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EBU Scientific Forum

22-23 September 2021

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	Building alternative protein-friendly sustainable and healthy food environments	

Detailed Agenda

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Wednesday, 22 September 2021

Welcome note and Podium discussion	Public event
10:00– 11:00 am	**Welcome note** Prof. Dr. Stephan Dabbert, President of the University of Hohenheim
	Podium **Moderator:** Marios Avraamides, Coordinator of Commission's Knowledge Centre for Bioeconomy, JRC
	Prof. Dr. Hubert Hasenauer, Rector, University of Natural Resources and Life Sciences (BOKU)
	Prof. Dr. Stephan Dabbert, President of the University of Hohenheim
	Prof. Gilles Trystram, General Director, AgroParisTech- National Institute of Technology for Life, Food and Environmental Sciences
	Prof. Nino Rotolo, Vice rector, University of Bologna, University of Bologna
	Prof. Tapio Määttä, Academic Rector, University of Eastern Finland
	Prof. Dr. Arthur Mol, Rector, Wageningen University and Research

Plenary Session I	Public event
11:00 –12:30 am	**Novel biobased value chains for Europe – developed and demonstrated by GRACE** Dr. Andreas Kiesel, University of Hohenheim
	Research Flagship Forests-Human-Machine Interplay (UNITE) Prof. Jyrki Kangas, University of Eastern Finland
	Unique reactivity of cellulosic materials mediated by surface-confined water, University of Natural Resources and Life Sciences Dr. Marco Beaumont, University of Natural Resources and Life Sciences
	Making the most of marginal lands to fuel the bioeconomy Prof. Dr. Benoit Gabrielle, AgroParisTech- National Institute of Technology for Life, Food and Environmental Sciences
	Magnificent - Microalgae as a Green source for Nutritional Ingredients for Food/Feed and Ingredients for Cosmetics by cost-Effective New Technologies Prof. Dr. Maria Barbosa, Wageningen University and Research
	BIObec - Preparing the creation of Bio-Based Education Centres to meet industry needs and boost the contribution of the bioeconomy to societal challenges Prof. Dr. Davide Viaggi, University of Bologna

	Public event

Parallel Session I	
1:30 – 3:00 pm	**Bioeconomy-related business models and sustainable entrepreneurship** Chair: Prof. Dr. Davide Viaggi, University of Bologna
1:30 – 1:48 pm	**Role of multinational enterprises in industry development in emerging market: Uruguayan forest sector** Dr. Irina Mihailova, University of Eastern Finland
1:48 – 2:06 pm	**Efficiency Enhancement in Arable Farming in Hohenlohe based on Nutrient Recovery from Farm Manure: Agriplus Hohenlohe** Andrea Bauerle, University of Hohenheim
2:06 – 2:24 pm	**External enablement of sustainability-oriented new venture creation: Entrepreneurial opportunities in the sustainable circular bioeconomy** Sebastian Hinderer, University of Hohenheim
2:24 – 2:42 pm	**Entrepreneurial orientation as a factor influencing collaboration within bioeconomy clusters** Nunzia Gabriella Fasolino, University of Bologna
2:42 – 3:00 pm	**Developing traditional ARA model to better capture the interlinkages between actors, resources and activities within the diversified business environment: Case-evidence from forest-based bioeconomy** Dr. Sara Fraccastoro, University of Eastern Finland
1:30 – 3:00 pm	**From biomass to biobased products** Chair: Prof. Dr. Luisa Trindade, Wageningen University and Research
1:30 – 1:48 pm	**Extractive bioconversion process for the production of bio-based organic acids: an integrated biological and separation model** Pedro Arana-Agudelo, AgroParisTech
1:48 – 2:06 pm	**Cascading PROcesses to extract and valorise proteins and bioactive molecules from Legumes, Fungi and Coffee agro-industrial side streams - THE PROLIFIC project** Prof. Dr. Annalisa Tassoni, University of Bologna
2:06 – 2:24 pm	**Conditions for a bioeconomy transformation- Increased use of wood in construction** Dr. Jaakko Jussila, Helsinki University
2:24 – 2:42 pm	**Designing sustainable biobased processing networks** Dr. Ellen Slegers, Wageningen University and Research
2:42 – 3:00 pm	**Edible basidiomycetes mediated bioprocess upcycles food side streams in a circular economy – cases study acid whey and pulse serum** Prof. Dr. Yanyan Zhang, University of Hohenheim
1:30 – 3:00 pm	**Sustainable biobased resources and ecosystem services for the bioeconomy** Chair: Prof. Dr. Benoit Gabrielle, AgroParisTech
1:30 – 1:48 pm	**Agricultural biomass at local scales: which managements and utilizations between compartmentalization, competition or integration?** Prof. Philippe Lescoat, AgroParisTech
1:48 – 2:06 pm	**QUABIO project: application of simple and complex indexes to assess soil quality under conventional and organic management** Dr. Martina Mazzon, University of Bologna
2:06 – 2:24 pm	**Perennial wildflower mixtures for bioenergy and biobased products - Current status and future prospects** Dr. Moritz von Cossel, University of Hohenheim

2:24 – 2:42 pm	Influence of environmental conditions on growth parameters, grain yield and oil quality of five Amaranth genotypes Dr. Meylin Terrel Gutierrez, University of Hohenheim
2:42 – 3:00 pm	Site impacts nutrient translocation efficiency in intra- and interspecies Miscanthus hybrids on marginal lands Elena Magenau, University of Hohenheim
1:30 – 3:00 pm	The integrative systems approach for the innovative bioeconomy Chair: Dr. Martin Greimel, University of Natural Resources and Life Sciences
1:30 – 1:45 pm	Bioeconomy and circular economy in the forest sector: a systematic review Dr. Jonathan Lenglet & Dr. Miguel Rivière, AgroParisTech
1:45 – 2:00 pm	Potentials, subsidies and tradeoffs of cellulosic ethanol in the EU Prof. Dr. Franziska Schuenemann, University of Hohenheim
2:00 – 2:15 pm	The potential of the Living Lab approach in forest bioeconomy Dr. Maxence Arnould, AgroParisTech
2:15 – 2:30 pm	DigiFoodTwin: Digital Biophysical Twins in Food Processing Prof. Dr. Christian Krupitzer, University of Hohenheim
2:30 – 2:45 pm	The smart, digitized food supply chain with machine learning Prof. Dr. Christian Krupitzer, University of Hohenheim
2:45 – 3:00 pm	Discussion
1:30 – 3:00 pm	Educate system changers: novel educational concepts and required skills profiles Tools in Bioeconomy education Chair: Gerlinde van Vilsteren, Wageningen University and Research
1:30 – 1:50 pm	ABBEE – the Bioeconomy MOOC platform Dr. Gerlinde van Vilsteren, Wageningen University and Research
1:50 – 2:05 pm	Collection of awareness-raising, communication and education tools from European sources Marco Maria Grande, University of Bologna
2:05 – 2:20 pm	New education project which promotes transition to an ecologically sustainable society. Solutions to biodiversity questions are sought through networked co-operation between universities Elli Hämynen, University of Eastern Finland
2:20 – 2:35 pm	Shaping the concept of bioeconomy in participatory projects - An example from the post-graduate education in Finland Dr. Jukka Tikkanen, University of Eastern Finland
2:35 – 2:50 pm	Insights on jointly organized Bioeconomy specialisation education in Eastern Finland – Life-long learning formats Dr. Piritta Torssonen, University of Eastern Finland
2:50 – 3:00 pm	Discussion

Parallel Session II	Public event
3:30 – 5:30 pm	**Educate system changers: novel educational concepts and required skills profiles** Chair: Riitta Tegelberg, University of Eastern Finland
3:30 – 4:30 pm	Bioeconomy Qualification programs
3:30 – 4:30 pm	**EBU label** Lina Marcela Mayorga Duarte, University of Hohenheim **FOEBE** Prof. Dr. Benoit Gabrielle, AgroParisTech **Pitch Bioceb: an Erasmus Mundus Joint Master Degree addressing the global Bioeconomy need for new skills** Prof. Stéphanie Baumberger, AgroParisTech **Pitches of Bioeconomy Master education programs of the EBU members** Prof. Dr. Iris Lewandowski Dr. Antti Haapala Prof. Dr. Benoit Gabrielle, AgroParisTech Dr. Davide Viaggi, University of Bologna Bernhard Kastner, University of Natural Resources and Life Sciences
4:30 – 5:30 pm	Networks on Bioeconomy education
4:30 – 5:30 pm	**BE CHANGE: A community of practice inspiring and encouraging bioeconomy education for systemic change** Dr. Sophie Urmetzer, University of Hohenheim **ICA Community of Practice for Bioeconomy Education in Europe (CoP Bio-Edu)** Han van Osch, CoP Bio-Edu **Bioeconomy Education towards Sustainability and Creativeness in the BioEast Region** Prof. Dagnija Blumberga, Riga Technical University
3:30 – 5:30 pm	**Research short presentations I** Chair: Dr. Martin Greimel, University of Natural Resources and Life Sciences
3:30 – 4:05 pm	**Forestry**
	Forest Ecosystem Services in policy – an example of Swedish forest policy Dr. Camilla Widmark, Swedish University of Agricultural Sciences **Strong sustainability: a review of forest-based bioeconomy literature** Satu Helenius, University of Eastern Finland **Innovative bioeconomy and forest ecosystem services** Dr. Camilla Widmark, Swedish University of Agricultural Sciences

	National regimes and drivers of change in multi-national pulp industries – case Uruguay and Finland Anu Laakkonen, University of Eastern Finland
4:05 – 4:30 pm	New crops and biobased resources
	Acrocomia: a multipurpose palm with high potential for becoming a sustainable industrial crop for the bioeconomy in Latin America Ricardo Vargas-Carpintero, University of Hohenheim Miscomar+: Exploration and Optimisation of Miscanthus Cultivation under Marginal Conditions" Eva Lewin, University of Hohenheim Environmental impact and nutritional value of seaweed-based food products Dr. Ellen Slegers, Wageningen University and Research
4:30 – 4:50 pm	Environmental dimension in the bioeconomy
	Automated Data Acquisition for farm LCA Jan Weik, University Hohenheim Valorisation of ecosystem services for a more sustainable intensification of agricultural biomass production in the growing bioeconomy: Development of an integrated assessment approach Bastian Winkler, University of Hohenheim Urban gardening and domestic compost production as climate change mitigation practices in a city environment Luca Mariani, University of Natural Resources and Life Sciences
4:50 – 5:30 pm	Value chain aspects
	Analysis of bio-based value chains for accelerating the transition towards a sustainable bioeconomy Stephanie Lang, University of Hohenheim DAGFOR-Digital tools for agricultural advisors in agroforestry systems Beatriz Herrera, University of Hohenheim Challenges and opportunities of circular biomass management in the agro-food-waste system – An application of the innovation platform approach in a nutrient-saturated area Sabine Neuberger, Rhine-Waal University of Applied Sciences Assessing farmers' interests and their willingness to cultivate miscanthus Nirvana Marting Vidaurre, University of Hohenheim
3:30 – 5:30 pm	**Research short presentations II** Chair: Prof. Luisa Trindade, Wageningen University & Research
3:30 – 4:20 pm	Process
	Biobased molecule production from renewable resources using an integrated strategy of fermentation/bioconversion and on-line extraction processes Dr. Marwen Moussa, AgroParisTech

	In stream extractive fermentation for intensified 2-phenylethanol production from renewable resources by Kluyveromyces marxianus Dr. Ana-Karen Sanchez-Castaneda, AgroParisTech Showing the Capabilities of Experimental and Computational Fluid Dynamics in Bio-Process Intensification: the Case of a Stirred Bioreactor for Bio-H2 Production Dr. Francesco Maluta, University of Bologna Sustainable Industrial Chemistry for Innovation in Bio-Refinery Processes Dr. Martina Milano, University of Bologna Urease inhibitory potential and soil ecotoxicity of pyrolysis liquids Dr. Chiara Samorì, University of Bologna Comparative environmental assessment of HMF produced from fructose and lignocellulosic biomass Jan Lask, University of Hohenheim A comparative economic evaluation of scenarios for the extraction of an oil containing fucoxanthin and EPA from P. tricornutum using FPA-PBR with artificial light or natural sunlight in Germany. Sebastian Weickert, University of Hohenheim
4:20 – 4:45 pm	Products
	Eco-friendly synthesis of (R)-3-hydroxydecanoic acid and analogues: New green pathway to highly potent elicitor(s) of plant immune system Dr. Amandine Flourat, AgroParisTech Green polymerization of readily accessible levoglucosenone-derived monomers: towards fully renewable functional crosslinked materials Dr. Sami Fadlallah, AgroParisTech Simultaneous extraction and enzymatic hydrolysis from mustard bran for the recovery of sinapic acid Valentin Reungoat, AgroParisTech
4:45 – 5:15 pm	Side streams
	Effect of the pH on the Extraction of Sinapic Acid Derivatives from Mustard Seed Meal Dr. Morad Chadni, AgroParisTech Myco-conversion of agro-waste into by-products Prof. Dr. Ornella Francioso, University of Bologna Polyhydroxyalkanoates from waste as a sustainable platform for the production of materials and chemicals Prof. Dr. Paola Galletti, University of Bologna Valorization of hempseed meal by the extraction of phenolic compounds Emilie Isidore, AgroParisTech

Thursday, 23 September 2021

Plenary Session II	EBU internal event
09:00 –10:30 am	**Moderator:** Dr. Davide Viaggi, University of Bologna
	Bioeconomy activities of the EBU alliance partners University of Hohenheim, Iris Lewandowski University of Natural Resources and Life Sciences, Bernhard Koch University of Eastern Finland, Prof. Heli Peltola Wageningen University and Research, Jeroen Ouburg University of Bologna, Prof. Dr. Davide Viaggi AgroParisTech- National Institute of Technology for Life, Food and Environmental Sciences, Prof. Dr. Benoit Gabrielle
	Bioeconomy activities of the EBU associated partners European Forest Institute, Prof. Pekka Leskinen and Diana Tuomasjukka Swedish University of Agricultural Sciences, Ylva Hillbur Warsaw University of Life Sciences, Dr. Marta Mendel, Prof. Nina Drejerska BIOEAST – Central and Eastern European initiative for knowledge-based agriculture, aquaculture and Forestry in the bioeconomy, George P. Sakellaris and Marie Kubankova

Workshops	EBU internal event	
10:30 –11:00 am	**Workshops introduction** Prof. Dr. Iris Lewandowski	
11:30 am – 1:00 pm	**Parallel Workshops I: Joint projects**	
	Innovation for sustainability **Sustainable biodegradable novel bio-based plastics** Dr. Martin Greimel and Bernhard Koch, University of Natural Resources and Life Sciences	**Boosting breeding for a sustainable, resilient and competitive European legume sector** Prof. Luisa Trindade, Wageningen University & Research
2:00 pm – 3:30 pm	**Parallel Workshops II: Joint projects**	
	Building alternative protein-friendly sustainable and healthy food environments Sebastian Weickert, University of Hohenheim	

The Novel biobased value chains for Europe – developed and demonstrated by GRACE

Kiesel, Andreas

University of Hohenheim, Biobased Products and Energy Crops (340b), Stuttgart, Germany

Relevance and aim of the study

The GRACE project aims to demonstrate 10 biobased value chains from biomass cultivation on low productive and abandoned land until production of biobased products at industry relevant scale.
GRACE is a BBI demonstration project which started in 2017 and is running for 5 years. The overarching aim of the project is to overcome bottlenecks in exploitation of miscanthus and hemp by increasing awareness and exchange amongst and between farming sector and industry.

Materials and methodologies used

Miscanthus and hemp are used to demonstrate and optimize biomass provision for biobased applications. Novel, seed-based miscanthus hybrids are trialled on multiple sites across Europe to test and demonstrate the suitability of novel hybrids for different climates and applications. The biomass quality will be assessed and compared, including various cell wall components, mineral contents and physical properties to allow optimization of biobased applications.
Several industrial partners are testing and developing their standard protocols for miscanthus and hemp biomass, which helps to utilize this biomass in industrial applications.

Major results and findings

Miscanthus hybrids showed site specific suitability for different climates, e.g. *Miscanthus sinensis* hybrids (Msin x Msin) performed better in more northern climates, while *Miscanthus sacchariflorus* x *Miscanthus sinensis* hybrids (Msac x Msin) performed better in Southern locations. Beside miscanthus species, this could be also affected by the location of the breeding programme: Msin x Msin breeding is located at Wageningen University, while Msac x Msin breeding is performed by Aberystwyth University largely in Southern Italy. Different applications showed high suitability for the tested biomass, including bioethanol conversion of miscanthus biomass and CBD extraction from hemp threshing residues. Especially Bioethanol production from miscanthus grown on abandoned land seems to make a nice business case, since the fermentation off-gas can be stored in expired oil wells, which overcompensates the GHG emissions from the whole value chain.

Conclusion of your research

Overall GRACE makes a strong contribution to develop utilization options for miscanthus and hemp biomass and thereby facilitates market development for the biomass of such crops.

A Finnish Flagship of Science: Forest-Human-Machine Interplay - Building Resilience, Redefining Value Networks and Enabling Meaningful Experiences (UNITE) 2020-2024

Prof. Jyrki Kangas
University of Eastern Finland

The UNITE Research consortium consists of the School of Forest Sciences at the University of Eastern Finland (UEF), forest research at the Natural Resources Institute Finland, the Finnish Geospatial Research Institute at the National Land Survey of Finland, and gamification and game cultures research groups at Tampere University. The consortium is coordinated by UEF.

UNITE got the Flagship funding by the Academy of Finland in the end of 2020. Practically taken, the flagship started about half a year ago. The Academy of Finland has chosen altogether ten National Flagships of Science. According to the Academy, the Flagship Programme represents the highest scientific world-class excellence and impact potential in Finland from various disciplines. It promotes collaboration between research, business and surrounding society, and helps to create solutions to societal challenges of our time, develops new business opportunities, and contributes to sustainable growth. Among Finnish Flagships, UNITE is the only one having its main focus on forest sector.

Within UNITE Flagship, we combine world-class scientific excellence in forest sciences, geospatial technology, and gameful human-technology. Our mission is to leverage the development towards biosociety, in which management and utilisation of forests will be both climate-smart, resource-efficient and multifunctional, and at the same time profitable for all actors within the forest-based value networks. UNITE will digitalize forests and their use and value networks based on forests, starting in Finland, and making collaboration and impacting globally. Our stakeholders and users of research results include forest and game industry companies and public bodies, associations representing for example forest landowners, nature conservationalists and outdoor recreation.

