Welcome at ATB

Leibniz Institute for Agricultural Engineering and Bioeconomy

Monomers production for bioplastics: fermentation insights and scale-up possibilities

Agata Olszewska-Widdrat, PhD

Foto: Manuel Gutjahr

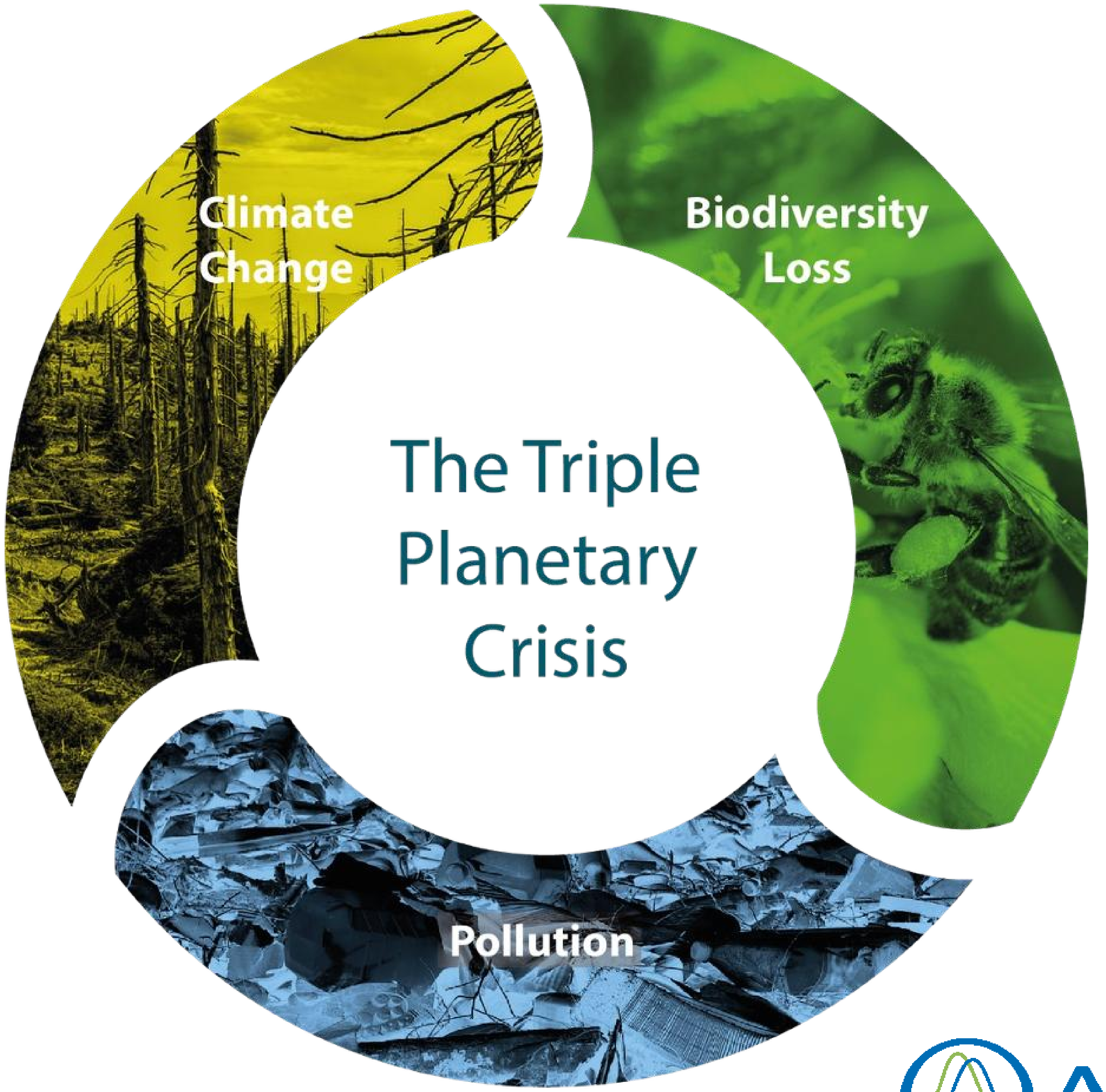
Agenda

- Introduction ATB
- Biorefinery concept
- Feedstock
- Bioconversion group
- Platform chemicals
- Lactic acid
- Succinic acid
- Conclusions

Pilot plant for platform chemicals production at ATB

Introduction to ATB
Our mission

We are a pioneer and driver of systemic-technological bioeconomy research.
We create the scientific foundation to transform agricultural, food, industrial and energy systems into a comprehensive bio-based circular economy.



Introduction to ATB
Ressources & Infrastrukture

- Approximately 290 employees, Interdisciplinary working groups
- Family-friendly human resources management

