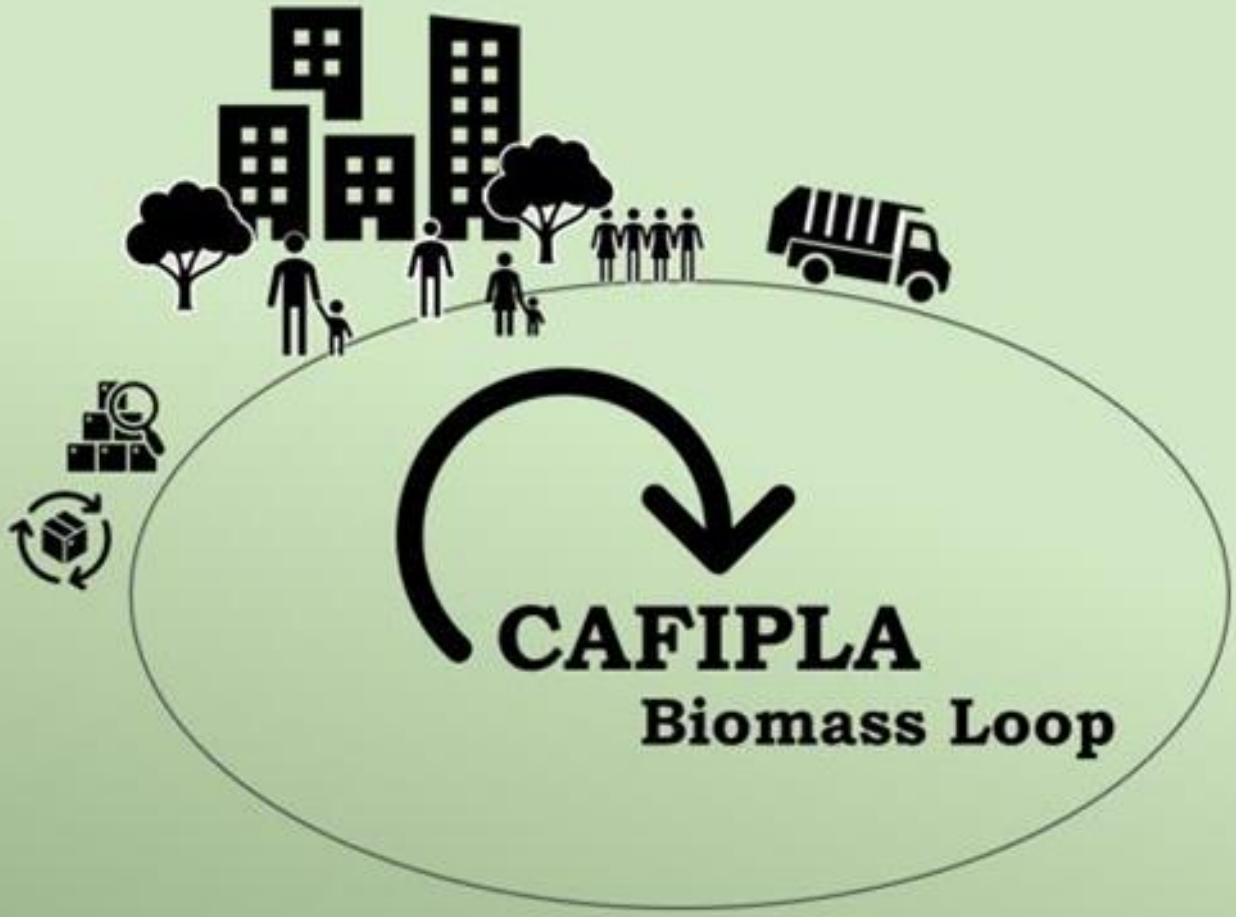

CONFERENCE

Urban Circular Bioeconomy

valorising biowaste - creating prosperity

Vitoria-Gasteiz (Spain)

10/05/2023

Notice

The proceedings of the conference “Urban Circular Bioeconomy – valorising biowaste – creating prosperity” were prepared in the context of the Bio-based Industries Joint Undertaking (JU) funded project CAFIPLA under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 887115. The JU receives support from the European Union’s Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

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To contribute to the effective up-cycling of available biomass resources and the establishment of a sustainable circular urban bioeconomy the cooperation between different actors and stakeholders along the value chain from public authorities, research centres, universities and industry partners is required. As biowaste flows in cities can be used to produce value-added bio-based products such as chemicals, plastics or nutrients, already in 2018, the European Commission established in the Bioeconomy Strategy (2018) that "…cities should become major circular bioeconomy hubs…".

The conference provided feasible pathways to transform biowaste into a resource/precursor for other industries via an innovative approach of the combination of a Short Chain Carboxylic Acid Platform and a Fibre Recovery developed in the context of the project CAFIPLA receiving funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887115.

Bioeconomy experts from Industry and Research provided insights in biorefinery, raw material availability, technology aspects of the combined platform approaches, fermentation pathways to transform short chain carboxylic acids into added value compounds to support the implementation of a circular biowaste based bioeconomy.