In our Scientific Advisory Committee there are members from top universities and research groups globally, and also members of four other Finnish research flagships with whom we make co-operation. From EBU, BOKU is represented in that Committee. Both Finnish forestry and forest and game industries are already success stories. We matchmake them for gaining synergies by combining their progresses and for finding new breakthrough innovations in science and in practice, and to find pathways to still better management of forests. This way – we think – UNITE can be a game changer not only in Finland but globally.

Briefly put, UNITE's thematic areas are: Acquisition, Creation, Management, and Engagement. We call that the ACME model – from the forest data to smart decisions and meaningful experiences:

- A: Technologies for capturing forest ecosystem structure and functioning, based e.g. on point clouds obtained by lidar sensors; more accurate, versatile, reliable, applicable forest data.
- C: Knowledge creation from the forest big data; modelling, including analyzing and understanding uncertainties within the data and models.
- M: Decision support for multifunctional, sustainable and profitable forest management, covering all uses and properties of forests, and all ecosystem services; by making use of simulation and optimization, foresight and scenarios.
- E: New opportunities by gamification and game technologies to forestry and to other nature-oriented application; gameful interaction for meaningful engagement, experiences and practices.

Our anticipated advances are based on game, mobile, and laser technologies, as well as robotics and machine vision applications in forestry and forest-based services. Areas of application include, among others, the acquisition and modelling of forest information, mapping and managing forest damages, the enhancement and management of wood procurement and other forestry operations, new location-based games, forests in climate change mitigation and in adaptation to global warming, the increase of health and well-being effects of nature, as well as forest biodiversity research.

Unique reactivity of cellulosic materials mediated by surface-confined water

Beaumont, Marco[1], Jusner, Paul[1], Gierlinger, Notburga[1], King, Alistair W.T.[2], Potthast, Antje[1], Rojas, Orlando J.[3], Rosenau, Thomas[1]

[1]University of Natural Resources and Life Sciences, Vienna, Wien, Austria, [2]University of Helsinki, Helsinki, Finland, [3]University of British Columbia, Vancouver, Canada

Relevance and aim of the study

Nowadays, the term chemistry is often associated with chemical processes that take place in organic solvents and thus clearly contrast with biochemical reactions in nature. The remarkable efficiency of natural processes is the result of biological evolution, often involving confined water. This type of water is present in cells and proteins and involved in biochemical processes making them more efficient. It might even be mandatory to enable reactions. Developments of bio-inspired systems, which exploit the potential of such water, have been so far rather complex and cumbersome and mostly based on synthetic polymers. In this contribution, we demonstrate that the inherently present surface-confined water in cellulosic fibers - the main component of wood and higher plants - can be utilized as nanomedium to endow a singular chemical reactivity.[1] It offers a high potential for making chemical reactions more sustainable and efficient in the future.

Materials and methodologies used

A bleached beech dissolving-grade pulp was used in all experiments, and the amount of confined water in the fiber was adjusted priorly. Influences of the modification onto the physicochemical properties were studied using a combination of infrared spectroscopy, gel permeation chromatography and nuclear magnetic resonance spectroscopy. The structure and surface chemistry of the fibers were evaluated with electron and Raman microscopy, respectively.

Major results and findings

We compared an acetylation reaction of cellulose in the presence of confined water with a conventional approach in the dry state: Confined water increased the reaction rate and efficiency by 8 times and 30%, respectively. In addition, the amount of confined water enabled control over chemical accessibility of selected hydroxyl groups through the extent of hydration, allowing regioselective reactions, so far a major challenge in cellulose modification. This is in stark contrast to conventional chemical reactions of cellulose, which are mostly conducted under water-free conditions, require energy in form of heating and involve the use of organic solvent.

Conclusion of your research

The reactions mediated by surface-confined water are sustainable and largely outperform those traditional systems in terms of efficiency and environmental compatibility. Our results demonstrate the unexploited potential of water bound to cellulosic nanostructures in surface esterifications, which can be extended to a wide range of other nanoporous polymeric structures and reactions.

References:

[1] Marco Beaumont, Paul Jusner, Notburga Gierlinger, Alistair W. T. King, Antje Potthast, Orlando J. Rojas, Thomas Rosenau, (2021), Unique reactivity of nanoporous cellulosic materials mediated by surface-confined water, Nature Communications, 2513, 12, https://www.nature.com/articles/s41467-021-22682-3

Making the most of marginal lands to fuel the bioeconomy

Gabrielle, Benoît[1], Van Cossel, Moritz[2], Njakou Djomo, Sylvestre[1], El Akkari, Monia[1], Ben Fradj, Nosra[1], Lewandowski, Iris[2], Elbersen, Berien[3], Starisky, Igor[3], Annevelink, Bert[3], Trindade, Luisa[3], Zanetti, Federica[4], Monti, Andrea[4]

1 AgroParisTech, INRAE, Department of Agriculture, Forestry and Environmental Sciences, Grignon, France.
2 University of Hohenheim, Biobased Resources in the Bioeconomy, Stuttgart, Germany.
3 Wagengingen University and Research, Earth Informatics & Plant Breeding, Wageningen, The Netherlands.
4 University of Bologna, Department of Agricultural and Food Sciences, Bologna, Italy.

Relevance and aim of the study

Sourcing biomass from marginal lands is increasingly promoted as a means to meet the growing needs of the bioeconomy while minimizing the risks of detrimental land-use change effects. However, it is proving a challenging endeavour in practice since it may imply lower crop yields, complicated logistics and unfavourable economics in general. Several EBU partners have been investigating and evaluating this option in the recent years in the context of the European Union, looking into various steps of the biomass supply chains and ways to optimize their performance. Their work encompasses plant breeding, suitability mapping for various candidate crops, cropping systems management, logistics modelling, cost analysis and overall sustainability assessment.

In this talk we will report on results originating from several projects lead by EBU partners, and in particular the ongoing H2020 project MAGIC.

Materials and methodologies used

The methods used to evaluate and design biomass supply chains from marginal lands involve mapping with GIS data and modelling, literature review and expert knowledge on crop growth requirements, meta-analyses, bioeconomic modelling of crop yields and land allocation, spatially-explicit logistics modelling. Decision-support systems were also developed to guide decision making in terms of crop and land allocation and crop management in relation to local conditions and potentials. Case-study were also analysed in various geographical and industrial (value-chain) contexts.

Major results and findings

Marginal land mapping based on biophysical constraints pointed to a potential of about 60 Mha in the EU, with regional variations in terms of dominant constraints and land availability. Suitability maps were derived for the 20 most promising industrial crops in this marginality context, which further highlighted regional specificities. Some crops such as perennial grasses (eg, Miscanthus) had a wide-ranging potential whereas others (eg, castor bean) were restricted to a small fraction of available lands. In one of the local case-studies, logistics modelling evidenced somewhat larger costs per ton of biomass delivered at the plant gate than reported for non-marginal lands. In general, bioeconomic modelling of energy crops development shows that perennial grasses are not allocated to marginal land but to low-productivity cropland and grassland, which also corresponds to the patterns observed so far in France.

Conclusion of your research

Marginal lands are a promising route to produce feedstock for the bioeconomy, and have a significant potential in Europe for a range of crops and bio-based products. However, estimating the actual yield potential of these lands in response to the multiple marginality factors which affect them remains a challenge, which hinders their uptake and actual exploitation. While the economics may not be favourable to such biomass production systems, they may claim other benefits in terms of ecosystem services or low risks of indirect effects, which increases their value. Further research is warranted to gain more insight into biodiversity impacts and yield potentials in response to global change.

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MAGNIFICENT Value chain for the production of sustainable ingredients from microalgae

Prof. Dr. Maria Barbosa, Wageningen University and Research

Today there are only market opportunities for high value applications due to production costs, which are still too high to make microalgae a competitive feedstock for commodities. There is presently a large production capacity for a limited number of microalgae strains in Europe. However, the number of concrete products and market applications is still limited. The enlargement of current market applications for high-value microalgae ingredients will lead to new business opportunities, industrialize the technology and provide the knowledge and experience required to enter the medium- low value market within 5-10 years.

MAGNIFICENT is an European project under the “Biobased Industries” umbrella which was set-up to expand the range of commercial products and their market volume substantially and in a sustainable manner. The overall objective of the project is to develop and validate a sustainable and economically feasible new value chain based on cultivation and processing, with the aim to transform microalgae biomass into valuable ingredients for food, aquafeed and cosmetics applications. Development and validation of new product formulations of microalgae are included in the project.

To achieve this, optimization was done: 1) Upstream, cultivation related processes via adaptation and selection of algae varieties, improvement of growing conditions and target product concentration in the cell and 2) downstream process steps (separation, extraction, purification) in order to achieve the overall aim to maximise the production of compounds of interest (phospholipids rich in omega-3 fatty acids EPA and DHA and fucoxanthin as main molecules). The work is supported by chain evaluation, market assessment, socio-economic impact assessment and LCA. Specific attention has been paid to the requirements of the existing EU regulatory framework.

The MAGNIFICENT consortium has 16 partners from 7 EU countries incl. 10 SME's, 3 LE's, 1 University and 2 RTO's, and comprises commercial partners in the entire value chain and the 3 target markets.
MAGNIFICENT started 3.5 years ago and the main results up to date.

Parallel Session I

Wednesday, 22 September 2021 1:30– 3:00 pm

Bioeconomy-related business models and sustainable entrepreneurship

Chair: Prof. Dr. Davide Viaggi, University of Bologna

Role of multinational enterprises in industry development in emerging market: Uruguayan forest sector

Mihailova, Irina[1], Rantanen, Sini[2], Tahvanainen, Veera[2], Pykäläinen, Jouni[2], Gabrielsson, Mika[1]

[1]University of Eastern Finland, International Business and Sales, Kuopio, Finland, [2]University of Eastern Finland, School of Forest Sciences, Joensuu, Finland

Relevance and aim of the study

The development of the pulp industry to a truly global in its scale has been associated with increasing involvement of multinational enterprises in the facilitating of activities of local entrepreneurial firms and industries in host countries. Currently, there is an extensive literature on the economic impact of multinational enterprises on host economies at a national or regional level, which focuses on productivity gains induced from the technological and managerial superiority of multinational enterprise. However, the impact of multinational enterprises on the performance and capabilities development of domestic firms has delivered contrasting results by showing two different effects: technology spill overs related to the technology space in which firms operate, and market rivalry dynamics that characterize firms' product market space. Both effects can either harm or benefit the performance of local companies, depending on the balance between gains and losses from technological opportunities and product market competition.

Thus, in order to address these contradictory findings, we aim to conduct an explorative research where we ask "how foreign multinational enterprise impact *emergence and development of industries in emerging markets.* Our objective is to undertake analysis at the firm- and industry levels and to examine how the presence of foreign multinational enterprise triggers local industrial growth and technological capabilities development of local entrepreneurial firms. We employ *the neo-institutional* and *network perspectives* to unveil the how various isomorphic pressures from foreign multinational enterprises and local government have jointly enacted the industry emergence and development in an emerging market.

Materials and methodologies used

We conducted a qualitative case study research in Uruguay forest sector and collected interview data from various industry stakeholders such as local firms, Finnish multinational enterprises as well as industry and government representatives.

Major results and findings

We enrich theorizing on the role of multinational enterprise in the industrial development in emerging markets by bridging together institutional and network perspectives.

Conclusion of your research

We develop a framework that enhances understanding about why and how the local industry succeeds and fails at different phases of development to benefit from foreign presence as well as complex impact of local institutions by delineating coercive, normative and mimetic pressures as well as network effects.

Efficiency Enhancement in Arable Farming in Hohenlohe based on Nutrient Recovery from Farm Manure: Agriplus Hohenlohe

Bauerle, Andrea[1], Müller, Benedikt[1], Karle, Thomas[2], Müller, Torsten[3], Lewandowski, Iris[1]

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Relevance and aim of the study

The targeted return of nutrients from liquid manure and biogas digestates to the corresponding cultivated areas often causes economic and logistic problems for the farmers concerned. The long and thus cost-intensive transport of agricultural residues from areas with intensive livestock farming should be avoided wherever possible. Furthermore, the local spreading of untreated residues often leads to environmental problems such as nitrate leaching or the formation of climate-relevant nitrous oxide emissions.

The European Innovation Partnership (EIP) Agriplus Hohenlohe addresses these problems in the Hohenlohe region and aims to increase the efficiency of arable farming by improving the nutrient management.

Materials and methodologies used

For this purpose, an industrial-scale plant was built in Füßbach, Hohenlohe in 2019. This plant enables the conversion of liquid manure and biogas residues into phosphorus and nitrogen fertilisers and an organic soil conditioner. These innovative fertilisers can then be specifically used in agriculture or cost-efficiently transported to areas with a prevailing nutrient deficiency.

Extensive agricultural on-farm trials are carried out in collaboration with four local farmers in order to compare the new fertilizers with commercial fertilizers as well as with untreated manure and digestate. In addition to the technical aspects, the project partners also integrate the logistical approaches of liquid manure transport as well as the production and marketing of the end products.

Major results and findings

The brief evaluation of the first results has shown that the new fertilizers are comparable to the other treatments. Unfortunately, the first vegetation period was affected by extremely dry weather. The field testing is continued to validate the obtained data and demonstrate the ongoing function of the system over several months.

Conclusion of your research

The project illustrates how sustainable agriculture can be fostered in Baden-Württemberg and exemplifies how nutrient cycles between livestock and arable farming can be merged. Agriplus Hohenlohe is thus making an innovative contribution not only to environmental protection, but also to stronger value creation in the region in accordance with the principles of a cycle-oriented bioeconomy.

The project is co-funded by the European Union and the Ministry of Rural Affairs and Consumer Protection in Baden-Wuerttemberg in the frame of the European Innovation Partnership "Agricultural productivity and Sustainability" (EIP AGRI).

External enablement of sustainability-oriented new venture creation: Entrepreneurial opportunities in the sustainable circular bioeconomy

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Relevance and aim of the study

Early conceptualizations of the field of sustainable entrepreneurship (SE) describe sustainable entrepreneurs as someone who identifies and exploits opportunities that arise from market imperfections causing environmental degradation or social harm and eventually contributes to a more sustainable future by reducing these market imperfections.

However, the micro-foundations needed to explain the entrepreneurial process of opportunity identification and exploitation for the field of SE remain unclear. Hence, this study aims to illustrate the entrepreneurial process in SE in the case of the sustainable and circular bioeconomy. Applying Davidsson's conceptualization of entrepreneurial opportunities through *External Enablement* [1], we propose a framework of the entrepreneurial process in SE.

Materials and methodologies used

We rely on a qualitative research design. We conducted semi-structured interviews with the (co-) founders of ten bioeconomy startups, that come all from EBU partner's networks, are younger than five years, sustainability-oriented, and innovative.

We asked the interviewees about their process of starting up and the challenges they were confronted with. Following a grounded theory approach, we employ open coding and axial second-coding to build eventually aggregate dimensions of a framework, that describes how opportunities for SE come into existence and how sustainable entrepreneurs act on them.

Major results and findings

We find four aggregate dimensions that describe the entrepreneurial process in SE for the bioeconomy case. S*ustainable valorization of biomass* and *marketing of biobased products* describe sustainable entrepreneurs' endeavors to identify viable business opportunities in the valorization of mostly so-far unutilized biomass, whereby the principle of cascading biomass use serves as an *External Enabler.* While *managing limited resources* refers to the typically limited access to resources during the venture creation process, the whole process is embedded in the fourth dimension of *transformative knowledge.*

Conclusion of your research

We see promising value in establishing the framework of *External Enablement* [1] in SE for the case of the sustainable circular bioeconomy. Especially, when considering additionally *transformative knowledge* [2] as an influencing factor on entrepreneurs' ability to evaluate the favorability of an entrepreneurial opportunity. It allows investigation into the characteristics of potential sustainable entrepreneurs and of opportunities and their interrelation.

References:
[1] Davidsson, P., (2015), Entrepreneurial Opportunities and the Entrepreneurship Nexus: A Re-Conceptualization, Journal of Business Venturing 30(5), 29-49
[2] Urmetzer, S., Schlaile, M., Bogner, K., Mueller, M., & Pyka, A., (2018), Exploring the Dedicated Knowledge Base of a Transformation towards a Sustainable Bioeconomy, Sustainability 10(6)

Entrepreneurial orientation as a factor influencing collaboration within bioeconomy clusters

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Relevance and aim of the study

Bio-based businesses are inherently interconnected given the integration of different and multi-output value chains aiming at the optimization of waste. Due to the complexity of emerging knowledge-based areas, they rely on a high degree of investments. It is required a large degree of collaboration to overcome the often-limited economic dimension of firms. In this sense, clusters play a fundamental role as an ideal environment for stimulating cooperative behaviours.The theme is highly promoted and it finds numerous empirical applications in the present scenario. However, the subject has not received attention in the literature. The collaborative behaviour poses numerous opportunities such as: higher bargaining power, higher investment capacity and facilitated access to information. The aim of the study is to investigate the relevance of clusters in the bioeconomy. In particular, the research focuses on the collaboration among selected representatives in the process of innovation dissemination. Consistently with this, we expect to identify the entrepreneurial orientation as a factor positively correlated to it.

Materials and methodologies used

The study starts from the existing literature on clusters with an emphasis on bioeconomy subsectors as defined by the EU ([EU]). We examine how knowledge transfer and learning processes are encouraged in collaborative settings and why they are crucial to foster sustainable transition. The analysis is carried out through a series of interviews gathering views from selected representative across EU.

Major results and findings

The research contributes at the development of a more comprehensive framework discussing the key role of clusters' synergies in supporting the development of bioeconomy fulfilling the present gap in the literature. We expect to be able to build a solid framework combining the sectoral and territorial experiences already existing in the European scenario and from the cluster theory.

Conclusion of your research

The novel aspect of the research is on the transformative role of stakeholders boosting the collaboration in bioeconomy. Through an empirical analysis we will evaluate the effectiveness of collaborative behavior. To conclude, the promotion of cooperation among stakeholders contributes to the progress of the bioeconomy directly associated with societal, environmental and economic benefits.

References:

[EU] Directorate-General for Research and Innovation (European Commission), (2018), A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bioeconomy Strategy, Bruxelles

Developing traditional ARA model to better capture the interlinkages between actors, resources and activities within the diversified business environment: Case-evidence from forest-based bioeconomy

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Relevance and aim of the study

No business is an island meaning that no business organization operates completely separated from other organizations and businesses existing within its operational environment. Business networks are observable structures of interrelated relationships existing among actors. Today's businesses are however becoming increasingly diversified and global in nature as digitalization is affecting the relationships with various actors within their network. Especially digital platforms have disrupted the operational environments of different business sectors. Despite these structural alterations, we still lack knowledge on how these changes influence the traditional business network-theories (ARA model by Håkansson & Johansson 1992). The aim of this research is therefore the one of scrutinizing how digital platforms alter the business structure and dynamics of an existing industry.