Zertifikat seit 2010
audit berufundfamilie

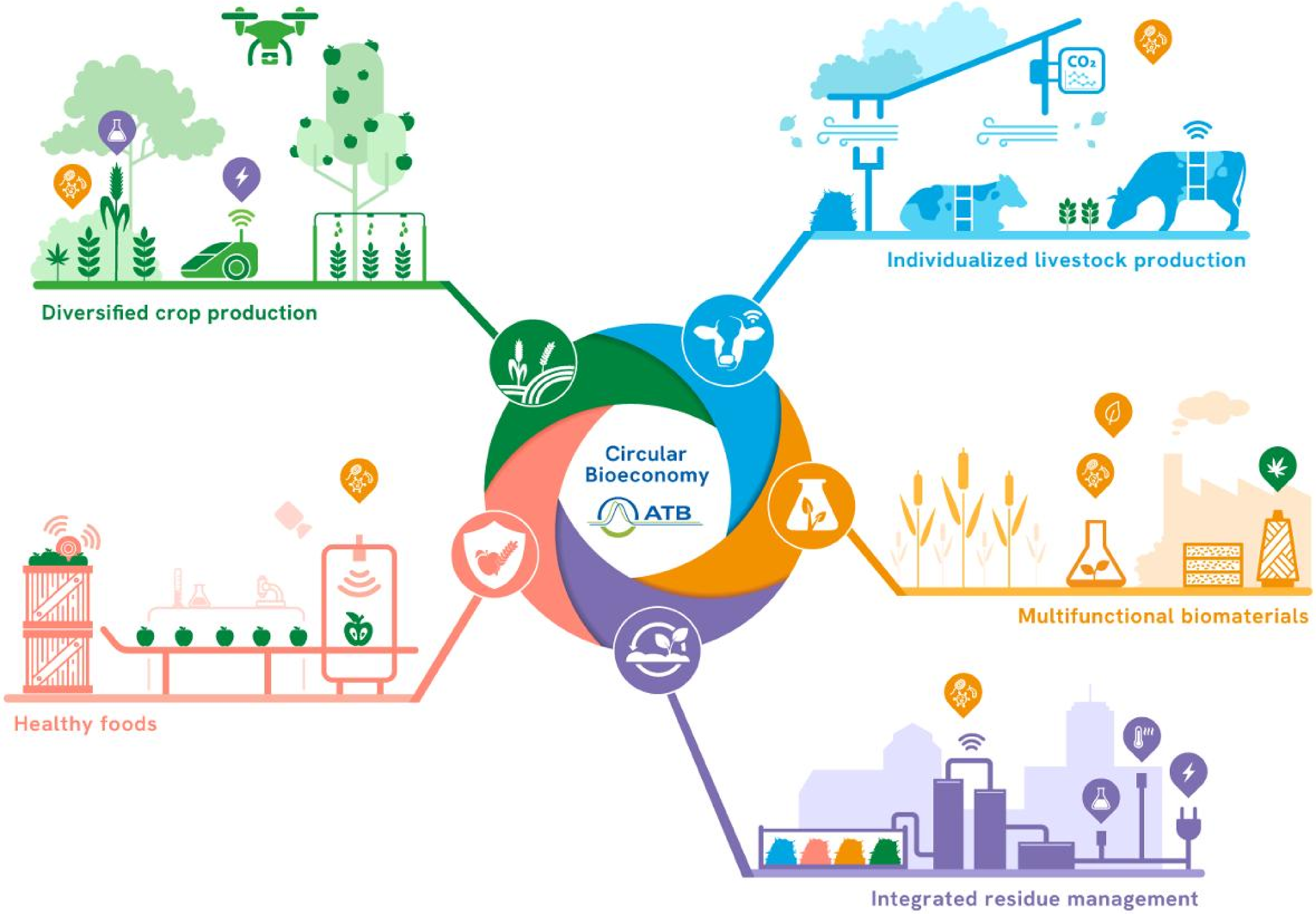
- Targeted support for early-career researchers

- Excellent scientific infrastructure (laboratories, pilot plants, experimental plots)
- Consistent scale-up

- Internationally networked
- Practical relevance through collaboration with agriculture and industry

- Institutional funding provided 50% each by the federal and state governments (total of 14.8 million euros in 2024)
- Additional third-party funding of approximately 10.3 million euros

