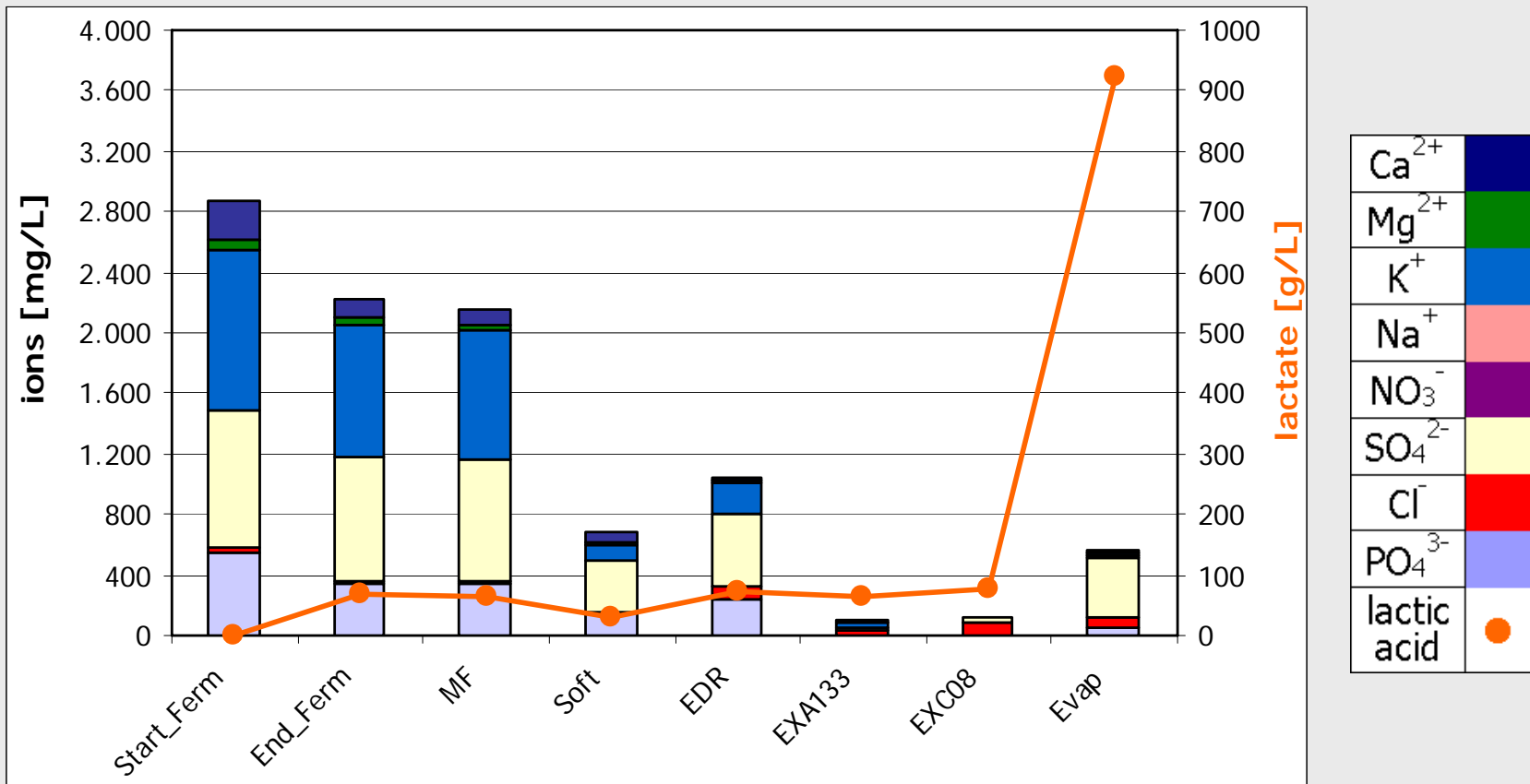


# Effect of several down-streaming steps on the purity of lactic acid

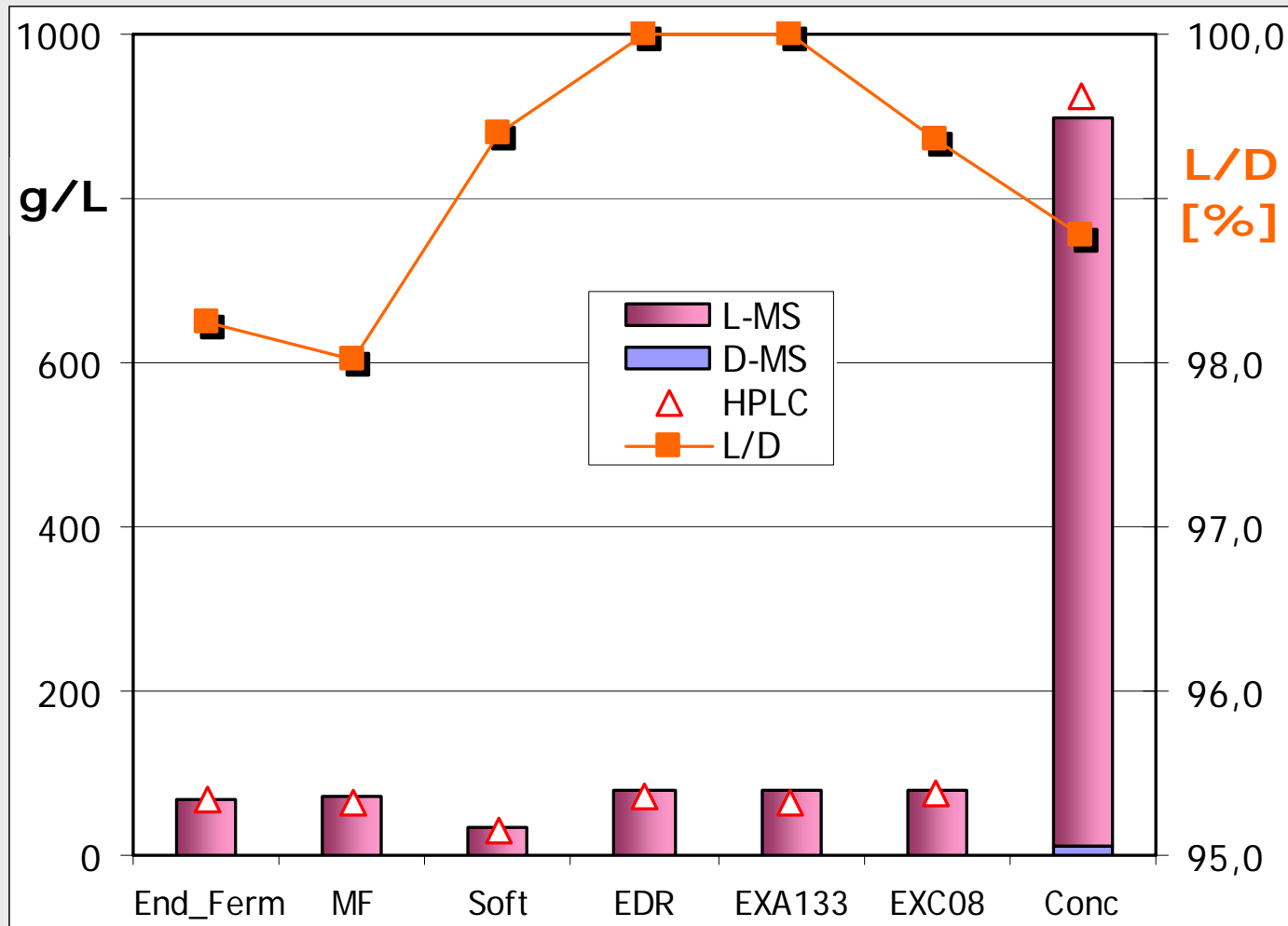
**Na-Lactate**  
(Fermentation)



**down-stream processing**  
(Filtration, Softening, Electrodialysis, Ion exchange, Decolorization, Evaporation)



# Dependency of the enantiopurity of lactic acid in the course of purification



## Key topics of the European biomass research

[EU action plan, Brussels, 7.12.2005 - COM(2005) 628 final]

The Commission's proposal for the 7th Framework Programme gives a high priority to biomass research:

... "Life sciences and **biotechnology** for sustainable non-food products and processes", including the use of **biotechnology** to improve the productivity, sustainability and composition of **biomass raw materials** and develop new **bio-processes**.