Materials and methodologies used

We conduct multiple case-study interviews with various actors operating in the Finnish forest-based bioeconomy industry. We gather extensive qualitative interviews with large multinational corporations producing paper, various small and medium sized firms commercializing forest and non-forest based bioeconomy products and platform businesses providing a large array of services to these actors. Our data analysis helps us to explain the diversified business environment spurring from the forest-based industry as a consequence of the structural alterations brought by platform businesses.

Major results and findings

We formulate a theoretical model explaining how actors, resources, and activities (ARA model) shift towards a model we name PARA, standing for Platforms-Actors-Resources-and Activities. We derive multi-fold scientific contributions. Firstly, by portraying the changes within the business-related structures and dynamics within the Finnish forest-based bioeconomy industry, we revise the traditional ARA model. We conceptualize a model including the unique characteristics associated with platform businesses and the role they play, which better captures the horizontal networking enabled by platform-based businesses across sectoral and country boundaries. Secondly, we illustrate how the diversified business environment and digital platform economy may disrupt the interrelation of actors, activities and resources within the entire business environment in traditional industries.

Conclusion of your research

Our findings help us to portray how the Finnish forest-based bioeconomy is a truly global and digitalized industry, forerunner in its kind.

Chair: Prof. Dr. Luisa Trindade, Wageningen University and Research

Extractive bioconversion process for the production of bio-based organic acids: an integrated biological and separation model

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Relevance and aim of the study

Microbial production of organic acids from renewable sources is a promising alternative to chemical ways in a bioeconomy context. The accumulation of inhibitory metabolites in culture media is still challenging for the implementation of biotechnological processes. In order to overcome this drawback, reactive liquid-liquid extraction assisted by Hollow Fiber Membrane Contactors (HMFC) is an encouraging strategy for in-stream product recovery (ISPR), since selective continuous product removal is possible, avoiding dispersive contact between aqueous and organic phases. Recently, ISPR modeling is drawing a lot of attention as a tool for bioprocess optimization. Nevertheless, few models considering biological and extraction reactions can be found in literature (Van Hecke et al., 2014).

This work aims to develop an integrated model describing extractive bioconversion for organic acids. The modeling approach is applied to 3-hydroxypropionic acid (3-HP), one of the most attractive building blocks to be produced from biomass (Bozell & Petersen, 2010). There are no models so far describing extractive bioconversions for 3-HP.

Materials and methodologies used

A model for biomass growth, substrate consumption and 3-HP production by *Acetobacter* sp was coupled with a reactive liquid-liquid extraction model of the acid by a tertiary amine in an HFMC.
Experimental validation was done in a 2.5 L bioreactor for bacterial growth in aerobic conditions. Bioconversion was triggered by adding 1,3-propanediol at ~ 6 g/L. Once substrate was depleted, a second addition at 6 g/L was done. pH control was achieved by ISPR consisting in a HFMC with a biocompatible organic phase circulating. The organic phase was regenerated in contact with a back-extraction phase in a second HMFC thus obtaining 3-HP in an aqueous phase. Metabolites concentrations were analyzed by HPLC. Microbial growth and physiological state were assessed using OD_{600} and flow cytometry, respectively.

Major results and findings

The proposed model describes successfully the evolution concentrations of chemical and biological species in all the phases involved in the process. Biological production of 3-HP was found to be faster than extraction by HFMC which turned out to be the limiting step. The developed model will be key test various process configurations to overcome this limitation.

Conclusion of your research

The development of integrated models for organic acids is a valuable tool for bioprocess optimization. The proposed modeling approach work can be extended to a large number of organic acids.

Cascading PROcesses to extract and valorise proteins and bioactive molecules from Legumes, Fungi and Coffee agro-industrial side streams - THE PROLIFIC project

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Relevance and aim of the study

Globally, 1.3 billion tons per year of biomass end up as co-products, residues and waste along the food chain (from field to fork). On the other end the projected global demand for proteins and bioactive compounds will be in 2030 well exceeding current production capacities, giving the rising world population. Agro-industrial residual biomass, side streams and food production byproducts may represent rich sources of valuable ingredients. Yet their potential is to be developed and the routes for their exploitation are still at an early stage. This is where PROLIFIC comes in. The project aspires to recover significant amounts of proteins, peptides, fibers and other value-added compounds from legumes, fungi and coffee processing residues.
For that, the PROLIFIC team optimizes, validates and scales up an integrated array of cascading extraction processes starting from non-compliant and wasted seeds of peas, green beans and chickpeas, leftovers of different fungi species, coffee silver skin and non-compliant coffee green beans.

Materials and methodologies used

A wide range of green extraction techniques are applied and the extracted molecules (i.e. proteins/peptides, polyphenols, fibres, chitosan) are validated for their safety and composition, and tested for a wide range of bioactivities in order to find several high-value applications in the food, packaging, cosmetic and feed sectors.

Major results and findings

Various different product prototypes from different industrial sectors, will be developed at the end of the PROLIFIC project such as high protein baked goods and breakfast cereals, functional packaging for meat products for extended shelf life, functional coffee capsules and cosmetic packaging, nutrient enriched or antimicrobial ingredients for animal feed, anti-aging or whitening property compounds for cosmetic products. The project also assesses the environmental, societal, ethical, safety and regulatory implications of its newly created value chains and develops economically competitive business strategies for the future commercialization of the developed product prototypes.

Conclusion of your research

In conclusion, within PROLIFIC, a highly integrated work plan is repurposing legume, coffee and mushroom agro-industrial side-streams and developing new bio-based value chains.

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Conditions for a bioeconomy transformation- Increased use of wood in construction

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Relevance and aim of the study

Climate change concerns all industries and countries, the construction sector in particular. It contributes to approximately one third of the greenhouse gas emissions. Construction practices, in particular choices of materials, are associated with opportunities for transitions towards circular bioeconomy systems. Wooden multi-storey construction (WMC) is an increasingly attractive alternative, due to possibilities for long-term carbon storage, substituting emission intensive concrete and steel in construction, and construction design that provides flexibility in the construction process. Many consumers also perceive matters such as naturalness and aesthetics as intangible benefits of wood. Increasing the use of wood in construction may provide growth to the whole forest-wood industry-construction value-chain and benefit local economies. Despite these drivers, WMC remains a niche in the residential construction sector, even in the forest-rich Nordic region.

Materials and methodologies used

In this project, we respond to this knowledge gap in an initial systematic literature analysis targeting to build a holistic research-based understanding on the WMC market, focusing on key barriers and enabling factors for WMC market growth, and key stakeholders.

Major results and findings

The results suggest that lack of experience from using wood in multi-storey construction, and path dependencies with concrete and steel industry are the key barriers for WMC diffusion. Enabling factors include benefits from increased prefabrication (e.g. material costs, safety and efficiency in construction processes) and perceived environmental benefits especially among consumers and architects. Key stakeholders covered in the literature include business actors (e.g. contractors, manufacturers and architects), whereas the literature from the residential perspectives and local governance mechanisms is more limited.

Conclusion of your research

The literature review supports the understandings of needs for empirical studies that captures key stakeholders' contributions to challenge the established concrete construction regime. These results guide the continued empirical studies in the research project (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/knock-on-wood/)

Designing sustainable biobased processing networks

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Relevance and aim of the study

Designing biorefineries is challenging since many feedstocks and processing technologies can be selected to obtain a range of marketable products. On a commercial scale probably various feedstocks and processing chains will be combined in a biorefinery network. To reduce the number of choices it is crucial to identify the most promising processing routes with both economic and environmental impacts taken into account.

Materials and methodologies used

A modeling approach is used to design and explore feasible processing routes in a biorefinery network. First, different processing technologies were listed and based on design targets a decision was for a limited number of these processes. These processes were combined in a processing network. Process simulation software was used to simulate the techno-economic performance and evaluate the Global Warming Potential. As example, we focussed on 3 agricultural residues, i.e. pig manure, sugar beet leaves, and wheat straw. The resulting network contains all feasible 1184 processing routes for the combination of the 3 residues.

Major results and findings

The iterative design method for processing networks enables the identification of optimal biorefinery systems within a large superstructure. In the best-balanced process for the 3 combined residues, the straw is digested. From the digestate, both struvite and organic fertilizer are produced. High-value Rubisco protein is extracted from the press juice of the sugar beet leaves while the fiber is dried and used as feed for cows. Nine process routes were identified as Pareto optimal. However, not a single route balanced both objectives best. In the best-balanced process, straw is digested. From the digestate, both struvite and organic fertilizer are produced. High-value Rubisco protein is extracted from the press juice of the sugar beet leaves while the fiber is dried and used as feed for cows. The type of process and scale of the processes have a great effect on the financial feasibility and environmental sustainability.

Conclusion of your research

With this method, a process route for the selected residues could be designed which integrates different biorefinery systems and is both financially attractive and environmentally friendly. A great advantage of the iterative nature is that it allows for adaptations of the superstructure based. The method could be extended with validation of the models and in risk quantification steps.

Edible basidiomycetes mediated bioprocess upcycles food side streams in a circular economy – cases study acid whey and pulse serum

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Relevance and aim of the study

In Europe, the matter of disposal and reuse of acid whey have become intractable problems of the industry owing to the high organic load, the low pH value and the intense off-flavor. The foreseeable food transformation from animals- to plants-base will lead to an analogue technical problem on sustainable recycling of serum from pulse-based vegan alternatives. In response of these challenges, our research developed basidiomycetes-driven fermentation process to upcycle both sorts of by-products, thus establishing a circular system where the low value waste is returned to food production chain as value-added mycoprotein, polysaccharides and flavors and novel drinks.

Materials and methodologies used

Edible basidiomycetes were used as key toolbox in the biological recycling of acid whey and soy serum, as they can adapt to a wide variety of substrates and form various odorants through their extracellular enzymes (secretomes).

Major results and findings

Our preliminary research revealed that many selected basidiomycetes well coped with the milieu conditions in sour whey (pH 4.3-4.6) and soy serum (pH 5.2), some of which were suitable for changing their off-aroma to diverse and intense pleasant flavors (e.g., marzipan-like, fruity, or nacho-cheese-like flavors) within 3 days. These findings pave a way for isolation of high valuable natural flavorings (EC 2008) as well as entire re-utilisation as innovative fermented drinks (e.g., Fungtn, UK; 2020) in economic merit. Besides, a number of fungal mycelia known as good sources of mycoprotein (EC 1997) and polysaccharides were harvested in the basidiomycetes-mediated process. Remarkably, we found that one mycelium during the fermentation of soy serum created an additional value-added property on flavor (intense savory, baked cheese-like), which has hardly been noticed so far besides the reported nutrition and texture of mycelia.

Conclusion of your research

To wrap up, through the targeted combination of edible basidiomycetes and the substrates with help of dedicated control of fermentation, the biological process could realize upcycling of acid whey and soy serum with zero waste. It also provided a new insight that both the flavor profile of the substrates and the fungi (mycelia) were modulated, thus further enhancing valorisation of the wastes. The fermentation system described has model character and can also be used as a platform technology for value creation from other organic side streams.

Sustainable biobased resources and ecosystem services for the bioeconomy

Chair: Prof. Dr. Benoit Gabrielle, AgroParisTech

Agricultural biomass at local scales: which managements and utilizations between compartmentalization, competition or integration?

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Relevance and aim of the study

Agricultural production in France has a high level of "efficiency". More agricultural biomasses are produced with a drastically decreasing number of farms over the last decades. However, French agriculture is facing strong challenges: fossile energies are the only used sources (out of the solar one) and mineral as Phosphorus are extensively used; agricultural production, as an inherent biological property, is impacting the environment (positively and negatively) including the climate; and due to an increasing World demand, there is a fierce competition regarding agricultural biomasses between food, feed and energy uses. Thanks to these complex issues, a consortium of interdisciplinary researchers proposed to develop a method based on socioeconomical metabolism approaches to help local agricultural stakeholders to improve their capabilities to manage the compulsory local ecological transitions.

Materials and methodologies used

The program was funded by the French Agency fo the Ecological Transition.This presentation is focusing on the North of the Aube (NA) department (in the Champagne region). In NA, agricultural production is cash-crops sold in Europe and abroad: wheat, barley, rapeseed, sugar beet, alfalfa, etc... Farms are several times the size of the average French farms and big companies, private or owned by cooperatives, are collecting, transforming and selling the local production. A three steps approach was performed: 1) Any quantitative database dealing with the local agricultural socioeconomic metabolism were analyzed to propose first representations 2) semi strutured interviews were performed with two populations: leaders of the local agricultural chains and a large sample of representative farmers from the territory 3) workshops with local leaders were organized to validate the diagnosis from steps 1 and 2 and to propose actions for the ecological transitions

Major results and findings

The combination of database and interviews stressed the complexity of depicting the agricultural biomass dynamics at local levels and the deadends of targetting an exhaustive representation. However, this combination and the workshops helped the stakeholders to improve their capacities to deal with complex issues, as the choices between agricultural biomasses utilizations.

Conclusion of your research

Representing and debating with agricultural stakeholders local socioeconomic metabolism are a fruitful way to stress the key-role of agricultural biomass utilizations in the compulsory ecological transitions to be observed in the coming years.

QUABIO project: application of simple and complex indexes to assess soil quality under conventional and organic management

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Relevance and aim of the study

Bioeconomy is based on sustainable use of renewable natural resources. Soil use and management are central point for a sustainable bioeconomy in terms of carbon conservation, soil quality and ecosystem services. Organic management aims to maintain and/or enhance soil quality with the adoption of cover crops, reduced tillage and application of organic fertilizers, thus being a great opportunity when talking about agronomic sustainable management.
To study this thematic, was chosen the MOnsampolo VEgetable organic long-term field experiment (Marche Region, Italy) that consists in a comparison between conventional (Conv) and organic (Org1 –with compost- and Org2 -intercropping with *Vicia faba*-) management.

Materials and methodologies used

Soil samples were analyzed for organic carbon (C) and nitrogen (N) pools and nine enzyme activities. Simple soil quality indexes such as the Specific Enzyme Activities (SEA, ratio of enzyme activity and microbial biomass C), the metabolic quotient (qCO_2, ratio of soil respiration and microbial biomass C), and the metabolic index (MI, ratio of dehydrogenase activity and extractable C) were measured. Soil ecosystem ratios (ratio of the natural logarithm of the enzymatic activities, i.e. N:Penz=ln(N-acetyl-β-glucosaminidase):ln(phosphomonoesterase)) and soil quality index (SQI, determined with a process including indicator selection and scoring, and socres integration into the index) were determined as complex indexes.

Major results and findings

Results highlight that Org1 and Conv promoted extractable C (+16%) and N (+42%), while microbial C and N result enhanced by Org1 and Org2. Hydrolytic enzyme activities involved in C and N cycles showed higher values with the Org1 (+15÷57%), while SEA showed lower values with the Org2. The qCO_2 and the MI showed opposite trends: qCO_2 decreased and MI increased following the order Conv<Org1<Org2. The C:Nenz increased with Conv<Org1<Org2, while C:Penz and N:Penz showed lower values with the Org2 (-11 and -18%). The SQI showed the lowest value in Conv with no significant differences between Org1 and Org2.

Conclusion of your research

The two organic managements led to better soil quality however, some differences emerged, highlighting that soil quality indexes considered were able to discriminate also between the different organic approaches. In the future it will be important to give an economic value to that indexes in order to valorize the most sustainable agronomic practices for soil quality improvement and for sustainable bioeconomy implementation.

Perennial wildflower mixtures for bioenergy and biobased products - Current status and future prospects

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Relevance and aim of the study

The research object of this study is a wild plant mixture (WPM) of annual, biennial and perennial flowering herbaceous wild plant species developed in Germany between 2008 and 2012 as part of a nationwide research project [1]. The aim was to help diversifying monotonous maize-dominated biogas cropping systems and increase ecosystem services other than biomass supply such as agrobiodiversity, erosion mitigation, groundwater protection and landscape aesthetics. In this regard, ten years of practice and research have shown that the development of the WPM was a success, whereas the utilization pathway deserves a closer examination. So far, WPM biomass was used for anaerobic digestion. However, it was found that the methane yield per hectare of WPM is significantly lower than that of common biogas crops such as maize, inducing both higher land use change effects and greenhouse gas emissions [2].

Materials and methodologies used

The most relevant wild plant species (WPS) common tansy (*Tanacetum vulgare* L.), common knapweed (*Centaurea nigra* L.) and mugwort (*Artemisia vulgaris* L.) were selected to investigate their suitability for thermochemical conversion. For this purpose, plant material from aboveground withered WPS as well as from *Sida hermaphrodita* L. Rusby (hereafter referred to as Sida) was harvested in February 2020, and both ash melting behavior and higher heating value were determined.

Major results and findings

For WPS, it was found that combustion resulted in about two times higher energy yields than anaerobic digestion. Furthermore, the WPS showed similar ash melting behavior to that of Sida, i.e. the ash did not sinter at temperatures up to 1100 °C. In general, the suitability of WPS as a solid biogenic fuel for combustion was found to be very similar to Sida.

Conclusion of your research

Therefore, the use of WPS for combustion could be feasible due to good combustion properties and a higher energy yield compared with anaerobic digestion. The positive impact of WPS on the agroecosystem can be significantly extended in case of combustion due to winter harvesting. It remains open as to whether WPS biomass can also be used for biobased products.

References:
[1] Von Cossel, M., (2020), Renewable Energy from Wildflowers—Perennial Wild Plant Mixtures as a Social-Ecologically Sustainable Biomass Supply System, Wiley, Advanced Sustainable Systems, 2000037, https://doi.org/10.1002/adsu.202000037
[2] Lask, J., Guajardo, A.M., Weik, J., Cossel, M. von, Lewandowski, I., Wagner, M., (2020), Comparative environmental and economic life cycle assessment of biogas production from perennial wild plant mixtures and maize (Zea mays L.) in southwest Germany, Wiley, GCB Bioenergy, 571–585, https://doi.org/10.1111/gcbb.12715

Influence of environmental conditions on growth parameters, grain yield and oil quality of five Amaranth genotypes

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Relevance and aim of the study

Amaranth grain oil is valued for its content in omega fatty acids, squalene, and antioxidants, giving it great potential for the food, nutraceutical and cosmetics sectors. Of special nutritional interest are the omega fatty acids as some of them are essential for humans, and have to be taken up through the food chain to prevent coronary disease. Previous studies indicated the distribution and diversity of amaranth, which was domesticated several times independently in Central (*A. hypochondriacus* and *A. hybridus*) and South America (*A. caudatus* and *A. cruentus*). In this study, it is hypothesized that the growth parameters, grain yield and oil quality for *A. caudatus* can be influenced by low temperature 22°C/16°C and 12h/12h photoperiod for day/night as they are adapted to the environmental conditions of the Andes and that those parameters may differ from the genotype *A. hypochondriacus, which is* coming from the South-Mexican-Caribbean biodiversity hotspot.