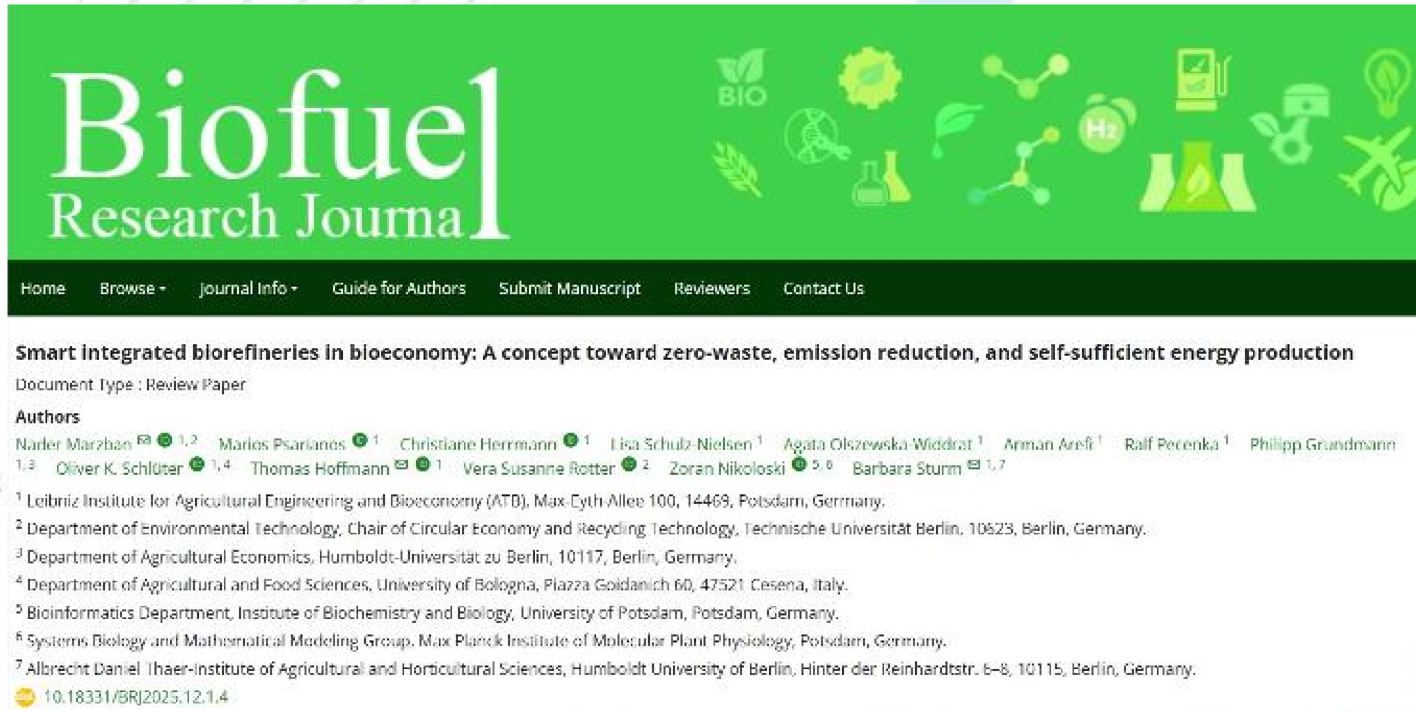
Research programme areas at ATB



Our solution

Systemic-technological innovation through inter- and transdisciplinary collaboration

Biorefinery concept


Biofuel Research Journal

Home | Browse | Journal Info | Guide for Authors | Submit Manuscript | Reviewers | Contact Us

Smart integrated biorefineries in bioeconomy: A concept toward zero-waste, emission reduction, and self-sufficient energy production

Document Type : Review Paper

Authors

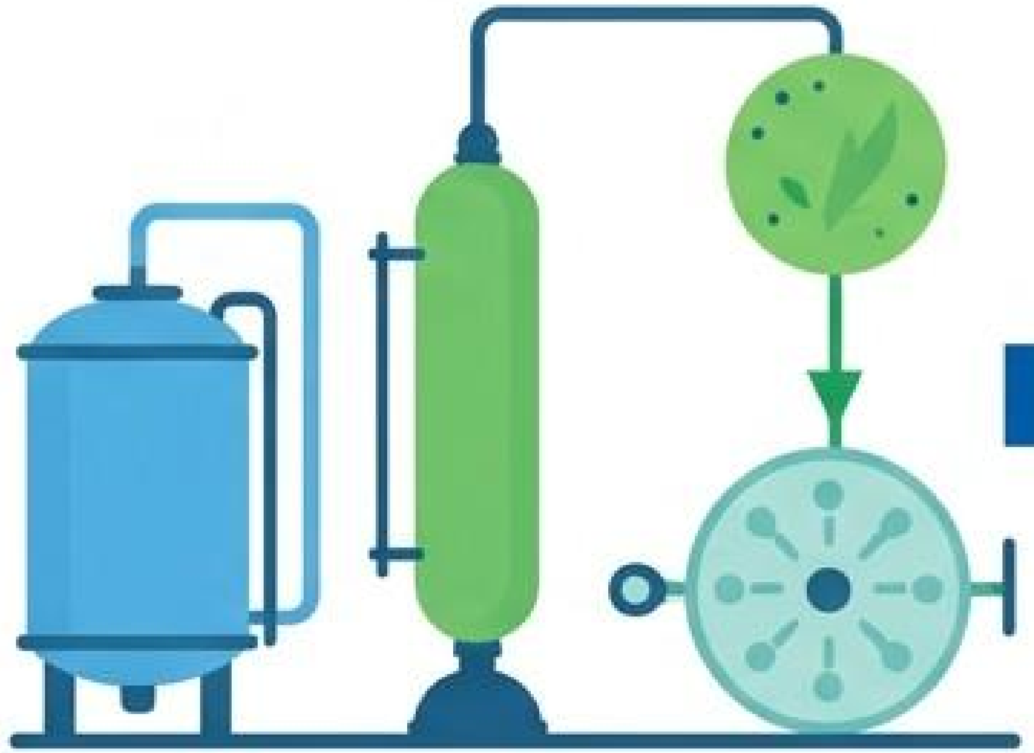
Nader Marzban [1,2] Marios Psarianos [1] Christiane Herrmann [1] Lisa Schulz-Nielsen [1] Agata Olszewska-Widdrat [1] Arman Arefi [1] Ralf Pecenka [1] Philipp Grundmann [1,3] Oliver K. Schlüter [1,4] Thomas Hoffmann [1] Vera Susanne Rotter [2] Zoran Nikoloski [5,6] Barbara Sturm [1,7]

[1] Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469, Potsdam, Germany.
[2] Department of Environmental Technology, Chair of Circular Economy and Recycling Technology, Technische Universität Berlin, 10623, Berlin, Germany.
[3] Department of Agricultural Economics, Humboldt-Universität zu Berlin, 10117, Berlin, Germany.
[4] Department of Agricultural and Food Sciences, University of Bologna, Piazza Goidanich 60, 47521 Cesena, Italy.
[5] Bioinformatics Department, Institute of Biochemistry and Biology, University of Potsdam, Potsdam, Germany.
[6] Systems Biology and Mathematical Modeling Group, Max Planck Institute of Molecular Plant Physiology, Potsdam, Germany.
[7] Albrecht Daniel Thaer-Institute of Agricultural and Horticultural Sciences, Humboldt University of Berlin, Hinter der Reinhardtstr. 6–8, 10115, Berlin, Germany.