This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887115. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

VENUE: EUROPA CONGRESS PALACE

Avenida de Gasteiz 85
01009 Vitoria-Gasteiz (Spain)

VITORIA GASTEIZ! green capital

Ayuntamiento de Vitoria-Gasteiz
Vitoria-Gasteizko Udala

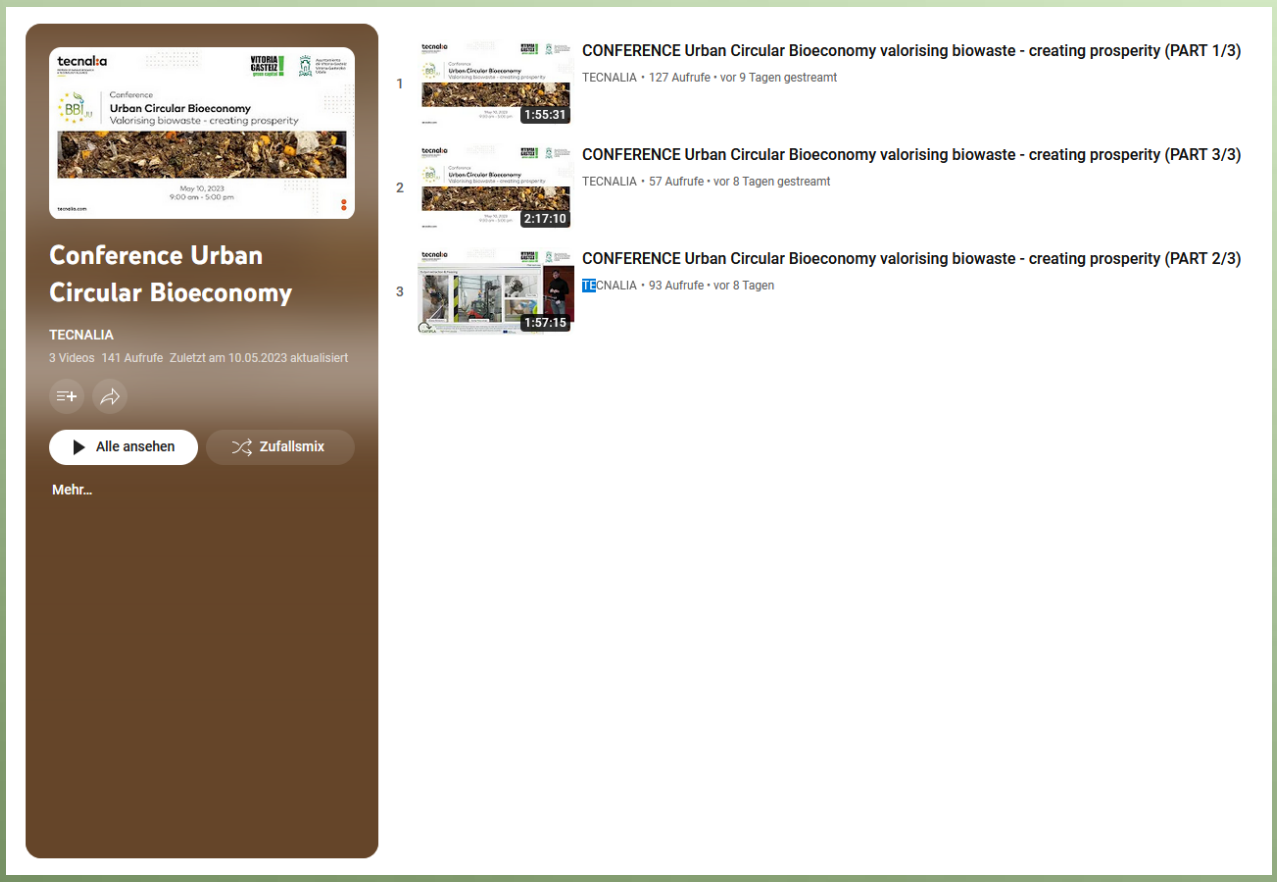
Thank you very much for joining the Conference and being part of the CAFIPLA community, separating your organic household waste properly.

We would also like to thank our partner projects VOLATILE (GA nº 720777), Tech4Biowaste (GA nº 101023200) and HOOP (GA nº 101000836) presenting research results at the conference.

The CAFIPLA Team

If you were not able to participate in the event you can also follow the conference in YouTube under the following link:

https://www.youtube.com/playlist?list=PLoKLbSNc5LnDedwXWyIkzOpPLFKH7URqQ



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Welcome

Mª Carmen Villaran - TECNALIA Research & Innovation (Spain)

Good morning and welcome to the conference Urban Circular Bioeconomy – valorising biowaste – creating prosperity.

First, I would like to thank you for your attendance at this conference which objective is to work on issues such as why urban biowaste is still waste, what we are doing currently with our biowaste and how biowaste can provide value.