Materials and methodologies used

Four genotypes of species *A. caudatus* and one of *A. hypochondriacus* were cultivated in pots and grown in three different environments: firstly, greenhouse conditions simulating the South-Mexican-Caribbean environmental conditions; a climate chamber with temperature 22°C/16°C and 12h/12h photoperiodic conditions after flower induction simulating the environmental conditions of the Andes; and finally, outdoor conditions (South west of Germany).

Major results and findings

The exposure of *A. caudatus* to the greenhouse environment caused delayed flower induction and resulted in increased vegetative growth with yields of thousand grain weight (TGW) of 0.60 g to 0.69 g. Whilst *A. caudatus* plants subjected to the simulated environmental conditions of the Andes throughout their flowering periods reached seed maturity substantially faster and exhibited heavier grains TGW of 0.66 g to 0.87 g. Oil yields for *A. caudatus* were significantly higher between 5.78 to 6.26 % in simulated environmental conditions of the Andes, when compared to 4.79 to 5.6 % in greenhouse conditions. Fractions for all analysed samples varied for palmitic acid varied from 19.78 to 22.08 %, for oleic acid from19.1 to 24.68 %, for linoleic acid from 48.8 to 52.82 % and for α-linolenic acid from 0.66 to 1.18 %.

Conclusion of your research

It is concluded that due to its genetic diversity and morphological plasticity the grown *A. caudatus* genotypes represent a promising genetic resource, but further adaptations might be needed to become suitable for central European conditions.

Site impacts nutrient translocation efficiency in intra- and interspecies Miscanthus hybrids on marginal lands

Magenau, Elena[1], Ashman, Chris[2], Ferrarini, Andrea[3], Kiesel, Andreas[1], Kontek, Mislav[4], Martani, Enrico[3], Roderick, Kevin[2], Clifton-Brown, John[2]

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Relevance and aim of the study

The growing bioeconomy increases the demand for biobased resources. Therefore, reliable yields are required, which are typically achieved by fertilisation. However, fertiliser production and application have a negative environmental impact as its production is energy demanding and its application can lead to environmental pollutions. Additionally, there is a global shortage of some nutrients, and therefore, the existing fertilisers are needed to reach worldwide food security. Therefore, biomass grown with a low or even no fertiliser demand is required as resources for the growing bioeconomy. Miscanthus is a biobased resource that can be produced with a low fertiliser amount due to its high nutrient use efficiency and its active and passive nutrient recycling. It is assumed that nutrients are actively translocated from the above-ground biomass into the rhizomes at the end of the vegetation period. Moreover, overwinter nutrients are relocated to the soil by leaf fall and leaching of water-soluble nutrients from the standing biomass. Up to now, nutrient contents of miscanthus biomass has been determined mainly for the genotype *Miscanthus giganteus*. This study aims to quantify the nutrient concentrations and stocks in the above-ground biomass of different miscanthus hybrids over one year at four different climatic locations in Europe.

Materials and methodologies used

Therefore, the biomass was estimated, and the nutrient concentration analysed from emergence until harvest. A sample of ten shoots per plot was taken biweekly with a cutting height of 10 cm. Of these samples, the ash and nutrient concentrations were analysed. Additionally, the core plots were harvested in spring 2021 to determine the nutrient stock. By the ratio between the harvested yield of the core plots and the weight of the ten shoot sample, the biomass over the vegetation period was estimated and the nutrient stock calculated.

Major results and findings

The ash and nutrient (nitrogen, phosphorus, potassium, calcium, magnesium) concentrations declined at the beginning of the vegetation period significantly and were relatively constant over winter. Only minor differences between the hybrids were found, but significant differences between locations.

Conclusion of your research

In conclusion, the ash and nutrient concentrations of the miscanthus biomass during the vegetation period are mainly influenced by the local site conditions and only miner influenced by hybrid-specific characteristics as emergence and flowering.

Chair: Dr. Martin Greimel, University of Natural Resources and Life Sciences

Bioeconomy and circular-economy in the forest sector: a systematic review

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Relevance and aim of the study

The circular economy (CE) and the bioeconomy (BE) are two concepts seeking to address sustainability issues. They were both developed over the last decades based on new approaches to the relationships between the economy and the environment proposing alternatives to linear economic models based on resource extraction. Recently, the combination of these two concepts with shifting contours produces a complex nebula of interpretations, where the least ambitious conceptions of sustainability often dominate. Consequently, there is an ongoing need to clarify the criteria defining a sustainable CBE as well as its goals and how strategies seeking to foster its implementation contribute to reaching them.

Materials and methodologies used

In this presentation, our general aim is to perform a state-of-the-art of the literature about CE and BE to clarify how they have been conceptualised and operationalised in academic research focused on the forest sector. We systematically explore the literature in several steps. First, we perform a keyword-based systematic search on academic databases, then a multi-layered network analysis on the set of retrieved papers is conducted and highlights the structure of the field, as well as dynamics within each research cluster.

Major results and findings

Among economic sectors, the forest sector is often taken as an illustration for the development of CE and BE. We underline the presence of methodological, conceptual, disciplinary and geographical divides in research on the forest BE and CE. We present an objective and quantified overview of the scientific literature, identify the different definitions of the concepts and document how they have been (and are being) developed across several research clusters. We then address key issues that are transversal to the development of forest CBE, and which may therefore be relevant for other sectors where the concepts are being used.

Conclusion of your research

This systematic analysis of the literature draws our attention to two specific, transversal questions which, in our view, need to be specifically addressed, and which we investigate by performing a more in-depth, narrative reading of the corpus of retrieved publications. These two issues concern (1) the insufficient accounting for the spatial dimension of the forest CBE, particularly at the territory scale and (2) the need to clarify how sustainability assessments of forest CBE should be performed, especially in a context of transition.

Potentials, Subsidies and Tradeoffs of Cellulosic Ethanol in the European Union

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Relevance and aim of the study

The EU's revised Renewable Energy Directive (RED2) sets high mandates for advanced biofuels like cellulosic bioethanol from agricultural residues. However, many residues are used for ecological and economic purposes such as soil organic carbon regulation and livestock bedding and fodder. The aim of our study is to comprehensively analyze the use of agricultural residues for cellulosic ethanol as postulated by the EU in the RED2 mandate by taking potential feedback effects with other uses into account and analyzing the actual magnitude of residue demand. Moreover, we investigate the size of potential subsidies per litter of cellulosic ethanol and the sensitivity to residue and oil prices.

Materials and methodologies used

We use an extended version of the global CGE model DART-BIO with a detailed representation of the bioeconomy to simulate the RED2 cellulosic bioethanol mandates and run sensitivity analyses regarding processing technology, straw and oil prices. We explicitly model the production of agricultural residues from different cereals and include a latent cellulosic ethanol sector that processes residues using both hexose and pentose sugars for fermentation.

Major results and findings

We find that the RED2 cellulosic ethanol mandates will require enormous amounts of residues that could exceed the sustainable available potential in the EU. Agricultural residue utilization changes substantially and the cellulosic ethanol industry becomes the main residue consumer. Results show that output and price impacts of advanced biofuel targets are small, but there is reallocation of land towards cereals that enter the agricultural residue sector away from other crops in the EU. Moreover, the size of cellulosic ethanol subsidies is very sensitive to actual straw and oil prices, so that climate policies should support the phasing in to reduce the size of subsidies.

Conclusion of your research

The introduction of cellulosic ethanol to the European transport sector must be handled very carefully to avoid trade-offs with competing users of agricultural residues. While we put a first number on the actual magnitude of residues needed to fulfil the EU advanced biofuel mandates, a comprehensive analysis of the environmental trade-offs arising from the increased demand for residues is vital. Given that the ecosystem is not a market player and cannot react to increased demand and price changes, the chances that the mandates will come at the cost of the environment and not the economy are high.

The potential of the Living Lab approach to stimulate responses to the challenges of the forest bioeconomy

Arnould, Maxence[1], Morel, Laure[2], Fournier, Meriem[3]

[1]Equipe de Recherche sur les Processus Innovatifs (Université de Lorraine) - UMR Silva (INRAE, AgroParistech, Université de Lorraine) - ADEME, Nancy, France, [2]Equipe de Recherche sur les Processus Innovatifs, Université de Lorraine, Nancy, France, [3]UMR Silva (INRAE, AgroParisTech, Université de Lorraine), Nancy, France

Relevance and aim of the study

Today, the development of the forest bioeconomy stimulates not only participatory processes but also and above all innovation. Indeed, it is necessary to have a cohesion and a collective organization of the concerned stakeholders to design innovative, adaptive and resilient forest systems in a rapidly changing world. Thus, we propose in our research to study the potential of the Living Lab participatory innovation approach. Our objective is to show how this approach is adapted to meet the challenges of the forest bioeconomy. We will show some examples of the results of our forestry Living Lab, which aims to involve more small private owners in the challenges of the French forest bioeconomy.

Materials and methodologies used

Living Labs are defined as open innovation ecosystems that engage, through a user-driven co-creation process, all stakeholders in the form of a Public-Private-Population Partnership (PPPP) to co-create products, services, social innovations... in a real-world context [Ref01]. Our methodology used is based on the main activities of a Living Lab: an analysis and integration of uses in the design process, collaborative work and experimentation of solutions in a real context [Ref02]. These activities are then facilitated and animated through co-creation, collective intelligence and user-centered methods.

Major results and findings

Our main results concern the co-construction of methods for the management, animation and facilitation of a Living Lab participatory innovation process that aims to address the challenges of the bioeconomy. Tools were also co-created with stakeholders to help in decision making, to characterize and understand users, to facilitate participatory workshops, etc. Finally, we will also show our results concerning the new mode of governance at the scale of a territory brought by the Living Lab.

Conclusion of your research

To conclude, we believe that Living Labs bring a new vision and organization to address the challenges related to the forest bioeconomy. The conciliation of the divergent opinions of the stakeholders is possible thanks to this participative innovation process conducted in the form of scientific mediation.

References:
[Ref01] Mokter Hossain, Seppo Leminen, Mika Westerlund, (2019), A systematic review of living lab literature, Journal of Cleaner Production, 976-988
[Ref02] Nathalie Skiba, Laurent Dupont, Laure Morel, Claudine Guidat, (2012), A space for innovation process acceleration, supporting collaborative citizens workshops, 18th International Conference on Engineering, Technology and Innovation

DigiFoodTwin: Digital Biophysical Twins in Food Processing

Noack, Tanja[1, 2], **Krupitzer, Christian**[1, 2]

[1]University of Hohenheim, Department of Food Informatics, Stuttgart, Germany, [2]University of Hohenheim, Computational Science Lab, Stuttgart, Germany

The term Industry 4.0 refers to current technological changes in the environment of industrial production enabled by advances in information technology. The focus of Industry 4.0 is the smart factory, i.e., the connection of cyber-physical production systems with Internet of Things (IoT) technology as well as intelligent data analysis. Whereby a core element is the *digital twin*: a virtual model of a product or process created with data collected by sensors that enables simulations or real-time analyses of the status of production.

The use of digital twins seems beneficial in food processing for various reasons. The Corona pandemic demonstrated the vulnerability of food supply resilience. To ensure the supply of food, production processes must allow a high flexibility and adaptivity. Furthermore, product quality is influenced by different quality levels of input materials. Especially in case of seasonal fluctuations of this raw material quality, an adjustment of parameters in the production process is essential. Introducing new products that are related to existing ones is also a challenge in food manufacturing. These introduction processes could be simplified by a digital twin of already existing products. In addition, product recalls (e.g., due to incorrect best-before dates) show that processes in the industry are still not 100% controllable.

However, digital twins of food products have additional specific requirements compared to digital twins of material goods. Due to the variability of raw materials, these cannot be based only on the processing steps, but must also take into account the chemical, physical, or (micro)biological properties of food.

The goal of this project is to create a *digital food twin* that can be used to track the current state of production at any time. While Industry 4.0 approaches often focus on the analysis of machine data, this project aims at a product-related data analysis (e.g., the effects of pressure exerted by machines). With the help of machine learning (ML) and artificial intelligence methods, the digital twin will be generated from production data and other data sources (e.g., scientific models, process data, or raw material data) to ensure the traceability of the current production and the food status, but also to enable the simulation of the variability of the food in the processing process.

The Smart, Digitized Food Supply Chain with Machine Learning

Henrichs, Elia[1, 2], **Krupitzer, Christian**[1, 2]

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The survey [1] "Die Ernährung 4.0 - Status Quo, Chancen und Herausforderungen" (Nutrition 4.0 - Status Quo, Opportunities and Challenges) by Germany's digital association Bitkom and the Federation of German Food and Drink Industries (BVE) showed that 70% of the more than 300 companies surveyed in the food industry consider end-to-end traceability from the origin of the goods to the customer to be an important scenario for the current decade. Various types of sensors exist to support this. The required technologies for Big Data analysis or blockchain for decentralized, unchangeable data storage are slowly finding their way into the industry. However, the potential is far from being exploited. In particular, there is no real-time integration of the sensors with the blockchain and data is analyzed retrospectively "in the cloud".

This project focuses on the intelligent integration of diverse technologies within the food supply chain to support food traceability and safety. Novel sensors integrated into the packaging design support the targeted collection and storage of relevant data in the blockchain. By integrating current trends in *machine learning on the edge* (Edge ML) [2], i.e. the analyses take place directly at the point of the data's origin and not retrospectively in the cloud, so the analyses are made possible in real time. This also allows forecasting to be integrated, for example, to predict critical conditions predictively and act adaptively instead of only identifying critical conditions afterwards. Since these analyses require a lot of computing power, they are often energy-intensive. Similarly, the sampling rate of sensors is often fixed and a lot of data is analyzed without detecting behavioral changes. In this project, intelligent monitoring techniques will be integrated to reduce the amount of data in the analysis and thus both the energy required and the computational line.

References:

[1] Bitkom and BE , (2019), Die Ernährung 4.0 - Status Quo, Chancen und Herausforderungen, https://www.bitkom.org/sites/default/files/2019-03/Bitkom-Charts%20190326%20Digitalisierung%20der%20Ern%C3%A4hrungsindustrie.pdf

[2] J.Sicking, T.Wirtz, A.Voss, and N.Paul, (2019), Maschinelles Lernen »On the Edge«, https://www.iais.fraunhofer.de/content/dam/iais/pr/pi/2019/WhitepaperMachineLearningontheedge/Whitepaper_Machine-Learning-on-the-edge_FraunhoferIAIS.pdf

Tools in Bioeconomy education

Chair: Gerlinde van Vilsteren, Wageningen University and Research

Strategic Partnership ABBEE (Accelerating the transition towards the Bio-Based Economy via Education)

The **overall objective** of this Strategic Partnership is to inspire and train a new generation of (bio-based economy) students and help accelerating the transition towards a bio-based economy via education of future professionals. New educational approaches can inspire students, professionals and entrepreneurs to become more active in the bio-based society. The focus of ABBEE is on developing, transferring and implementing innovative practices in the field of bio-based economy and to exchange experiences at a European level.

The project is a collaboration of four universities with different expertise. It is coordinated by Wageningen University as the lead partner. The leading companies, like BIOPRO GmbH, Metsä Group, INBIOM, SEGES and Start Life, have given input to these courses.

Outcome - For the four new courses the learning objectives, assessment rubrics and the course descriptions are ready and have been validated within the ABBEE-team (peer reviews by teachers and students). The courses fit in within the study program of the leading university as well as be a relevant add-on to the study program of the other universities. The four courses together will form an interesting portfolio for MSc-students as well as professionals. The online courses are available via www.abbee.eu and via the European BioEconomy University

The Course "Concepts of Sustainable Economy" (lead partner: University of Hohenheim) is defining the concept of bioeconomy. The courses "Forest bioeconomy in Europe" (lead partner: University of Eastern Finland) and "Sustainable Agroproduction for biorefinery and bioenergy" (lead partner: Aarhus University) are providing the biomass and infrastructure. To make a sustainable impact, we offer the course "Advanced Sustainable Entrepreneurship" (lead partner: Wageningen University).

Additional outcome

- Professional learning: via an online survey and in-depth interviews we've asked the industry to define their requirements for (future) employees for their biobased activities as input for the learning objectives. The courses are available for professional learners.
- BISC-E: WUR, in close cooperation with TKI-BBE and BIC, has launched the Biobased Innovation Student Challenge – Europe. This challenge is now adopted by BIC.
- Mapping of MSc-study programmes in Europe on biobased economy is available.

Collection of awareness-raising, communication and education tools from European sources

Grande, Marco Maria[1], Maccaferri, Simone[2], Viaggi, Davide[1]

[1]ALMA MATER STUDIORUM - Università di Bologna, Department of Agricultural and Food Sciences, Bologna, Italy, [2]ALMA MATER STUDIORUM - Università di Bologna, Research Services Division (ARIC), Bologna, Italy

Relevance and aim of the study

The transition towards a sustainable bioeconomy can lead to positive environmental and socio-economic impacts. Making people aware of this potential and providing the needed skills in the bioeconomy are key challenges for change[1].
This work aims to evaluate the existing tools for awareness-raising, communication, and education activities in the European Bioeconomy. The twofold aim is to improve knowledge about information exchange in the Bioeconomy and, in this way, further fostering the exploitation of these tools.
This work was supported by the European Union under the Horizon 2020 research and innovation programme, through the project Transition2BIO (GA No. 101000539).

Materials and methodologies used

Relying on the experience of the Transition2BIO's consortium, we gained the sources from which to start the collection. We consulted the resources of relevant projects and initiatives from the European Bioeconomy Library (EBL), the European Bioeconomy Network, the members of European Bioeconomy University, and the EC Joint Research Centre and Knowledge Centre for Bioeconomy. The tools were classified using the contents type categories of the EBL.

Major results and findings

A total of 749 tools were collected from 77 different sources. The tools targeted mainly (and by large) the multipliers (79%) of the European Bioeconomy, while less attention is given to the demand side (7%) and the supply side (12%). Most of the tools were in English (81%), but the tools available in other languages showed a large linguistic diversity including 18 languages. “Project deliverables” and “Presentations” are the most frequent contents type, followed by “Publications”, “Factsheets”, “Videos”, “Case studies”, and other less represented categories.

Conclusion of your research

Our preliminary results suggest an unbalanced attention of the main actors developing contents and tools for who may amplify their messages, instead of focusing on their end targets. English predominance is a possible limit to the usability of the tools, as even multipliers usually enjoy materials in their native languages[2]. Further work is needed to enlarge our research and evaluate the use of the tools.