10.18331/BRJ2025.12.1.4

Agricultural & industrial waste streams

Biomass utilisation within the framework of the biorefinery concept



Bioenergy

Biomaterials

Platform chemicals

Biofuels

Marzban, N.; Psarianos, M.; Herrmann, C.; Schulz-Nielsen, L.; Olszewska-Widdrat, A.; Arefi, A.; Pecenka, R.; Grundmann, P.; Schlüter, O.; Hoffmann, T.; Rotter, V.; Nikoloski, Z.; Sturm, B. (2025): Smart integrated biorefineries in bioeconomy: A concept toward zero-waste, emission reduction, and self-sufficient energy production. Biofuel Research Journal. (1): p. 2319-2349. Online: https://doi.org/10.18331/BRJ2025.12.1.4

FEEDSTOCK

Agricultural & industrial waste streams

- **Cheap**
- **Abundant**
- **Local**
- **Sustainable** / no competition with food & feed sector

Bioconversion group - Pilot plant for the biotechnological use of residues for the production of platform chemicals (funding: EFRE)

Bioconversion - Workflow

Upstream – Fermentation – Downstream Processing

1. **Pretreatment** - breaking down the raw material structure
2. **Hydrolysis** - degradation of biopolymers such as starch, cellulose, etc. to sugars such as glucose (C6) and xylose (C5) with the help of hydrolytic enzymes
3. **Fermentation** - conversion of sugars into the desired products by specialized microorganisms; classical batch, fed-batch or continuous modes (chemostat, high-cell-density cultures, cell-recycling)
4. **Separation and purification of the products** – e.g. membrane and resin based unit operations

Pilot plant for the production of bio-based chemicals at the Leibniz Institute ATB, Potsdam

Platform chemicals

What are platform chemicals?

Molecular building blocks derived from renewable biomass,
used to synthesize higher-value chemicals, materials & bioproducts.

Key examples:
- **Succinic acid, lactic acid**, glycerol
- Methanol, ammonia
- Furan derivatives (HMF, furfural)

Applications:
- Bioplastics & polymers
- Solvents & detergents
- Performance materials
- Biofuels

Why it matters:
Reduces fossil dependence, lowers GHG emissions,
supports integrated biorefineries & circular economy.

https://news.sustainability-directory.com/news/platform-chemicals/

Lactic acid

Lactic Acid (LA) - Market Update 2025/2026

- Global market: USD 3.68 billion (2025)
- Projected: USD 6.65 billion by 2033
- Growth rate: 7.7% CAGR (2026-2033)
- Global volume: 1.9 million tonnes (2025)

Key drivers:

- PLA bioplastics (~29% market share)
- Sugarcane as leading feedstock (~38.6%)
- Clean-label food & pharma applications
- Government incentives for bioplastics
- Expanding packaging & 3D printing markets

Applications:

- Biopolymers (PLA)
- Propylene glycol, acrylic acid
- Green solvents (esters)
- Food preservatives & pH regulators

https://www.marketdataforecast.com/market-reports/lactic acid-market

https://wallsheaven.com/photos/fermentation

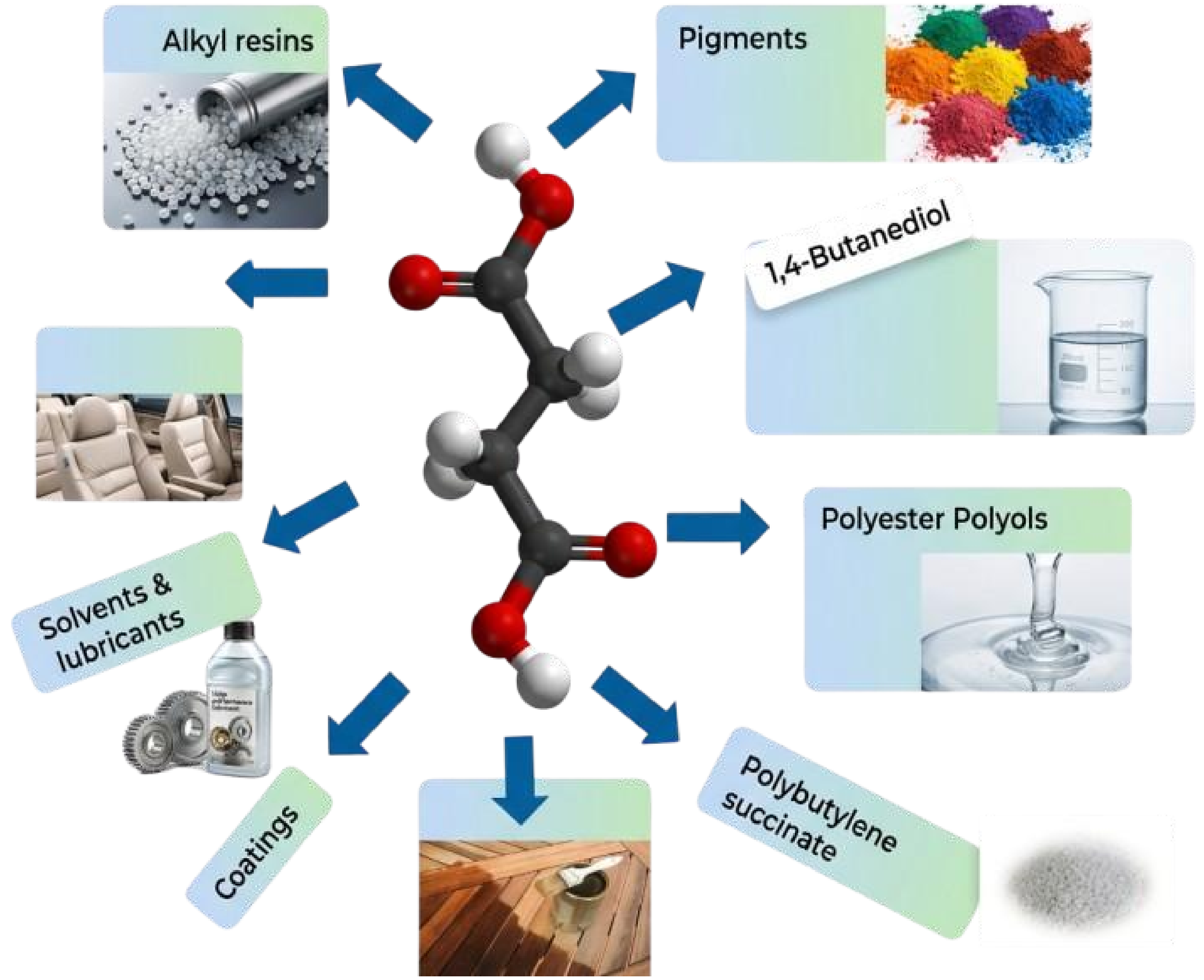
Succinic acid

Succinic Acid - Market Update 2026

- Global market: **USD 223.5 million** (2026)
- Projected: **USD 449.2 million by 2034**
- Growth rate: **3.85% CAGR** (2026-2034)
- Bio-based segment: **12.3% CAGR** (2026-2033)