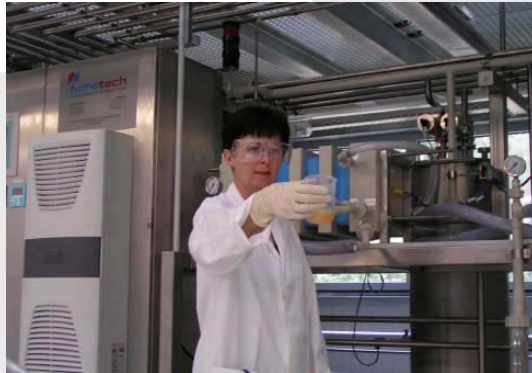
KBBE-2009-3-7-01: Sustainable Biorefineries  
Call: FP7-2009-BIOREFINERY

Development of advanced biorefineries for sustainable processing of biomass into building blocks for the production of bio-based chemicals, materials, second generation biofuels, power and heat. **The biorefineries shall demonstrate their performance, sustainability and feasibility at least at pilot scale** in an integrated approach.

With the support of:



Bundesministerium für  
Ernährung, Landwirtschaft  
und Verbraucherschutz



Thank you very  
much  
for your kind  
attention!

## Pilotanlage Milchsäure

DIESES PROJEKT WIRD VOM  
EUROPÄISCHEN FONDS FÜR REGIONALE  
ENTWICKLUNG KOFINANZIERT