References:
[1] European Commission, (2018), A sustainable bioeconomy for Europe - Strengthening the connection between economy, society and the environment: updated bioeconomy strategy
[2] DESIRE, (2013), REACH OUT Toolkit, http://desire.eun.org/toolkit

Abstract about a new education project which promotes transition to an ecologically sustainable society.Solutions to biodiversity questions are sought through networked co-operation between universities

Hämynen, Elli, Oksanen, Elina

University of Eastern Finland, Department of Environmental and Biological Sciences, Joensuu, Finland

Relevance and aim of the study

Biodiversity is a prerequisite for the well-being of the planet and people, as well as for sustainable development. Biodiversity is declining at an alarming rate due to the unsustainable use of natural resources, climate change, the fragmentation of ecosystems, the spread of invasive species, the destruction of habitats and other human activities. In order to be able to take biodiversity into account comprehensively in all decision-making, education and co-operation in educational planning are needed. Diverse and multidisciplinary biodiversity education supports sustainability of bioeconomy at all levels.

Materials and methodologies used

The Universities of Eastern Finland, Helsinki, Oulu, Turku and Jyväskylä have launched a joint project to develop a nationwide biodiversity education network. The project is funded by the Ministry of Education and Culture.

The study themes aim to cover forests, waters, swamps, arctic and tropical ecosystems, agricultural environments and urban ecosystems.

A group of experts from the participating universities is collaborating in education planning and sharing expertise to identify the study contents and to find the blind spots in the education.

In the project, the selected courses will be digitalized and diversified to create an interactive package of biodiversity studies. Practical competence is very important in answering biodiversity-related questions and in finding sustainable ways of working in bioeconomy. This is why co-operation in organizing field courses is one target of the project and striving for more efficient use of field stations is seen important.

Major results and findings

Co-operating universities bring expertise from their areas of strengths for the use of the entire network. This supports learning possibilities of the students in all universities and also takes lifelong learning into account. As a result, a national biodiversity education network model, to meet the learning needs (skills and knowledge) in biodiversity issues, will be developed. This helps to understand the importance of biodiversity and ecosystem services better.

The project promotes Finland's transition to an ecologically sustainable low-carbon society and strengthens Finland's role in international biodiversity questions.

Shaping the concept of bioeconomy in participatory projects - An example from the post-graduate education in Finland

Tikkanen, Jukka, Research and Development group on Bioeconomy Education

University of Eastern Finland, School of Forest Sciences, Joensuu, Finland

Relevance and aim of the study

Takala, T., Tikkanen, J., Haapala, A., Pitkänen, S., Torssonen, P., Valkeavirta, R., Pöykkö, T. 2019. Shaping the concept of bioeconomy in participatory projects. An example from the post-graduate education in Finland. Journal of Cleaner Production 221 (2019) 176-188

Evolving complex concepts, such as bioeconomy, cannot be applied without selecting (consciously or unconsciously) some definitions and excluding others. This process of selection may have a considerable impact on how bioeconomy is understood. This paper presents how the concept of bioeconomy took shape in a participatory development project that created foundations for new professional specialisation studies within the Finnish bioeconomy.

Materials and methodologies used

Written documents (n 21), produced in different phases of the project, were analysed with qualitative content analysis to find out how bioeconomy was A) understood as an activity, and B) conceptually linked with different global meta-discourses.

Major results and findings

Bioeconomy was primarily understood as an intensive use of diverse biomasses within a forest cluster, agriculture, the food industry, waste management and the energy sector, whereas many other bioeconomy sectors were marginalised or excluded. The idea that biomasses should be saved was very rare, and the concepts that prioritise some biomass uses over others, such as the cascade principle, were excluded. Bioeconomy itself was understood as a societally and globally influential new way of thinking i.e. as a meta-discourse. Strong associations were also made to nationalistic and statist meta-discourses. Conceptual transformation during the project was most distinct in the sustainable development meta-discourse: sustainability turned from a self-evident characteristic of bioeconomy into a consciously reflected and desirable goal. The results illustrate how a common consensus of bioeconomy is built through exclusion and inclusion in a participatory development project.

Conclusion of your research

Project organisers should be conscious about this process and explicitly state how and why some aspects, actors and activities are emphasised while others are downplayed or excluded in their bioeconomy projects. Only then we can create far-reaching policies and considered actions to guide societies toward the desired and defined future.

Insights on jointly organized Bioeconomy specialisation education in Eastern Finland

Torssonen, Piritta[1], Tomppo, Laura[2], Pentinsaari, Tanja[3], Rantanen, Sini[4], Tikkanen, Jukka[5]

[1]University of Eastern Finland, School of Forest Sciences, Joensuu, Finland, [2]University of Eastern Finland, Department of Applied Physics, Kuopio, Finland, [3]Savonia University of Applied Sciences, Varkaus, Finland, [4]Karelia University of Applied Sciences, Joensuu, Finland, [5]University of Eastern Finland, Joensuu, Finland

Relevance and aim of the study

Lifelong learning is a key challenge for educators in all education levels globally. Towards this direction, many countries have developed novel education measures. Among others in Finland, the Ministry of education and culture launched, in 2015, the specialisation education as a form of novel lifelong learning. The specialisation education complements previous degrees for people working in certain professions in order to have stronger expertise in their current jobs. The specialisation education is offered in cooperation between the universities and employers in fields where degree programmes are not available.

Materials and methodologies used

Bioeconomy specialisation education has been designed in a national network of eight universities of applied sciences and two traditional universities to meet this challenge. The studies are implemented in regional university consortiums. University of Eastern Finland, Karelia and Savonia Universities of Applied Sciences, and companies and other organisations working in the field of bioeconomy developed a work-based model of learning and teaching, which was first piloted in the bioeconomy specialisation education in 2018–2019 and then developed further. Currently, the second group of students is participating in this education.
The concrete objectives of the development were:
- Tailoring the national bioeconomy specialisation studies for the needs of the business sector in Eastern Finland
- Adopting a work-based education model for the needs of Eastern Finland by utilising the best models and experience of work-based pedagogy
- Integrating the best bioeconomy expertise of the universities to solve the development problems of companies through training

For achieving these objectives, for example the following novel educational practices were piloted: double mentoring, company-specific development tasks, consistent support for peer-to-peer learning and blended learning. As mentioned different kind of pedagogical approaches were used in education. Students filled feedback forms after each course and various discussions were held during the studies. Students feedback and discussions are used to develop the education.

Conclusion of your research

Based on the feedback, the students see the provided education valuable for their professional development. However, there are challenges related, among other things, to activating the mentoring relationships as well as in the inflexible and varied administration practices of the co-operating universities.

Parallel Session II

Wednesday, 22 September 2021 3:30– 5:30 pm

Educate system changers: novel educational concepts and required skills profiles

Chair: Riitta Tegelberg, University of Eastern Finland

Bioeconomy Qualification programs

EBU Label

Lina Mayorga, University of Hohenheim

The successful integration of different scientific areas in an interdisciplinary approach is essential for the achievement of a number of sustainable Development Goals (SDGs) on various scales by the bioeconomy. The sustainable implementation of the bioeconomy requires changes and actions beyond technological innovations and economic aspects, and involves policy and society as a whole. Principles of a sustainable bioeconomy comprise the transformation of production and consumption models, innovative governance approaches, and understanding the embeddedness of the bioeconomy in society and planetary boundaries. The transition towards a bioeconomy is a priority in European policy and research agendas. This transformation process will be a major economic, social and environmental challenge for the European Union in the coming years. Given the crucial role of science in the bioeconomy, a key strategy comprises educating a new generation of European experts, fostering rigorous, relevant and responsible research, and transferring knowledge into society.

The European Bioeconomy University (EBU) wants to offer a common qualification supplement that will be granted to master students of bioeconomy-relevant study programs offered at the six EBU partners. By integrating the current curricula with the skills and competences that have been identified as crucial for bioeconomy curricula such as cross-sectoral mind-set and collaboration, inter- and transdisciplinarity, critical thinking, creativity and problem-solving, sustainability transformation and transition knowledge, among others, the students will be encouraged to develop a T-shaped skills profile consisting of disciplinary expertise, relevant soft skills as well as sustainability competences.

The EBU qualification supplement will encourage interdisciplinarity and collaboration by connecting students from different European universities. In addition, it will reward individual activities such as participation in optional soft skills trainings, summer schools, student challenges, entrepreneurial activities, etc. The EBU certificate thus promotes a form of study which views the bioeconomy from different perspectives and encourages thinking outside the (disciplinary) box.

This transnational approach will impact positively in the education of experts capable of shaping the system transformation to a sustainable European bioeconomy with a focus on regional and local challenges that fit into a broader panorama at European and global scale.

Fostering entrepreneurship for the bioeconomy: the FOEBE project.

Gabrielle, Benoît[1], Leblanc, Laura[2], Godaux, Marine[2] & all the representatives involved from the FOEBE partner universities: AgroParisTech, BOKU, University of Bologna, University of Eastern Finland, University of Hohenheim, Wageningen University and Research, & Warsaw University of Life Sciences.

[1] AgroParisTech, Department of Agriculture, Forestry and Environmental Sciences, Grignon, France.

[2] AgroParisTech, International Relations Office, Paris, France.

Bioeconomy is a key strategy for the European Union, whose thorough deployment is a prerequisite for the success of the Green Deal. This new, systemic approach, which includes different economic sectors and is based on circularity and sustainability principles, requires a paradigm shift in both training curricula and pedagogical practices to equip young professionals with sustainable entrepreneurship skills.

The FOEBE strategic partnership (funded under the Erasmus+ programme of the European Commission) aims at tackling this skills mismatch and becoming a game-changer for the bioeconomy education in Europe. Its overarching objective consists of equipping bioeconomy students at Master's and PhD levels with tailor-made sustainable entrepreneurship skills. Seven excellent higher education institutions, fully active and recognized under the umbrella of the European Bioeconomy University decided to join forces to provide the best possible training curricula to graduate students.

The general approach of FOEBE revolves around a blended learning format which combines e-learning and face-to-face sessions, with an emphasis on innovative pedagogical practices. FOEBE will offer a set of modules that students enrolled in bioeconomy Master's or PhD programmes can attend as extra or elective courses. This will provide an "enhanced curriculum" thanks to flexible add-on modules, compatible with the graduate curricula currently offered in European HEIs.

A digital learning platform will be set up to support the development of courses and training materials, building on the partners' expertise. The resulting add-on module will be tested with two successive cohorts of Master's and PhD students from partner HEIs, starting in early 2022. Based on the experience gained in this process, guidelines will be drafted on innovative teaching formats to foster entrepreneurship through training. The progress of students enrolled in the FOEBE modules will be closely monitored and assessed, and learners' feedback will be used to improve the content of courses and the pedagogical approaches.

The final output of the project will consist of guidelines and recommendations on how to best equip bioeconomy graduate students with the skill set relevant to this area, and put them in a position to become innovators and bring their ideas to the market. This report will enable other universities to design their own implementation of the FOEBE add-on curricula and offer them to their graduate students.

Bioceb: an Erasmus Mundus Joint Master Degree addressing the global Bioeconomy need for new skills

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Relevance and aim of the study

According to the European Bioeconomy Strategy,[1] bioeconomy addresses the production of renewable biological resources and their conversion into a large panel of bio-based products and bio-energy. Research and innovation in this field are identified as means to reduce Europe's dependency on fossil fuels and contribute to meet its energy and climate change policy targets, while rising growth. To reach these objectives, new skills need to be addressed by training, among which the systemic approach and the awareness of markets and products.[2]

Materials and methodologies used

The Erasmus Mundus Joint Master Degree (EMJMD) Bioceb (Biological and Chemical Engineering for a Sustainable Bioeconomy) is a 2-year international programme with a core in-depth training in biotechnology encompassing biological resource diversity and optimal use, bioprocess design and upscaling, and biobased products engineering for targeted markets. Through its joint curriculum based on 5 mobility tracks, it favors value chain approach from biomass to bioproduct, at multiple scales and addressing linked economic and environmental issues. It is implemented with the support of Erasmus+ programme for the period 2019-2025.

Major results and findings

Bioceb was born on the analysis of the gaps of the current offer and the willingness to provide a tailor-made solution, in connection with the relevant socio-economic actors, ensuring future employability of its graduates either in Europe or in their home countries. An added value of the Bioceb Master is to involve five higher education institutions from countries representing different biorefinery models and resources (AgroParisTech and the University of Reims Champagne-Ardenne in France, the University of Liège in Belgium, Aalto University in Finland, and Tallinn University of Technology in Estonia). Moreover, through its worldwide associated partners network, it includes some region where markets for biobased products are growing.

Conclusion of your research

The objective of the proposed poster is to share experience of this new multidisciplinary training programme and to show how it answers the needs of the bioeconomy sector in well-trained graduates, able to develop innovative and sustainable bio-based products and bioprocesses. It will also highlight connections of this education project with research and innovation projects, including Zelcor which was previously coordinated by Bioceb coordinator.

BE CHANGE: A community of practice inspiring and encouraging bioeconomy education for systemic change

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Relevance and aim of the study

The societal transformation to a bioeconomy is legitimized by its potential contribution to sustainable development. But this potential is neither self-evident nor exclusive. The transformation towards a sustainable circular bioeconomy (SCB) requires a fundamental reconfiguration of predominant models of natural resource use, production and consumption. So-called systemic innovations must accompany the necessary technological change. Current bioeconomy curricula mainly serve the advancement of the latter.

Materials and methodologies used

BE CHANGE (**B**ioeconomy **E**ducation for systemic **Change**) is an international community of bioeconomy educators determined to strengthen skills development for systems change. This initiative emerged from a workshop on bioeconomy education at the Global Bioeconomy Summit 2020 (1) and builds on the assumption that a renunciation of current unsustainable practices is unlikely to happen within current innovation logics and their inherent values. Present value chain rationales, consumption practices, and development models contradict many of the principles of a sustainable economy. The systems to be changed are thus manifold: innovation systems, production systems, social systems, and many more. It must be emphasized that none of these systems will be changed unless a critical mass of individuals changes.

Major results and findings

Intended multi-level systems change requires decision makers, scientists, and practitioners that are willing and able to walk unprecedented paths (2). System changers are in a position to incite, implement, and catalyze novel ways of social and economic activity at various levels (e.g., within their organization, community, state, etc.). While each of the specific levels require specific skills, an entrepreneurial mindset is crucial. No matter what the focal system is – change making starts with people who are able to reflect on their own worldviews, challenge conventions, question common sense, and dare to take action.

Conclusion of your research

BE CHANGE seeks to identify, co-create, prototype, and disseminate appropriate academic education and training contents, formats, tools, and institutional conditions. We aim to provide an international collaborative laboratory where concrete best practices of academic teaching and learning for change are created and tested. In the context of the EBU Scientific Forum, we will present the community and first learnings and invite interested EBU-affiliated collaborators to join this initiative.

Presenting the European Community of Practice Bioeconomy Education (COP-BioEdu)

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The **European Community of Practice for Bioeconomy Education (CoP Bio-Edu)** is a network of European Educators and Education managers in the context of Bioeconomy.

The goal of this network is to enhance the quality, offer and diversity of education for the sustainable circular Bioeconomy in Europe. To achieve this, they

- develop educational projects to create and evaluate new educational materials, strategies and innovative training concepts and
- share experiences and good practices among educational actors coming from different educational sectors and regional perspectives, and
- consult with industry and stakeholders about skills demands and educational outcomes can be organized.

A combined effort of professionals working on related goals will enhance the outcomes of education and training for the circular bioeconomy. The CoP Bio-Edu will address experience exchange, up-skilling and training among faculty and teachers, which is a first and necessary step to promote the education of an adequately skilled workforce for the Bioeconomy.

Dedicated trans- and interdisciplinary events on Bioeconomy education will be organized to facilitate networking and training. Besides its substantial contribution to the specific domain of Bioeconomy, the established network shall contribute to the New Skills Agenda for Europe and improving the job market in Europe. Towards this goal we will establish a digital platform, where educational resources and materials can be stored and exchanged.

The CoP Bio-Edu will also provide a means for academia of interacting with industry partners and policy makers to identify skills demands early and to enhance the quality of Bioeconomy education. The educational perspective will be aligned with European priorities for growth, offering a good potential for improvement in all levels (technological, economic social and regulatory).

The network is open for new members, who can show educational practice in relation to the Bioeconomy or in related fields that are anticipated to expand towards the bioeconomy.

Bioeconomy Education towards Sustainability and Creativeness in the BioEast Region

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Relevance and aim of the study

Bioeconomy tends to become a key technology and a substantial element for development and growth in Europe. It is based on a novel concept including the valorization of natural resources and human manpower in a sustainable way. Multi-disciplinary and cross-sectorial consideration are the main characteristics of the whole Bioeconomy frame, meaning that a wide spectrum of scientific disciplines and technical expertise are required. Particularly focusing on the Regional dimension, it is important to mention that despite the very sound regional character of Bioeconomy, the factors underlying its specificity they vary on a case by case basis and they can include environmental particularities, geographic characteristics, different economic development, diversified general public in terms of perceptions, attitudes and cultural patterns.

Materials and methodologies used

In this presentation will be provided a quick overview of the current status of Sustainable Bioeconomy in the BioEast region including economic and social parameters as well as the current policies and governance actions. Further on, will be demonstrated the current situation of the Bioeconomy Education in the region: Particularly will be given an overview of the involved Institutions, their structure, organization, synergies, curricula, and outcomes. There will be presented data on the participation of the Institutions of the region in consortia, common projects and networks. Data will also be provided reflecting the cooperation of these Institutions with the public sector and the related with Bioeconomy Industry. The specific targets and audiences will be specified.

Major results and findings

In this contribution, will be presented as a case study the innovative teaching and training approach in Bioeconomy study programs in Riga Technical University, to discover both innovation engineering, economic, social and environmental aspects and potential and possibilities of involvement of students and professionals in the development of Bioeconomy ideas. Moving towards competence-based learning program, such approaches as hackathon and role game is presented in educational process in Riga Technical university that provides students with opportunity to apply theoretical knowledge in practical simulation of reality improving their cross sectoral thinking. Furthermore, role game will be implemented in summer school with emphasis on Bioeconomy.

Conclusion of your research

Conclusions can be extracted, on Educational frames, Evaluation criteria, Outreach activities and Support systems.

Research short presentations I

Chair: Dr. Martin Greimel, University of Natural Resources and Life Sciences

Forestry

Forest Ecosystem Services in policy – an example of Swedish forest policy

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Relevance and aim of the study

Sweden has a long tradition of forestry and forest policy with the first forestry act in 1903, with the aim of securing regeneration. The forestry act has been revised multiple times during the 20th century, ensuring sustainable use of the forest resource. However, until the 1990s, the main focus of forest use was production. The aim of this study is to analyse how forest ecosystem service related climate- and energy-policy objectives are integrated with existing nature conservation- and forest sector policy on a national level.

Materials and methodologies used

The study is based on a text analysis of current forest policy documents in Sweden, within the areas of climate, energy, nature conservation and forest policy related to forest ecosystem services, based upon a theoretical framework of policy integration.