Key drivers:
- Biodegradable plastics (PBS)
- 1,4-Butanediol (BDO) production
- Coatings & pharmaceuticals
- Regulatory push for bio-based chemicals
- Improved fermentation technology

Applications:
- PBS bioplastics (fastest-growing)
- Solvents & plasticizers
- Resins & coatings
- Food & beverage acidulants
- Cosmetics & personal care (10.18% CAGR)

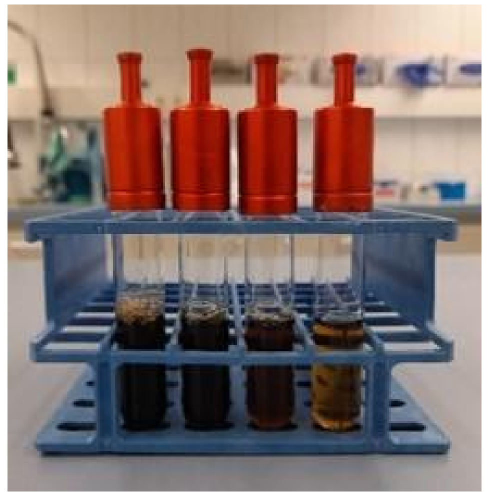


https://www.marketdataforecast.com/market-reports/succinic-acid-market

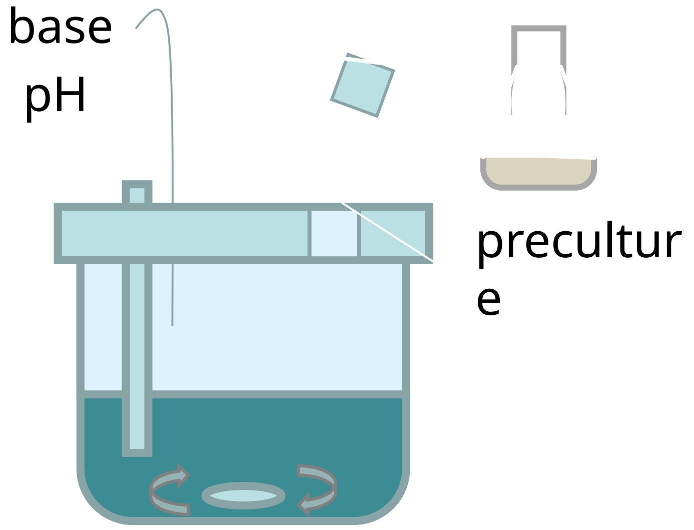
Lactic acid production at the technical scale

glucose & pentoses → **lactic acid** → poly – lactic acid

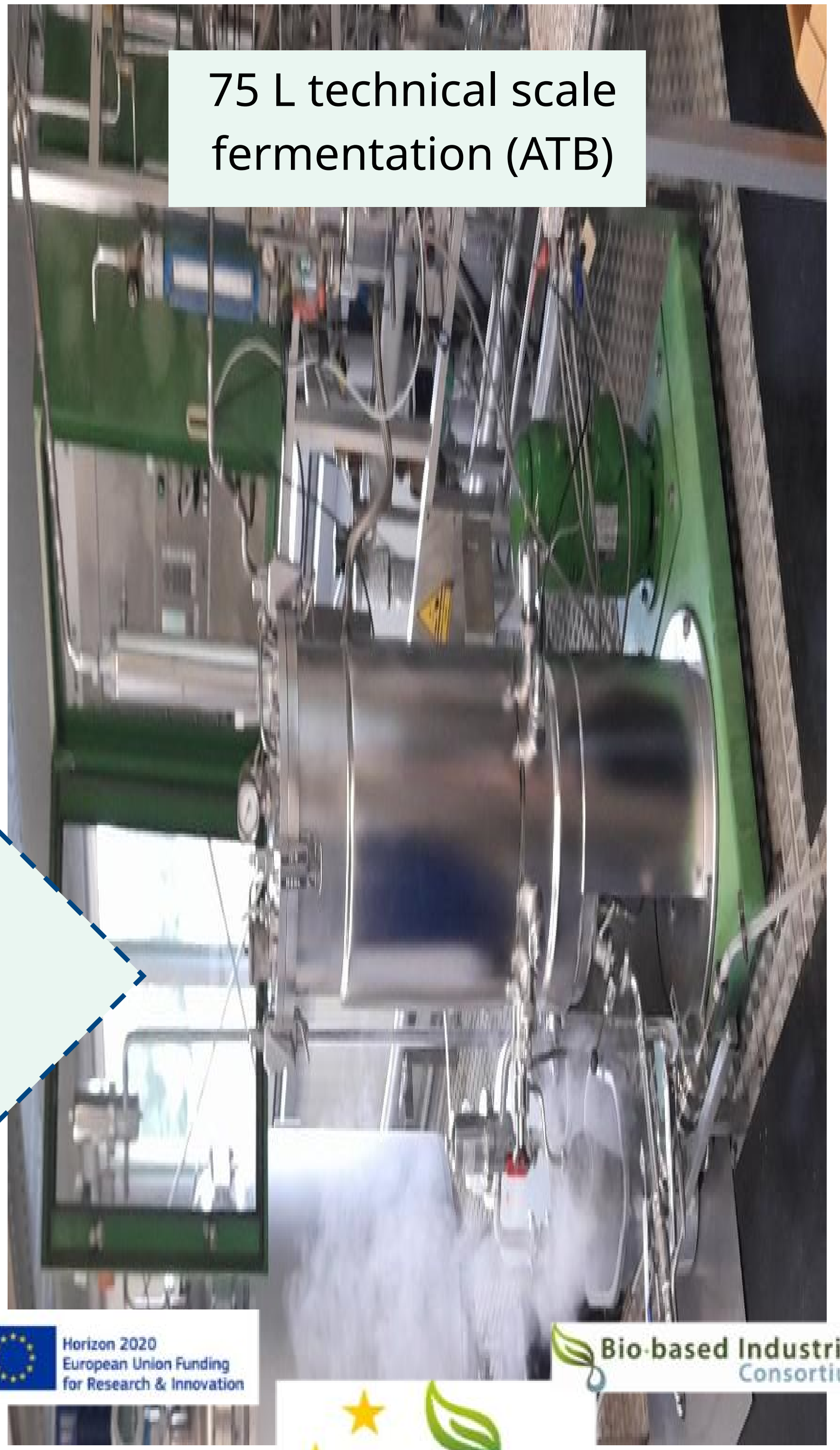
Bioscreen C
growth curve analysis system



Inoculation in test tubes



batch fermentation



***H. coagulans* strains show…**

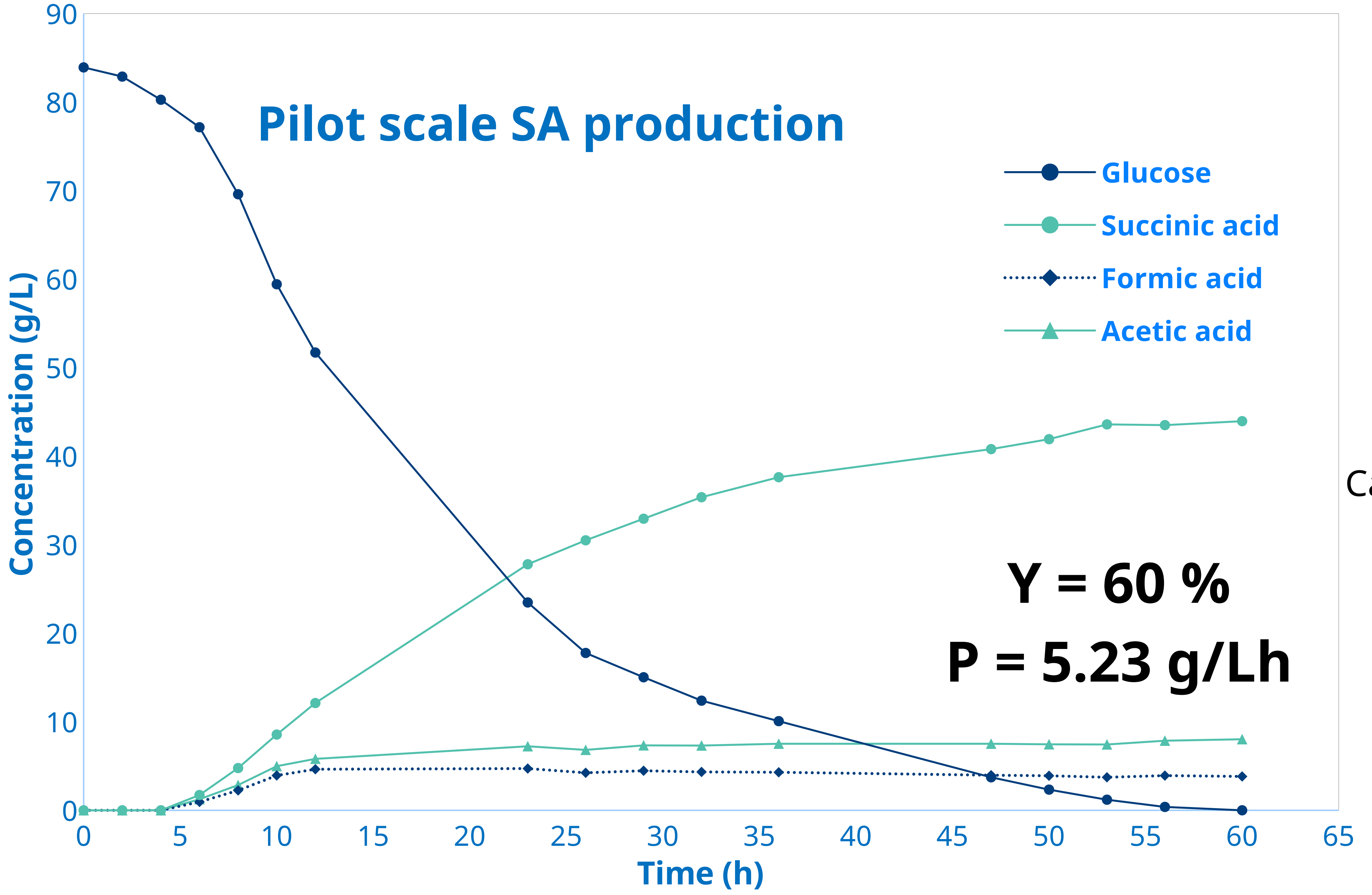
c(LA) = 89 g /L
Y = 92 %
P = 1.9 g/Lh

- high optical purity of LA > 99.4 %
- growth inhibitor tolerance
- no by-product formation
- utilization of mixed sugars

Betula pendula

Susmozas A, **Schroedter L**, Manzanares P, Iglesias R, Schneider R, Venus J, Ballesteros I, 2025. Enhanced enzymatic digestibility of steam-exploded short rotation hardwood species Betula pendula and its potential for lactic acid production. *Journal of Cleaner Production*, Vol. 494, 145042. https://doi.org/10.1016/j.jclepro.2025.145042