Major results and findings

As the demand for different goods and services from the forest grew (e.g., climate mitigation, bio-based products and energy, recreation, biodiversity), the concept of forest ecosystem services was introduced when discussing forest use. With the extensive revision of the forestry act in 1990s, the challenge of balancing production and environmental issues became in focus, with two main goals stating that the production goal and the environmental goal were to be equal. With this, the Swedish forest policy became de-regulated, initiating a freedom under responsibility to achieve the two equal goals. This meant that the responsibility to achieve goals, like sustainable management of forest, making trade-offs and synergies of forest ecosystem services, became even more the responsibility of forest owners. With the further increasing needs of forest ecosystem services, and increasing number of stakeholders, the forest becomes connected to several different activities, resulting in goal conflicts. Observing forest policy in Sweden, we find that forest policy is integrated with other policy areas like climate, energy and conservation.

Conclusion of your research

The results can facilitate the understanding for where improvements need to be done to make sure objectives set for sustainability, actually can be met and implemented and create decision support to safeguard the provision of forest ecosystem services in a bioeconomy transformation.

This study is presented in a master thesis by Karolina Tanse and Anna Gebre-Medhin, and main supervisor was Camilla Widmark. This research is part of POLYFORES - a ERA-Net Sumforest project.

Strong sustainability: a review of forest-based bioeconomy literature

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Relevance and aim of the study

Forestry and forest-based bioeconomy visions are seen as the main pathways for phasing out fossil-based economy and tackling sustainability challenges. Even though the research exploring the sustainability and sustainability impacts of forestry and forest-based bioeconomy is vast there is still yet less emphasis on the concept of strong sustainability that stresses the natural capital as the critical key concept of sustainability, whereas the majority of existing research is still highlighting the optimal allocation of scarce resources. As we are surpassing already four of the planetary boundaries (Rockström et al. 2009; Steffen et al. (2015), we need to steer our attention to sustainability science that helps to regenerate the carrying capacity of natural capital.

Materials and methodologies used

A systematic literature review was conducted for studies featuring forestry and forest-based bioeconomy in the context of strong sustainability, Overall, 22 documents were selected for review from the period of 1997-2021.

Major results and findings

Despite the low number of published articles on the topic, the number of documents shows an increasing trend during the time-frame.

Conclusion of your research

This review will produce information of how is the distribution of publications across the time period and geographic areas situated as well as what research methodologies applied in these research concepts.

Innovative bioeconomy and forest ecosystem services

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Relevance and aim of the study

The forests in Nordic countries have been a source of food, products and welfare for both local communities and for the nations as long as there has been any settlement. More recently, the way the forest supports the climate has become more pronounced. However, humans now face major challenges due to climate change as well as societal and environmental challenges. Fundamental changes are needed to ensure future prosperity in the face of growing resource depletion, climate changes and environmental degradation. What has become clear is that fossil dependence must be overcome and be replaced with bio-based materials and innovations to support the more efficient use of resources — thus, creating a more bioeconomy-based society.

Materials and methodologies used

In a comparative study of Finland, Sweden and Norway, the role of the forest in bioeconomy transformation and green innovation in the northern part of Europe are described and highlights the challenges facing forests in this emerging bioeconomy. The study reveals similarities and differences in approaches toward forest ecosystem services between the Nordic countries, which are relevant for policy making for developing the innovative bioeconomy.

Major results and findings

Forests are crucial for the development of sustainable bioeconomy in the Nordic countries in substituting fossil fuel-based materials and energy. Forest biomass has a large potential for developing new bio-based products. However, bioeconomy and circular economy transformation depend on both technical and social innovations together with societies adapting to a bio-based sustainable future, which emphasises the ecologic, economic, and social functions of forests. In policymaking and forest management, synergies need to be realised and trade-offs evaluated and addressed in forest management in general.

Conclusion of your research

As such, the consumers are a main driver of bioeconomy transformation replacing the demand of fossil-based materials with bio-based and together with choices, both in policy and forest management as well as by individual consumers, choices have to be made to support the continuous provision of all forest ecosystem services.

This work is an interdisciplinary study involving:
Widmark, Camilla; Heräjärvi, Henrik; Katila, Pia; Kurttila, Mikko; Lier, Marcus; Mutanen, Antti; Øistad, Knut; Routa, Johanna; Saranpää, Pekka; Tolvanen, Anne; Viitanen, Jari

National regimes and drivers of change in multi-national pulp industries – case Uruguay and Finland

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Relevance and aim of the study

The global operational environment of pulp-based industry is constantly being affected by myriad of factors from climate change to changing economic conditions and new technologies. These factors have remarkable effects, inter alia, on possibilities to replace fossil-based products with renewable ones. In this study, we analysed the socio-technical regime, landscape and niche innovations on country level. Finland and Uruguay were selected as case countries because of their highly intertwined national pulp industries. The study aimed to answer the following questions (i) *What are the differences and similarities between the socio-technical regimes of pulp industries in Uruguay and Finland?* and (ii) *What kind of drivers of change put pressure on the current regimes and how?*

Materials and methodologies used

The data of documents and expert interviews were analysed with theory-based qualitative content-analysis.

Major results and findings

There are similarities in industrial structures and operational functions; same multi-national companies are implementing the Nordic forestry solutions and pulp production technologies. The export driven pulp industry is an important part of the national economy having a special status in national policies. However, the industry traditions differ with Finland having over 100 years longer history in pulp industry, and thus more positive social license to operate compared to Uruguay. The forest management and ownership differ too: in Uruguay, short rotation eucalyptus plantations mainly owned by companies are utilized, when in Finland long rotation multiple-use forests with indigenous tree species owned by non-industrial forest owners dominate. Same global challenges, market trends and related policies affect both countries and at the niche level, both countries have high hopes for new pulp-based products and side stream utilization: in Uruguay the focus is more on efficient pulp production, where as in Finland in biorefining concept and service-based innovations.

Conclusion of your research

Overall, the pulp industry forms a considerable part of the production matrix of both countries, and they share the same global challenges and megatrends. However, the regimes in these countries differ greatly in spite of the evident commonalities in their business networks. Thus, the global challenges and resulting niche innovations are viewed differently in each country. Still both countries have an important role in the global pulp industry thus contributing to the transition toward sustainable bioeconomy.

Acrocomia: a multipurpose palm with high potential for becoming a sustainable industrial crop for the bioeconomy in Latin America

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Relevance and aim of the study

Acrocomia is a palm genus native to the neotropics and distributed from northern Mexico to northern Argentina. Oil-bearing fruits from wildly-growing acrocomia palm trees as well as other parts have been traditionally used by local communities in different ways, including industrial processing at small-scale. Acrocomia is able to cope with a wide range of environmental conditions outside tropical rainforests and could suits to agroforestry systems. High oil and biomass productivity, adaptability, sustainable intensification potential and the multipurpose capacity makes this palm genus specially interesting as an alternative oil crop. Thus, acrocomia could serve as a model for the development of regional bioeconomy systems based on local biodiversity in Latin America.

Materials and methodologies used

Research activities on acrocomia have increased to accelerate the domestication and to develop processing routes and technologies for integral valorisation of oils and fruit's by-products. However, acrocomia's research history is recent compared to other traditional crops and thus knowledge gaps and challenges need to be addressed. In order to analyse research topics, trends and gaps, we conducted a systemic literature review following the biomass-based value web approach (Virchow et al., 2016). This concept is an extension of the term 'value chain' and facilitates the comprehensive analysis of multiple biomass uses in a systemic way, from biomass production to final uses. Scientific literature retrieved from Scopus was classified firstly into fundamental and applied research, and secondly, into specific topics. Based on this, multiple potential products from acrocomia palms were identified.

Major results and findings

Our results confirm the multipurpose characteristic of acrocomia as a potential crop for manifold sectors of the bioeconomy. Research has continued to increase over the last decade, especially on *A. aculeata* and is driven by the interest in biodiesel. Fruits from acrocomia have a high potential to suit to the integrated processing concept of biorefinery, targeting material and energetic uses of oils and by-products.

Conclusion of your research

Acrocomia have a positive prospect as a novel industrial crop. However, a sustainable supply of biomass, market development for acrocomia-based products and the consideration of context-dependent aspects and social-ecological boundaries are key for the implementation of acrocomia value webs and regional bioeconomy systems in Latin America.

Miscomar+: Exploration and Optimisation of Miscanthus Cultivation under Marginal Conditions”

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Relevance and aim of the study

The large-scale implementation of bioenergy crops could increase competition with food crops and lead to unwanted land use change effects. The cultivation of bioenergy crops on marginal, contaminated, or industrially damaged lands unsuitable for food production could potentially increase bioenergy production without increasing competition with food crops. Miscanthus is a promising C4 grass with the ability to grow on marginal lands, remaining productive for up to 20 years. However, a successful establishment of miscanthus is necessary to achieve productive yields, whereby miscanthus is highly susceptible to cold and drought stress during its establishment period. The aim of the Miscomar+ project is to improve the establishment success of miscanthus on marginal lands, testing a number of different strategies to ensure plants establish successfully in the first year. Miscomar+ looks at novel seed based miscanthus varieties, which have lower establishment costs in comparison to the commercial clonally-propagated genotype miscanthus genotype. Miscomar+ is the successor to the Miscomar project which looked at the performance of stress tolerant miscanthus hybrids.

Materials and methodologies used

The effects of different treatments will be tested on 4 miscanthus genotypes across three experimental sites in Germany and Poland. Growing conditions at these sites are marginal, possessing characteristics such as heavy metal contamination, low nutrient availability, shallow soils, dryness, and spring frosts. Treatments include different planting dates, the addition of biochar to mediate heavy metal contamination, the use of a plastic mulch layer to increase temperature and keep in moisture, miscanthus mulch as a weed suppressant, and the addition of mycorrhiza. Each treatment is tested in combination with a seed-based genotype of the commercial variant *Miscanthus giganteus*. The effect of overwintering plants before planting will also be examined.

Major results and findings

Experiments are ongoing, but it is expected that plastic mulch will have an effect protecting plants from spring frosts and maintaining moisture during the early establishment period.

Conclusion of your research

This research will provide information about how the establishment success of miscanthus might be improved under marginal conditions. It will be examined, how effective plastic mulch is at preventing frost damage, and how stress tolerant the novel seed-based varieties are. This will contribute to developing strategies of establishing miscanthus on marginal sites.

Environmental impact and nutritional value of seaweed-based food products

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Relevance and aim of the study

Seaweeds are often seen as a healthy component of future diets with low environmental impacts compared to other food ingredients. Cultivation of seaweeds does not require land, nor fertilizers, and is expected to cater to the needs of a growing world population. However, data to support these statements is sparse. The goal of this study is to quantify the environmental impact of cultivated *Saccharina latissima* applied in food products and to evaluate if the addition of seaweeds makes diets more sustainable.

Materials and methodologies used

Life Cycle Assessment has been used to quantify the environmental impact of *S. latissima* cultivated in the North Sea and the impact of food products containing seaweed. The selected products are a seaweed burger, salt with 10% seaweed and salt replacement made from 100% *S. latissima*. The performance under current cultivation conditions and in the future was evaluated using a scenario analysis, drawing on data provided by Dutch companies. The environmental benefits of inclusion of seaweed in diets, taking into account its nutritional value, were evaluated also.

Major results and findings

Our results show that currently seaweed cultivation has a significant contribution to the environmental impact of the assessed food products. In particular, the vessel used for transport of the modules and harvested seaweed contributes significantly to the Global Warming Potential. Further reductions can be achieved by increasing yields and increasing the lifespan of materials used in the infrastructure. In the future cultivation scenario, with estimated future yields and more efficient infrastructure design and transport, the impact of *S. latissima* to the total burger and salt products diminished significantly. The inclusion of *S. latissima* in vegetarian burgers or as salt replacement has multiple positive effects, reducing impact on Global Warming Potential and Land-Use of the overall diet.

Conclusion of your research

This study confirms that seaweeds like *S. latissima* can play a role in future sustainable diets, provided that a solution is found to deal with the iodine content. A next step is to expand the product portfolio as well as the seaweed species included. Since the seaweed sector is in development, it is too early to have a definitive judgement on the environmental impacts of seaweed products compared to conventional food products. Instead, the main contribution of this work lies in pinpointing environmental hotspots and directing future investigations.

Automated Data Acquisition for farm LCA

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Relevance and aim of the study

Empowering farmers as ecosystem managers to actively shape the sustainable intensification of agriculture requires readily available quantitative data of their farm's environmental performance. More importantly, this data should be available without much effort. While LCA has high access barriers (i.e. cost, knowledge, data availability), we recommend to leverage the increasing digitalisation of agricultural enterprises to lower these access barriers and provide farmers with automated LCA results.

Materials and methodologies used

In this research, readily available data streams within the German agricultural sector were collated with the data requirements of agricultural LCA. First, mandatory reporting obligations based on EU and national regulations were reviewed, as well as voluntary reporting schemes. Considering three farming business units (i.e. livestock, arable farming, bioenergy), the identified data points were categorized into the dichotomy of life cycle inventories (LCI): Inputs and Outputs. Then, the data requirements of agricultural LCA were established with respect to specific requirements for 18 midpoint impact categories (ReCiPe 2016). Finally, the two input-output catalogues were analysed side by side to illustrate opportunities to automate data acquisition, and to identify data availability gaps.

Major results and findings

Agricultural enterprises in Germany face detailed reporting requirements. Especially the fertilizer and pesticide use is documented in detail per field and crop. Livestock production require detailed documentation of herd and manure management. On-farm bioenergy plants document feedstock and energy generation.

Conclusion of your research

Already today, farm documentation software could incorporate LCA results for products and the entire organisation. By adding only few data points to the mandatory reporting requirements, the data accuracy could be increased. Also, impact categories like biodiversity and soil quality could be included.

Valorisation of ecosystem services for a more sustainable intensification of agricultural biomass production in the growing bioeconomy: Development of an integrated assessment approach

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For the growing bioeconomy, the biomass supply needs to be intensified sustainably. This requires a fundamental transformation from input-based towards process-based agricultural systems that not only reduce negative environmental and social impacts but increase and operate beneficial ecosystem services (ES) such as nutrient cycling, carbon sequestration, water filtration, biodiversity, and cultural services.
The consideration of both the ES in the planning of agricultural systems, however, requires a holistic assessment methodology applicable in practice. In particular, the spatial variation of ES as well as their temporal dynamics represent a repertoire of functions and processes that need more research and consideration in agricultural biomass production.

The recent update of the *Ecosystem Services Valuation Database* (ESVD), providing a total number of 4042 monetary values for ES (including ES in agricultural systems) [1], the *ISO Norm 14008* (Monetary valuation of environmental impacts and related aspects), and the approach of the *German Association for Landscape Management* (DVL) for assessing the monetary value of biodiversity, climate, and water protection services at farm level [2] provide potential starting points for the development of a methodological approach for ES assessment in agricultural systems. Unlike the approach of DVL, which focuses on the estimation of the 'public goods' provided by farms [2], the research proposed here focuses on exploration, assessment and utilisation of functions, processes and services created by the diverse above and below-ground floral and faunal species of cropping systems. The enhancement and productive use of provisioning, regulating, habitat and cultural services at field level can support sustainable intensification and benefit the farmers, the society and the environment.

References:
[1] de Groot, R.; Brander, L.; Solomonides, S. 2020., (2020), Update of global ecosystem service valuation database (ESVD), FSD report No 2020-06, Wageningen, The Netherlands., 58, https://www.es-partnership.org/wp-content/uploads/2020/08/ESVD_Global-Update-FINAL-Report-June-2020.pdf, 2021-06-09
[2] Neumann, H.; Dierking, U.; Taube, F., (2017), Testing and evaluation of a new procedure for the benchmarking and remuneration of the biodiversity, climate, and water protection services provided by agricultural holdings, Bundesministerium für Ernährung, Landwirtschaft (BMEL), Berichte über Landwirtschaft, Band 95, Ausgabe 3

Urban gardening and domestic compost production as climate change mitigation practices in a city environment

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As a rising solution to fight climate change in city environments, in the last decades many citizens around the world got in charge of things by setting up urban vegetable gardens, discovering the many advantages that gardening activities can bring about: for example from greater physical and psychosocial health to growing healthy and safe produce that can help lowering food expenses. Generally speaking, many people report positive behavioural changes in their health and environmental awareness.

This research idea tries to investigate this matter even further, highlighting a particular focus that could make it even more sustainable, all in the broad framework of **environmental economics and policies**: the usage of self-produced compost, to establish a closed loop for biomass. In this way, household organic waste is turned into compost, which is used in vegetable gardens to grow food whose discarded parts can be turned into compost, and so on. Many studies have highlighted the environmental advantages of using compost, beside the general emissions savings: from the formation of carbon sinks which lower atmospherical CO2, to avoiding soil erosion unlike conventional agricultural practices.

This research effort is used to stimulate a debate around this idea, given that although some studies have been published about it, it does not have yet a central part on the discourse about climate change mitigation in urban and cities environments. It can however represent a positive drive towards a **bio-based economy**: if on the one hand its social and environmental advantages are quite clear, on the other hand however policy efforts are not always straightforward and easy to put in practice, given the difficulty to regulate the phenomenon and to assign allotments to citizens. Moreover, as many socially focused activities, it's difficult to be evaluated in monetary terms, and therefore it's hard for cities to assess the return on the investment made.
The point of all this would be, then, to sparkle potential solutions in many scientific fields (from urban planning to human geography, from agricultural sciences to soil ecology), in the hope of spreading these actions among European cities, starting by e.g. analyzing the many practices around the world to look for the best ones, to hopefully define in the end policy making suggestions for municipalities.

Analysis of bio-based value chains for accelerating the transition towards a sustainable bioeconomy

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Relevance and aim of the study

The transition towards a sustainable bioeconomy requires major changes at all levels of our economic system and the society. The fundamental idea of bioeconomy is replacing carbon-based material with bio-based material and energy sources to achieve higher degrees of sustainability. For this transformation, a fundamental reorganization of prevailing production and consumption systems is required to overcome lock-in effects of fossil-based resource dependencies. This is where the dedicated innovation system (Pyka, 2017) perspective comes in. Understanding the interaction of different economic agents within innovation systems is crucial to gather knowledge on how to accelerate the bioeconomy transition. These agents include amongst others, policy makers, NGOs, consumers, and firms. The question arises which role – either supporting or hindering the transformation – they play in the bioeconomy transition.

Materials and methodologies used

With our research, we focus on firms and how they react to the pressure of change driven by sustainability challenges and their contribution to the bioeconomy transformation. More precisely, we will analyze the bioplastic industry as a case study to reveal the development of new bio-based value chains and the interactions of the dedicated agents within these chains. We will collect qualitative data on dedicated firms in the bioplastic industry and examine their strategies on adapting to the bioeconomy transition.