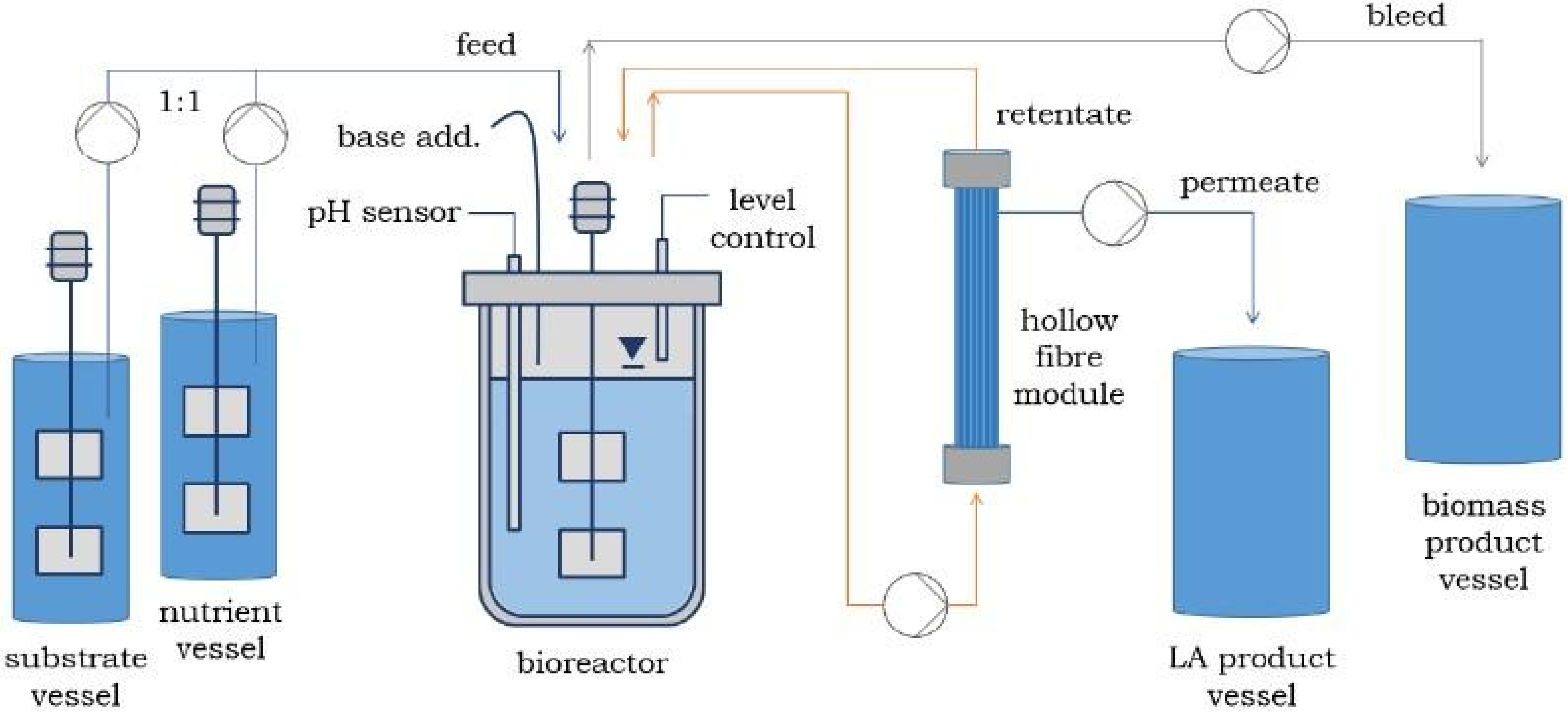
Succinic acid production from fibre sludge



Fermentation broth
↓
Microfiltration
↓
Softening
↓
Electrodialysis
↓
Decolorization
↓
Cation/Anion Exchange
↓
Destillation
↓
Crystalisation

Olszewska-Widdrat, A.; Portugal Rios da Costa Pereir, L.; Schneider, R.; Unger, P.; Xiros, C.; Venus, J. (2025): Pilot scale succinic acid production from fibre sludge followed by the downstream processing. Food and Bioproducts Processing. (May 2025): p. 118-126. Online: https://doi.org/10.1016/j.fbp.2025.03.001

Lactic acid continuous production from waste wood



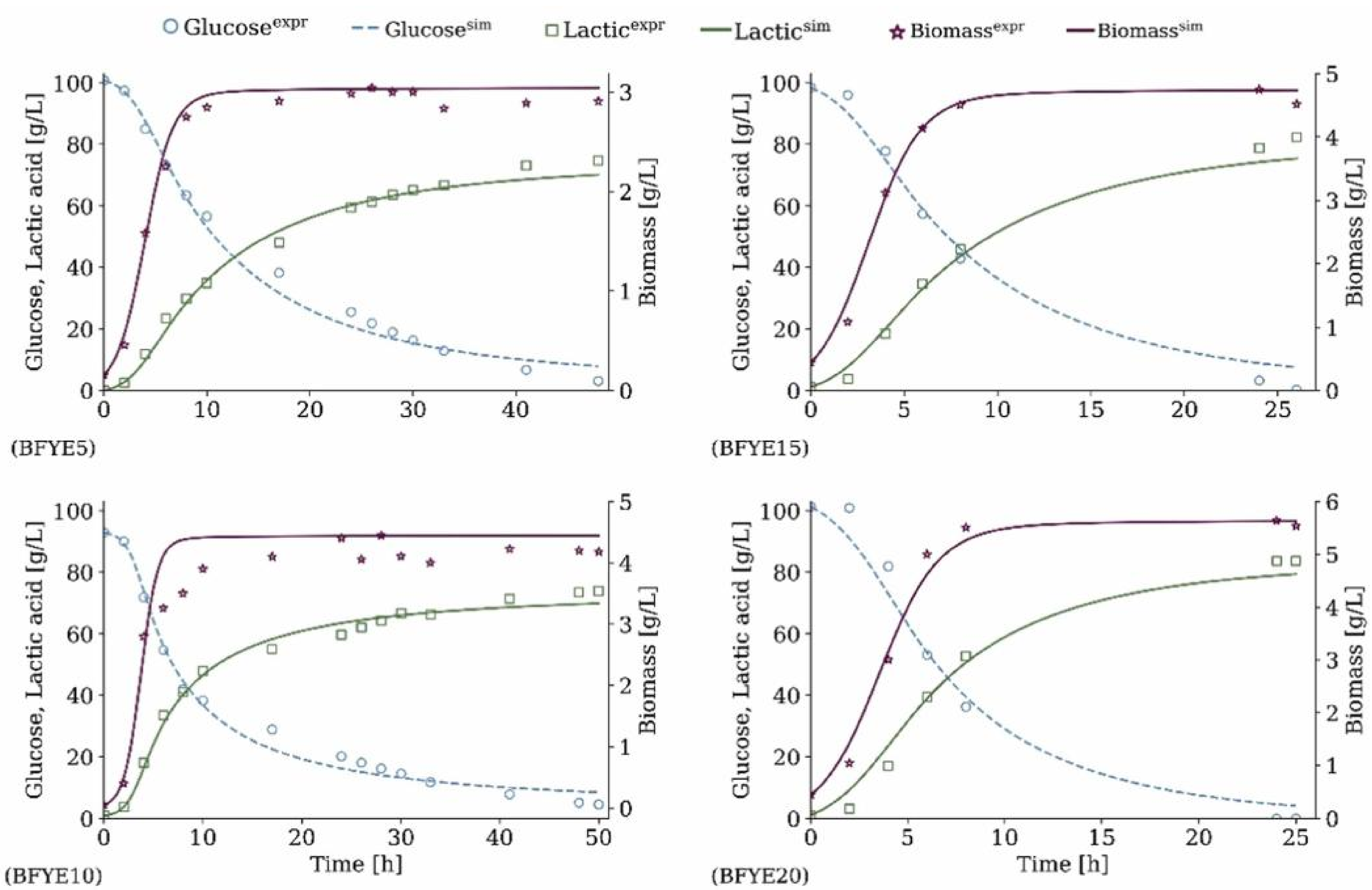
Productivity = 7.6 **g·L^{-1}·h^{-1}**

Yield = 0.9 **g·g^{-1}**
LA = 40.2 g·L^{-1}

Productivity increase by factor 4.5 – 5.8

Schroedter, L.; Schneider, R.; Venus, J. (2024): Transforming waste wood into pure L-(+)-lactic acid: efficient use of mixed sugar media through cell-recycled continuous fermentation. Bioresource Technology. (March 2025): p. 132010. Online: https://doi.org/10.1016/j.biortech.2024.132010

Digital Twin as a helping tool for real-time monitoring



Process dynamics of lactic acid production from glucose using batch fermentation of *B. coagulans* strain with mediums containing different yeast extract (YE) concentrations:

10 % Yeast Extract – the highest maximum growth rate, maximum glucose consumption, optimal yield of LA from glucose

Can we apply it for multi-substrate continuous systems?

OLSZEWSKA-WIDDRAT, A.; BABOR, M.; HÖHNE, M.; ALEXANDRI, M.; LÓPEZ GÓMEZ, J.; VENUS, J. (2024): A mathematical model-based evaluation of yeast extract's effects on microbial growth and substrate consumption for lactic acid production by Bacillus coagulans. Process Biochemistry. (November): p. 304-315. Online: https://doi.org/10.1016/j.procbio.2024.07.017

Conclusion & Call to Action

- ❑ Alternatives for the production of platform chemicals (LA; SA)
- ❑ Cheap wood biomass
- ❑ Continuous process
- ❑ Scale-up
- ❑ Predictive models

Previous/Current projects

- **PERCAL –** Chemical building blocks from versatile MSW biorefinery - **07/2017 - 12/2020**, https://www.cbe.europa.eu/projects/percal
- **BBI Project CAFIPLA** "Combining carboxylic acid production and fibre recovery as an innovative, cost effective and sustainable pre-treatment process for heterogeneous bio-waste" (BBI grant agreement Nº 887115) – **06/2020–05/2023**, https://cafipla.eu/
- **BBI Project BeonNAT** "Innovative value chains from tree & shrub species grown in marginal lands as a source of biomass for bio-based industries" (BBI grant agreement Nº 887917) – **07/2020–06/2025**, https://beonnat.eu/
- **EU Project BIOMAC** "European Sustainable BIObased nanoMAterials Community" (H2020 grant agreement Nº 952941) – **01/2021–06/2025**, https://www.biomac-oitb.eu
- **Bio4Act -** Biogene Aktivkohlen und Plattformchemikalien aus Restbiomassen zur Implementierung einer nachhaltigen zirkulären Bioökonomie, **08/2023 - 07/2028**
- **LiGNUM** - Microbial upcycling of lignin-based streams into sustainable biomaterials , BMBF call for funding "Innovative bioproduction for a climate-neutral industry" – **02.2026 – 01.2029**

LiGNUM

Thank you for your attention

With the support of:

Contact:
Dr. Agata Olszewska-Widdrat aolszewska-widdrat@atb-potsdam.de
Dr. Joachim Venus: jvenus@atb-potsdam.de
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)
Max-Eyth-Allee 100, 14469 Potsdam, GERMANY
Tel.: +49(331)5699-852