Major results and findings

Established firms need to decide whether to substitute incumbent technologies or to develop new technologies alongside old ones, which leads to different business models depending on the firms' strategy (Iles & Martin, 2013). Key drivers for the bioeconomy transition include new competitors and changing behaviors of consumers. Hence, established firms fear that they might not survive the transition process, or at least might lose their comfortable market dominance if they take the required innovative steps and adapt themselves to the systemic change.

Conclusion of your research

The reactions of established firms can only be understood in the context of the redesign of the innovation system. Therefore, in our study we highlight the coexistence and interrelations of new, emerging firms and old, established corporations as well as its implications for the whole bio-based value chain.

DAGFOR-Digital tools for agricultural advisors in agroforestry systems

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Agroforestry systems are acknowledged as a promising sustainable intensification alternative which expansion in the next decades is considered a core strategy to achieve both local productivity and global environmental goals. Due to its diversity and vital role, knowledge awareness and promotion of these systems need to be accelerated, especially boosting the role of farm advisors. Novel articulations in the knowledge systems, such as digital transformation, are creating new opportunities and deepening already existing divides. To harness the potential of farm advisors in the food system transformation, accessibility towards digital innovations are needed. Transdisciplinary research, where researchers, advisors and developers co-create and test digital innovations under real conditions (living-labs), is a potential pathway to increase the rates of acceptance and scaling-up of innovations in the advisory system and reduce the digital divide in the agricultural sector.

Although there is an increased number of emergent technologies and digital solutions in agriculture, the adoption rates are lower than expected. Usually, the role of knowledge brokers such as advisors, has been overlooked. Our interest is to conduct transdisciplinary research about digital solutions used by extension and advisory services in the implementation of agroforestry systems. We aim to systematically set up *real labs* in multiple contexts, for the identification, selection, development and testing of digital tools relevant in the advisory services provision. The proposal has three major objectives 1) mapping of digital ecosystems for agricultural advisors; 2) co-creation of digital solutions for agricultural advisors and 3) the assessment and upgrading of digital skills within the extension systems in both selected countries of the global south and the EU. Expected impacts will be the inventory of current digital innovation tools in the agroforestry sector, knowledge about factors affecting the acquirement of digital skills, a platform for the exchange of good practices among advisors and the assessment and compilation of transdisciplinary research methods.

We are a team of researchers in the chair *Communication and Advisory Services in Rural Areas* at Hohenheim University. We study learning and innovation processes in rural areas with a focus on Agricultural Knowledge and Information Systems, transdisciplinarity research methods and assessment of adoption of innovations and innovation support services. For addressing these multiple aspects, the project would require several disciplines involved such as social science, crop science, farm economics and computer/technological science.

Challenges and opportunities of circular biomass management in the agro-food-waste system – An application of the innovation platform approach in a nutrient-saturated area

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Relevance and aim of the study

Animal manure and human organic wastes are valuable resources and were therefore traditionally recycled in agricultural production systems. Latest developments such as the introduction of cheap inorganic fertilizers, agricultural specialization and globalization of agricultural trade reduced recycling and led to massive spatial imbalance in the supply and demand of biomass. Consequently, modern agricultural is one of the largest drivers of biogeochemical flows exceeding the earth's boundaries. To reduce nutrient losses in the food system, systemic change is necessary. To this end, numerous strategies regarding system changes are available and under development which include technological and social innovations. However, achieving systemic change requires a participatory approach to involve various actors in the agro-food-waste system. A participatory approach commonly applied in developing countries but not so much in industrialized countries are innovation platforms.
This research aims to determine challenges and opportunities for the agro-food-waste system with regard to a circular biomass economy in a nutrient saturated area.

Materials and methodologies used

We conducted a case study and piloted a practical application of the innovation platform approach in the Dutch-German cross-border region Rhine-Waal. Therefore, we invited actors of the agro-food-waste system in the Cleves district and its surroundings to a workshop. Guiding questions were formulated to lead through the workshop and notes were taken during the discussion of the 24 participating actors. The qualitative data was analysed through inductive coding.

Major results and findings

We observed that challenges and opportunities exist at three levels: 1) the individual motivation, 2) the general material flow and 3) the information flow provided within the system but also to the wider public and other systems. A topic particularly important for actors was to share experiences of nutrient management among different stakeholders in different subsystems, especially with regard to cooperating with partners from the Netherlands. Through sharing experiences, a wider community can access information and move faster to improved nutrient management.

Conclusion of your research

The case study has shown that there are several opportunities, which can be exploited, and challenges, which should be overcome, to facilitate a transition towards local circular biomass management. These lessons learned are a first step towards the development of nutrient cycling strategies.

Assessing farmers' interests and their willingness to cultivate miscanthus

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Relevance and aim of the study

As we transit towards the Bioeconomy, biomass demand for energy and fibers is expected to increase. Miscanthus is a perennial grass originating from Asia, characterised by its low requirement for nitrogen fertiliser and its potential adaptation to a wide range of climates and soils including marginal lands and low quality soils. Miscanthus represents a promising source of biomass for energy and material purposes. Local farmers play a central role in the crop production, as crop supply will depend on the farmer willingness to cultivate the crop. This study builds on a case study in the region of Sisak-Moslavina in Croatia. Sisak-Moslavina county is located in the southern central part of Croatia and is part of the continental area of the country, approximately 60 km away from the capital city Zagreb. While the city of Zagreb is home to 20% of Croatia's population, only 4% live in Sisak-Moslavina county. In 2018, 23% of the population in this county was older than 65 years. According to the Croatian Bureau of Statistics, in 2018 the county experienced a natural decrease of its population of -7,9 predominantly through out-migration. Also high unemployment rates have been reported in the county. The existence of abandoned lands in this region represent an opportunity for biomass production potentially benefiting the economical conditions of the locality. This study aims to understand what are the preferences of local farmers in this region of Croatia in regards to the selection of crops and to understand if they are willing to plant miscanthus.

Materials and methodologies used

To achieve this aim, a questionnaire asking about farmers' preferences regarding crop characteristics was provided to 50 farmers of the region of Sisak-Moslavina.

Major results and findings

The results describe the level of importance that farmers assign to the following characteristics of a crop: high returns, requirement of inputs, periodicity of recultivation, incentives, easiness of cultivation, need for additional machinery, aesthetic of the crop and traditions linked to the crop.

Conclusion of your research

This study gives an overview of the interests of farmers in regards to crop characteristics and their willingness to cultivate miscanthus in a specific region of continental Croatia.

Process

Biobased molecule production from renewable resources using an integrated strategy of fermentation/bioconversion and on-line extraction processes

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Within the framework of the development of the bioeconomy there is an increasing drive towards the sustainable production of chemicals from renewable biomass resources. In this respect, interest in using fermentation and microbial bioconversion to produce bio-based alcohols, VOCs and polymer building blocks, is growing.

To develop robust biotechnological processes, it is necessary to address challenges on the upstream and downstream processing steps and their integration. Indeed, favorable conditions are needed for high cellular activity, whereas some “new” complex substrates expose cells to inhibition/toxicity effects. Moreover, when metabolites accumulate in the bioreactor, similar deleterious effects can occur, which results in low productivity and dilute product streams. One way to tackle these limitations is the implementation of an “In Situ/In Stream Product Recovery” (ISPR) or extractive fermentation. However, there are still several questions to be answered towards the mastery of extractive fermentation, such as using adapted and robust microorganisms, finding optimal bioprocess conditions that comply with the integrated recovery operation and choosing biocompatible recovery operations.

SayFood Unit has been conducting research on extractive fermentation for the production of bio-based alcohols (butanol, ethanol), organic acids (lactic acid, 3-hydroxypropionic acid) and VOCs (2-phenylethanol, sulfur compounds). Lactic acid bacteria, acetic acid bacteria and yeast are studied as cell models. Membrane-based techniques of pervaporation and membrane contactors are studied given their expected biocompatibility and advantageous environmental impact. Throughout this integrated strategy, we focus on understanding and modelling the mechanisms governing inhibition at the cellular level, fermentation performance and membrane mass transfer, in order unlock technical issues at the process level.

Such an approach raises scientific questions of utmost importance that need interdisciplinary and cross-fertilization work strategy in line with the scientific challenges exposed above: bioprocess engineering, downstream processing, integrated process modelling, environmental assessment. In this respect, we are strongly interested to jointly build-up collaborations within EBU network to contribute to the knowledge-based bioeconomy in the frame of Horizon Europe and Era-Nets calls.

In stream extractive fermentation for intensified 2-phenylethanol production from renewable resources by Kluyveromyces marxianus

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Relevance and aim of the study

Biotechnological production of Volatile Organic Compounds (VOCs), like the aroma compound 2-phenylethanol (2-PE), has become increasingly attractive. Due to consumer preferences, there is a demand for natural 2-PE obtained from biosynthesis. Natural 2-PE is obtained by extraction from plant material or produced by microorganisms. This latter option offers advantages like cost reduction, purity improvement and raw resources' preservation. The most promising 2-PE producers are yeast that can produce it through bioconversion of L-phenylalanine (L-phe). However, to develop a robust biotechnological process for industrial implementation, technical issues have to be resolved such as end-product inhibition by 2-PE accumulation in the medium. Extractive fermentation or ISPR (In-Stream Product Recovery) is an attractive strategy towards bioprocess intensification. This work focuses on studying 2-PE bioproduction by fermentation and its intensification via In-stream Membrane-Based Solvent Extraction (MBSE) in hollow-fibres contactor.

Materials and methodologies used

Prior to implement the integrated extractive fermentation process, we first studied the performance of several organic solvents in order to classify them with regard to their extraction performance (partition coefficient and extraction kinetics in the membrane contactor) and their biocompatibility towards the microorganisms. Biocompatibility was evaluated in terms of impact on the cell physiological state, assessed by fluorescent double staining detected by flow cytometry. Then, we set up the conditions of substrate and oxygen supply for fermentation in a bioreactor, to produce 2-PE via the bioconversion of L-phe using the yeast Kluyveromyces marxianus CBS 600. Finally, the fermentation was integrated with the MBSE system.

Major results and findings

Two solvents with the best compromise between extraction performance and biocompatibility were selected to be evaluated in extractive fermentation. Flow cytometry results showed that the integrity of the membrane and cells enzymatic activity were preserved during contact with these solvents. A 53% increase in 2-PE titre was achieved compared to non-extractive fermentation. L-phe consumption and 2-PE production were strongly dependent on the N source and oxygen supply.

Conclusion of your research

MBSE was proven to be an effective strategy to alleviate end-product inhibition and intensify 2-PE bioproduction with *K. marxianus* CBS 600. In addition, results gave insight to understand the mechanisms of cell inhibition for further process optimization.

Showing the Capabilities of Experimental and Computational Fluid Dynamics in Bio-Process Intensification: the Case of a Stirred Bioreactor for Bio-H2 Production

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Relevance and aim of the study

This work provides an example of the capabilities of Experimental and Computational Fluid Dynamics (CFD) in the development and scale-up of traditional and cutting-edge bio-processes. Specifically, a novel bioreactor coupled with a membrane separation unit is proposed for the simultaneous production, stripping and purification of bio-hydrogen, thus accomplishing the integration of multiple operations, in line with one of the key concepts of process intensification. The application is on the dark fermentation of organic scraps. The success of the initial design is experimentally demonstrated, then a geometrical optimization to increase H_2 production is proposed, based on the local analysis of the predicted variables[1].

Materials and methodologies used

The bioreactor is a dual impeller tank provided with a draft tube, for the self-ingestion of the stripping gas from the liquid free surface. H_2 is produced under batch and attached-growth conditions, then it is stripped from the liquid phase. The design of the bioreactor fosters the contact of the two-phases and allows the subsequent disengagement of the gas, which is circulated through an external pipe in which a membrane module is located. A computational approach describing the flow field, that is validated by experimental data collected by Particle Image Velocimetry, bio-reaction kinetics, interphase mass transfer and hydrogen separation is presented.

Major results and findings

The CFD study highlights that the original design of the bioreactor meets the challenging requirement of integrating reaction and separation by an energy saving self-ingesting configuration and it can be realistically predicted by a 3D-CFD model. Afterwards, based on the local gas-liquid flow field and on the power drawn by the impellers, a new configuration is proposed. It is found that, while the original reactor provides higher mass transfer coefficients, changing the position of the biomass supports the production increases.

Conclusion of your research

The proposed CFD approach proved helpful in the assessment of the bioreactors performances, allowing local analyses of bio-reaction rate and interphase hydrogen fluxes. The potential of the computational approach in devising novel design, without experimental studies, is shown. It can be easily applied to any scale and other innovative processes.

References:
[1] Maluta, F., Paglianti, A., Montante, G., (2019), Modelling of biohydrogen production in stirred fermenters by Computational Fluid Dynamics, Elsevier, Process Safety and Environmental Protection, 342-357

Sustainable Industrial Chemistry for Innovation in Bio-Refinery Processes

Cavani, Fabrizio, Fornasari, Giuseppe, Albonetti, Stefania, Basile, Francesco, Benito, Patricia, Dimitratos, Nikolaos, Lucarelli, Carlo, Tabanelli, Tommaso, Mazzoni, Rita, Maluta, Francesco, Montante, Giuseppina, Paglianti, Alessandro, Giorgini, Loris, Benelli, Tiziana, Mazzocchetti, Laura, **Milano, Martina**

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The Industrial Chemistry Department of the University of Bologna contributes to sustainable bioeconomy through a wide range of complementary research activities.

The **Catalytic Process Development Group** is specialized in the **development of innovative catalytic materials and alternative catalytic processes** for innovative sustainable and efficient bio refineries. Some example are the production of hydrogen from cellulose and bio-based compounds, the development of innovative, continuous-flow reduction processes using bio-alcohols as the reducing agent, the implementation of improved oxidation processes using air as oxidant in mild conditions, and the production of new, more efficient electro-catalysts for bio-platform molecules valorisation.

In bio-refinery processes where high selectivity requires liquid homogeneous catalytic approaches, the **Organometallic Group** contributes with iron and ruthenium **molecular catalysts** designed for sustainable **H_2 production** and suitable in closing the circular economy of winery production chain with **the second-generation bio-fuel production** from waste bio-ethanol.

Process design is implemented by the development of robust and fully predictive methods based on **Computational Fluid Dynamics** for devising novel (bio-)reactors, separation equipment and for scaling up chemical and biochemical production technologies going from laboratory to **industrial scale.** Examples are a self-ingesting bioreactor for the dark fermentation of organic scraps based on combined experimental and numerical analyses that resulted in **maximization of hydrogen production**; scale-up of aerated fermenters ensuring intensification of interphase **mass transfer** and prediction of **power requirements** at any flow regime. **System specific scale-up** methodologies are devised.

For **sustainable processes on polymeric materials**, an innovative batch plant is available in the **Polymer Group** for pyrolysis of low-density polyethylene with a hydraulic guard ensuring a safe process. This is a versatile way to recover polyethylene wastes into valuable oils (rich in aliphatic and simple aromatic hydrocarbons) or gas, to be used as petrochemical feedstock or fuel, thus providing a sustainable method for material and energy recovery of waste packaging. Polymer Group is involved also on the synthesis of (bio)materials and amphiphilic polymers for drug delivery as well as on the study of high performance and low environmental impact formulations.

Urease inhibitory potential and soil ecotoxicity of pyrolysis liquids

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Relevance and aim of the study

Urease is a Ni(II)-dependent enzyme widely spread in nature and produced by plants, fungi, and bacteria.[1] It is of critical importance in the global nitrogen cycle by hydrolyzing urea to eventually yield NH_3 and CO_2, a reaction that causes an overall increase of soil pH that negatively impacts on plant germination or early growth.[1] Urea is the main source of N in worldwide crop production, however, its rapid hydrolytic decomposition catalyzed by soil urease results in a substantial decrease of the efficiency of urea-based soil fertilization due to fast ammonia volatilization process.[2] The practice of using urease inhibitors as N-stabilizers has been implemented to counterbalance these negative aspects in various ecosystems. The most widely used urease inhibitor for agronomic purposes is N-(n-butyl)-thiophosphoric triamide (NBPT); catechol (1,2-dihydroxybenzene) and aromatic polyhydroxylated compounds (e.g. polyphenols)[3] have shown an excellent anti-urease activity. Therefore, the aim of the present work is to explore the use of “natural” aromatic polyhydroxylated compounds as urease inhibitors to develop safe and cheap formulations useful in agricultural applications.

Materials and methodologies used

To this purpose, various lignocellulosic biomasses (poplar, switchgrass, and larch) have been pyrolyzed to produce lignin-derivatives (monomers, dimers, and small oligomers) whose activity was tested against urease through *in vivo* and *in vitro* tests and compared with NBPT and catechol activity. Specifically, the water-soluble part of the resulting pyrolysis liquids ($WS_{bio\text{-}oil}$) was here investigated, since this fraction resulted enriched in catechol and aromatic monomers that can synergistically exert an inhibition role. The ecotoxicity of such bio-oil fractions was also tested against plants (emergence and early growth tests) and earthworms (survival and reproduction tests).

Major results and findings

The preliminary results clearly demonstrated that even small amounts of $WS_{bio\text{-}oil}$ (2.5-4.5 mg/g_{soil}) were capable to inhibit urease activity thanks to the combined action of catechol and the aromatic compounds pool, giving results comparable to NBPT and better than catechol alone. The emergence and early growth of *Avena sativa* was not affected by $WS_{bio\text{-}oil}$, as well as the reproduction of *Eisenia andrei*.

Conclusion of your research

These results highlight the potential of pyrolysis liquids as "natural" urease inhibitors for agricultural purposes.

1. Microbiol. Rev. 1989, 53, 85
2. Ann. Appl. Biol. 2013, 162, 145
3. ACS Sustain. Chem. Eng. 2019, 7, 15558

Comparative environmental assessment of HMF produced from fructose and lignocellulosic biomass

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Relevance and aim of the study

A growing bioeconomy requires sustainable and renewable solutions for supplying the demand for chemical products such as plastics. Hydroxymethylfurfural (HMF) is a promising alternative to classical fossil-based platform chemicals and is mainly produced from high fructose corn syrup. In order to avoid potential conflicts with food crops, substantial efforts are undertaken to widen the resource basis for HMF production to lignocellulosic material. For this purpose, the University of Hohenheim is running a biorefinery pilot plant where lignocellulosic biomass (e.g., miscanthus) can be processed to platform chemicals. In the first process step miscanthus is converted to lignin and solved C5 and C6 sugars in an acid catalysed hydrothermal process (HTP). The lignin-rich fraction can be utilized for applications such as the production of phenols, while hemicellulose and cellulose are further converted to furfural and HMF. The purpose of this work is the identification of environmental hotspots in the HMF production process and to compare the environmental performance of the carbohydrate source (miscanthus vs. high fructose corn syrup (HFCS)).

Materials and methodologies used

For this reason, a comprehensive environmental assessment is conducted. For both feedstock alternatives, miscanthus and fructose, a cradle-to-gate analysis is performed accounting for all operations from biomass production to the conversion and the refinery gate. The assessment is based on detailed process simulations. Data on mass and energy flows are derived using the programs AspenPlus V.9 and V.11 based on experimental data from laboratory and pilot plant trials. Information for the miscanthus cultivation are derived from field trials conducted within the GRACE project.

Major results and findings

For the impact assessment a range of midpoint indicators from the ReCiPe2016 methodology is selected and evaluated. Preliminary results showed that, across most impact categories, the provision of heat and cooling energy accounts for a substantial share of the impacts associated with the HMF production process. In addition, the use and disposal of the auxiliaries for the separation units contributes a substantial share of the global warming impacts.

Conclusion of your research

The comparison between the feedstock alternative highlights that the favourability of lignocellulose-derived HMF (in comparison with fructose-HMF) depends largely on the valorization routes of the by-products from lignocellulose processing like furfural.

A comparative economic evaluation of scenarios for the extraction of an oil containing fucoxanthin and EPA from *P. tricornutum* using FPA-PBR with artificial light or natural sunlight in Germany

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Relevance and aim of the study

This study determined and analyzed the costs of a process for the cultivation of *P. tricornutum* using artificial lighting or natural sunlight and the subsequent extraction of an oil rich in eicosapentaenoic acid (EPA) and fucoxanthin in four scenarios.

Materials and methodologies used

The calculations of the techno-economy assessments were based on experimental data obtained at laboratory (downstream process) and pilot scale (upstream process) in Germany.

Major results and findings

In the calculated scenarios, the use of artificial illumination was found to be of economic advantage. The decisive factors for the production costs of the process as a whole were found to be the electricity and associated energy requirements for either artificial lighting (32-35%) or temperature control for cultivation in sunlight (19-23%). Without a permanent artificial light supply, the costs of providing the cultures with CO2 also shift into focus (approx. 17%). The results are however highly dependent on location (electricity prices, wage costs, emission factors).

Conclusion of your research

Therefore, cultivation with sunlight is not recommendable from an economic point of view under the modelled process parameters and the climatic conditions of Germany.

Eco-friendly synthesis of (R)-3-hydroxydecanoic acid and analogues: New green pathway to highly potent elicitor(s) of plant immune system

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Relevance and aim of the study

To face the challenge of feeding nearly 10 billion human beings without poisoning soils and water, agriculture has to evolve. One way to ensure good productivity is to protect crops from diseases by stimulating their natural immune system, this solution being called elicitation. This stimulation can be induced by molecules issued from pathogens such as fungi or bacteria. Among these molecules, rhamnolipids, in particular the 3-hydroxyfatty acids constitutive of the lipidic moiety of the rhamnolipids, exhibit very promising activities. Recently, (*R*)-3-hydroxydecanoic acid has been identified as a highly efficient elicitor to protect vine against pathogens such as powdery mildew. Unfortunately, existing synthetic pathways for this molecule do not comply with the green chemistry principles. Herein we will propose an eco-friendly approach to synthesis this valuable compound and analogs.

Materials and methodologies used

Using levoglucosenone as the starting material, a chiral cellulose-based synthon, allowed to develop a bio-based, eco-friendly and versatile alternative for the synthesis of functionalized 3-hydroxyfatty acids. The calculation of green metrics (Ecoscale and Process Mass Intensity (PMI)) were performed in order to compare this new protocol with existing methods. *In vitro* assays on vine plant are planned to evaluate the activity of the analogues compared to (*R*)-3-hydroxydecanoic acid.

Major results and findings

The (*R*)-3-hydroxydecanoic acid and a library of analogs were succesfully synthesized following the principles of green chemistry. In particular, PMI of each step of the new procedure was very low ensuring good atom economy. Use of toxic reagents was limited, that improve safety of the global process, leading to high Ecoscale.

Conclusion of your research

To conclude, molecules with potential high elicitation properties can be synthesized through green chemistry to perform *in vitro* assays on plant and determine structure/activity relationship. These results could be of high interest to choose microorganisms able to produce the best cocktail of rhamnolipids with the objective to apply elicitation at high scale to limit or replace pesticides.

Green polymerization of readily accessible levoglucosenone-derived monomers: towards fully renewable functional crosslinked materials

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Relevance and aim of the study

The first successful homopolymerization of the recently reported bis(γ-lactone), **2H-HBO-HBO**, is established.

Materials and methodologies used

All manipulations with air-sensitive chemicals and reagents were performed using standard Schlenk techniques on a dual-manifold line, on a high-vacuum line. All chemicals and reagents were used as received without purification.

Major results and findings

Levoglucosenone (**LGO**)[1] is a chiral molecule produced from the acid-catalyzed flash pyrolysis of cellulose. **LGO** can be used as a versatile platform for a wide range of high value-added compounds. For instance, (*S*)-γ-hydroxymethyl-α,β-butenolide (**HBO**) can be readily obtained from the Baeyer-Villiger oxidation of **LGO**. Moreover, the catalytic hydrogenation of **HBO** leads to the quantitative formation of (*S*)-γ-hydroxymethyl-γ-butyrolactone (**2H-HBO**). We reported recently an easy one-pot synthesis of a new bicyclic diol, **2H-HBO-HBO**, *via* H_2O_2-mediated Baeyer-Villiger oxidation/rearrangement of **LGO**-Cyrene™.[2] The reactivity of the two hydroxy groups of **2H-HBO-HBO** was tested in the solvent-free polycondensation of **2H-HBO-HBO** with diacyl chlorides. Interestingly, polyesters with glass transition (T_g) values ranging from −1 to 81 °C and good thermostability were obtained.[2]

Following the aformentioned results, we became interested in the synthesis of polycarbonates from **2H-HBO-HBO** and renewable organic carbonates, such as di(methyl carbonate) isosorbide (**DCI**). Unfortunately, all our trials to prepare polycarbonates failed. Such unexpected behavior was ascribed to the higher reactivity of the **2H-HBO-HBO** towards itself. Interestingly, the homopolymerization of **2H-HBO-HBO**, was simply achieved under mild conditions and the formation of poly(**2H-HBO-HBO**) was fast and quantitative.

Conclusion of your research

The environmentally benign polymerization of **2H-HBO-HBO**, which is readily accessible from cellulose byproducts, leads to the formation of 100% renewable polymers. The easiness of preparation of these polymers, their low-cost production process, as well as their interesting and tunable thermal properties, make them suitable to substitute petrochemical-derived commodity polymers.

1- J. Kühlborn, J. Groß, T. Opatz, *Nat. Prod. Rep.* **2020**, *37*, 380.
2- F. Diot-Néant, L. Mouterde, S. Fadlallah, S. A. Miller, F. Allais, *ChemSusChem* **2020**, *13*, 2613.

Simultaneous extraction and enzymatic hydrolysis from mustard bran for the recovery of sinapic acid

Reungoat, Valentin[1], Mouterde, Louis M. M.[1], Chadni, Morad[1], Couvreur, Julien[1], Isidore, Emilie[1], Allais, Florent[1], Ducatel, Hélène[2], Ioannou, Irina[1]

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Relevance and aim of the study

Sinapic acid is a high value-added phenolic acid. It stirs more and more interest from researchers due to its many biological properties such as free radical scavenging, anti-inflammatory, anti-carcinogenic and anti-UV properties [1]. It is contained in mustard seed industrial by-products as ester derivatives, the main one being sinapine (>90%). Therefore, the simultaneous extraction and enzymatic hydrolysis of sinapine from a mustard seed by-product was designed for the recovery of sinapic acid.

Materials and methodologies used

An initial spectrophotometric screening was conducted on 15 commercial enzymatic cocktails and on a mono-enzymatic feruloyl esterase. Then, different extraction processes on a mustard by-product (bran) were designed. The yields of sinapine and sinapic acid were measured by HPLC. The respective efficiencies of the processes were discussed.

Major results and findings

The initial spectrophotometric screening allowed the identification of sinapoyl esterase activities in the commercial enzymatic cocktails of Depol 740L, Ultraflo XL, Deltazym VR AC-100, Pectinase PL Amano and in a mono-enzymatic solution of rumen FAE. These enzymatic cocktails were shown not very tolerant to ethanol with a diminution of 70 to 90% of the activity in presence of 10%v of ethanol.
The implementation of the simultaneous aqueous extraction and enzymatic hydrolysis with Depol 740L allowed to recover 68% of the accessible sinapic acid (25.4 ± 0.1 µmol/g of mustard by-product dry matter) in 2h40 under mild conditions (pH 7, 50 °C).

Conclusion of your research

This study shows the efficient biocatalytic production of sinapic acid from mustard seed by-products using a commercial enzymatic cocktail. It paves the way for new developments in the design of a sustainable production process.

1. Nićiforović, N. & Abramovič, H. Sinapic Acid and Its Derivatives: Natural Sources and Bioactivity. *Comprehensive Reviews in Food Science and Food Safety* **13**, 34–51 (2014).

Side streams

Effect of the pH on the Extraction of Sinapic Acid Derivatives from Mustard Seed Meal

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Relevance and aim of the study

The aim of this study is to investigate the effect of the pH on the extraction of sinapic acid and its derivatives (sinapine, ethyl sinapate) from mustard seeds meal.

Materials and methodologies used

Extraction of sinapic acid derivatives (SADs) from mustard seed meal was performed in a 250 mL tricol flask with a condensing column. The solvent used is water at different pH (acidic pH (pH 2), basic pH (pH 12) and distilled water (uncontrolled pH ~4.5)) and absolute ethanol at different percentages (VEthanol/Vwater), the liquid-to-solid ratio was fixed at 10 mL/g of seed meal. The temperature of extraction was fixed during the extraction at 70 °C. Time of extraction was fixed at 2 h.

Major results and findings

The maximum extraction yield for sinapic acid (13.22 µmol/g of dry matter (DM)) was obtained with a buffered aqueous solution at pH 12. For ethyl sinapate, the maximum extraction yield reached 9.81 µmol/g $_{DM}$ with a 70% ethanol/ buffered aqueous solution at pH 12 solution. Maximum extraction yield of sinapine (15.73 µmol/g $_{DM}$) was achieved with a 70% ethanol/buffered aqueous solution at pH 2 solution. The antioxidant activity of each extract was assessed by DPPH° assay, the results indicated that sinapic acid-rich fractions exhibit the higher antioxidant activity followed by ethyl sinapate- then sinapine-rich extracts.

Conclusion of your research

This work highlights the importance of controlling the operating conditions of the extraction process for the recovery of sinapic acid derivatives (SAD) from mustard seed meal. It has been found that extraction at basic pH with a buffer solution maximizes the antioxidant activity of the extract by increasing the selectivity of the extraction process for sinapic acid. In a concept of valorization of mustard seed meal, techno-economic calculations will have to be made in order to determine the economic viability of such a process.

Myco-conversion of agro-waste into by-products

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Relevance and aim of the study

Agriculture is a productive activity producing a large volume of agro-waste, which, if mishandled, poses health, food safety, and environmental risks. Adequate processing of agricultural waste has advantages in reducing greenhouse gas emissions and reducing fossil fuels, as well as contributing significantly to the development of new markets and job opportunities. In this context, fungi are an attractive resource for agro-waste bioprocessing into value-added by-products. Fungal mycelium growth promotes the degradation of the most recalcitrant macromolecules (*e.g*. lignin, hemicellulose and cellulose) and pollutants (*e.g.* pesticides, plastics), allowing a significant reduction in the volume of residual waste. In addition, mycelium colonizing the substrate reduces carbon losses and provides nutrients for a wide range of microorganisms that drive the diversity and composition of microbial communities and, thereby, increase biodiversity on the reuse of transformed wastes in soil.
This research aimed to exploit the potential of agro-wastes to create a new chain of products obtained through technological innovation. Specifically, we sought to: i) evaluate the potential of waste for the production of low-cost mushrooms; ii) bioconvert waste into new bio-based by-products (e.g. recovery of biopolymers, nutrients, biofertilizers).

Materials and methodologies used

The experiment was performed on the solid fraction of corn digestate from a biogas plant located in Malalbergo (Bologna, Italy). The high level of nitrogen and lignin in the solid digestate makes it a suitable substrate for growing edible mushrooms. *Cyclocybe aegerita*, *Pleurotus cornucopiae* and *Pleurotus ostreatus* were grown on both corn digestate and conventional substrates. The spent substrates after mushroom production were analyzed in C and N content and structural composition using FT-IR spectroscopy. The mature fruiting bodies were collected for 3 months; the fresh weight was recorded to evaluate biological efficiency. The resulting fruiting bodies were processed to extract chitin, which was characterized by FT-IR and FT-Raman spectroscopies.

Major results and findings

P. ostreatus showed the highest biological efficiency and fruiting body production on the corn digestate. *Pleurotus ostreatus* and *P. cornucopiae* were both able to degrade lignin as detected by FT-IR analysis.

Conclusion of your research

These results confirmed the possibility of economic use of anaerobic digestate for mushroom production.

Polyhydroxyalkanoates from waste as a sustainable platform for the production of materials and chemicals

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Relevance and aim of the study

Polyhydroxyalkanoates (PHAs) are biobased and biodegradable polyesters of hydroxy acid monomers bio-synthesized by different kinds of bacteria through the aerobic conversion of various feedstock, and potentially capable to replace fossil-based plastics thanks to similar mechanical and physical proprieties. The development of technologies able to obtain this plastic material from wastes through the use of mixed microbial cultures, opened the possibility to produce it in a more sustainable way.

Materials and methodologies used

In B-PLAS_DEMO[1] project we realized a fully automated prototype that allows to convert waste sludge and other organic residues into PHA suitable for packaging, disposable items, molding and 3D printing.
In this context our research group is now developing new strategies in order to recycle PHA and PHB as it is or use it as a sustainable platform for the synthesis of chemicals.[2]

Major results and findings

The chemicals can thus be used in the same PHA production cycle (eg. highly efficient solvents for PHArecovery: MHB and MMB) or for totally different applications, such as the synthesis of high value molecules or the manufacture of new polymers.

Conclusion of your research

B-PLAS DEMO realized the conversion of organic waste into bio-plastic, extracting value from waste and opened the way to the use of PHAs as a sustainable platform for the production of materials and chemicals

References:
[1] https://site.unibo.it/b-plas/en
[2] Parodi, A.; Jorea, A.; Fagnoni, M.; Ravelli, D.; Samori, C.; Torri, C.; Galletti, P., (2021), Green Chemistry, 3420–3427

Valorization of hempseed meal by the extraction of phenolic compounds

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Relevance and aim of the study

Cannabis sativa L. is usually divided into two categories of cultivars based on their content in the psychoactive compound tetrahydrocannabinol (THC). The non-drug type, commonly known as hemp, must have a THC content below 0.2% in most European countries. The cultivation of hemp to produce fibers and oil generates different by-products including hempseed meal. This by-product is composed of different classes of phenolic compounds. These high value-added molecules are well-known for their biological activities and find applications in diverse industries.

Materials and methodologies used

This study gathers the relevant literature data on the extraction processes and major phenolic compounds of hempseed meal as well as the reported biological activities of the extracts. An intensive search of studies focusing on the extraction of hempseed meal was carried on, mainly through the Scopus database. The influence of the extraction parameters was discussed as well as the resulting activities of the extracts.

Major results and findings

The extraction techniques used for the recovery of phenolic compounds from hemp include conventional solvent extraction and ultrasounds assisted extraction among other techniques. The use of ultrasounds to intensify the extraction allows a reduction of the extraction time. Hempseed meal extracts are composed of common phenolic compounds; however, the major components belong to the lignan class. In particular, *N-trans*-caffeoyltyramine and some cannabisins exhibited interesting contents and a strong antioxidant activity.

Conclusion of your research

Although the extraction of hempseed meal has been explored with different techniques, more development of intensification techniques may be interesting. The implementation of sustainable extraction processes for the recovery of biobased molecules is indeed a necessary step in the biorefinery of hemp by-products.

Workshops

Thursday, 23 September 2021 11:30 am – 1:00 pm and 2:00 pm – 6:00 pm

The workshops are intended to work together to ideate, brainstorm and define a project proposal as response to the different calls of Horizon Europe Work Programme 2021-2022. Through the workshops, the participants will be able to connect to other interested researchers who work at different and/or similar disciplines from the EBU partners and associates and are able to work in a potential project together. By connecting the researchers and creating a common and first interesting project idea, we aim to foster collaboration and research among and between the EBU partners.

Thursday, 23 September 2021 11:30 am – 1:00 pm

Workshop 1: Innovation for sustainability: Sustainable biodegradable novel bio-based plastics: innovation for sustainability and end-of-life options of plastics

Moderator: Dr. Martin Greimel and Bernhard Koch, University of Natural Resources and Life Sciences

This workshop focuses on the need to develop innovative, sustainable bio-based and biodegradable plastics with novel properties and production processes and intends to formulate a project that expects to develop bio-based plastics value chains with improved functionalities and environmental performances, less toxicity substances, lower waste production and better product safety control. The project idea should include the development of novel sustainable bio-based biodegradable plastics, optimizing innovative aspects of the production process, testing the biodegradability in specific environments, and demonstrating scale-up potential.

Workshop 2: Boosting breeding for a sustainable, resilient and competitive European legume sector

Moderator: Prof. Luisa Trindade, Wageningen University & Research

Striving for sustainable farming systems, legumes could play an important role as they are source of food, feed and environmental services. During this workshop, the participants will work on a proposal that aims to improve legume varieties and availability of open access to data on breeding methods, increase competitiveness, improve biodiversity and diversification of farming systems and agri-food value chains, and expand the delivery of environmental services from agriculture. The project idea should include a development of a catalogue of legume species and varieties, and an open repository of breeding methods, analyse the cost-effectiveness of legume breeding, design training to the needs of different actors in the sector, and foster demonstration and testing of legume breeding.

Thursday, 23 September 2021 2:00 pm – 3:30 pm

Workshop 3: Building alternative protein-friendly sustainable and healthy food environments

Moderator: Sebastian Weickert, University of Hohenheim

The food environment affects consumer choices and could have a positive impact on health if done properly. This workshop aims to create a project proposal that improve the effectiveness and efficiency of food environments to ensure that people, including the most vulnerable groups, have choices in terms of alternative proteins, ensure an overall improvement in public health, and reduce environmental burdens of European diets. The project idea is expected to empower the actors from middle part of the food system such as industry, processors, cooks, among others, to diversify the offer of protein source and ensure easier access, develop a typology of food environments across Europe, explore how the food environment can become “crisis-proof”, and include social innovation especially if social change is required.