The conference is organized in the context of the project CAFIPLA funded by the BBI JU. The project develops two platforms combining carboxylic acid production with a fiber recovery as an innovative and sustainable pre-treatment approach for heterogenous biowaste. Therefore, thank you to the partners of the consortium for the organization of this event.

The business area for food and heath of TECNALIA is coordinating the CAFIPLA project. It is important to mention that the circular economy is one of the seven areas of action in which TECNALIA works and through which, it contributes to achieve the objectives of the European Green Deal.

TECNALIA's circular economy activities are based on supporting the industry and public institutions in the implementation of a sustainable economic model that introduces circularity in production systems, optimizing the use of feedstocks and raw materials, products / services and energy in which waste is reduced to a minimum, helping to strengthen the competitiveness of companies and the generation of new economic activities based on the “Green Economy”.

Today’s speakers are experts in bioeconomy from industry and research and will provide information on biorefinery, availability of raw materials, technological aspects of a combined platform approach to produce carboxylic acids and to recover fibers as well as the fermentative transformation of these short chain carboxylic acids into added-value compounds, supporting thereby the implementation of a circular bioeconomy based on heterogenous biowaste.

Additionally, I would like to thank the participants of the roundtable Marie-Aline Pierrard from IDELUX, Martin Soriano from CETENMA and Bruno Ferreira (CEO of Biotrend). The roundtable will be moderated by Mª Carmen Villaran, director of the Food & Health Business area of TECNALIA.

The conference is organized in Vitoria-Gasteiz because of its commitment to the green transition which led to the selection as European Green Capital. The city is continuously working to improve the selective collection of municipal waste, including biowaste. Joseba Sanchez from the City Council of Vitoria-Gasteiz will present us achievements and strategies implemented by the city.

As it is well known, the use of petrochemical resources contributes to greenhouse gas emissions and climate change and therefore negatively affects our health and the environment.

Therefore, new strategies are developed to shift our economies towards the use of renewable raw materials. However, a new report on the use of biomass reveals that under current conditions exist a biomass gap from 40-70% between biomass supply and demand.

Taking this biomass gap into account, available biomass resources including biowaste should be used in a sustainable manner focusing on biomass up-cycling strategies to transform these biomass resources into value-added biobased products and to improve the circularity aspects of biomass.

In this context, the European Commission established already in 2018 in its Bioeconomy Strategy that cities should become important hubs for the circular bioeconomy. In this transformation one of the main challenges is the recovery of municipal biowaste due to its heterogenous composition.

Therefore, the conference today will provide answers to open questions related to the valorization of heterogenous biowaste and the technological approaches to be used.

We will begin the conference with a presentation of Joseba Sanchez on bioeconomy strategies at the local level in Vitoria-Gasteiz.

Subsequently, the partners of the CAFIPLA project will present results of the project that has led to the implementation of a pilot plant at TRL 5 with a capacity to treat around 6.25 ton of biowaste per month. The pilot plant was implemented at IDELUX, a waste treatment facility in Belgium.

Likewise, Martin Soriano from CETENMA will present us the perspective at the European Level.

We will conclude the today conference with a roundtable to debate most relevant issues.

And without further preamble I give way to Joseba Sanchez. Thank you very much for joining us today.

PHOTO SESSION







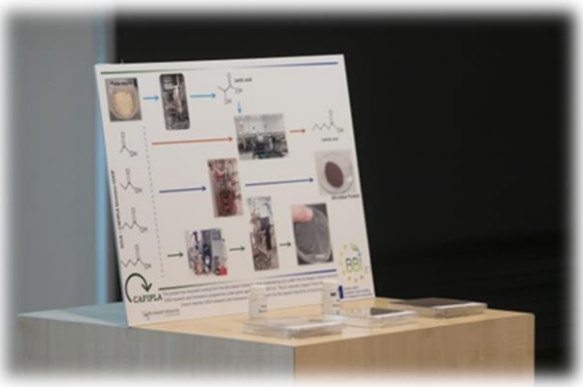









EXPOSITION



Walking towards a local model of organic waste management

Joseba Sanchez - City Council Vitoria-Gasteiz, Department of Environmental Planning (Spain)

The speech will consist of three different parts:

The ***first part*** will talk about the general data on the collection and management of organic waste in Vitoria-Gasteiz. From general city data to the amounts that are collected and recycled in the city.

The ***second part*** will address the current management of organic waste in Vitoria-Gasteiz. Starting from the collection infrastructure (new intelligent container with user identification) to the treatment that we are currently carrying out; intensive composting in trenches and biomethanization through Dranco technology.

Finally, we will address the future prospects of the city. From the plans to increase selective collection, to the needs for new organic waste treatment infrastructures and the recovery of the rejects that are currently going to the landfill and that have great potential for use.

CAFIPLA – Heterogenous biowaste a valuable resource

Thomas Dietrich – TECNALIA Research & Innovation (Spain)

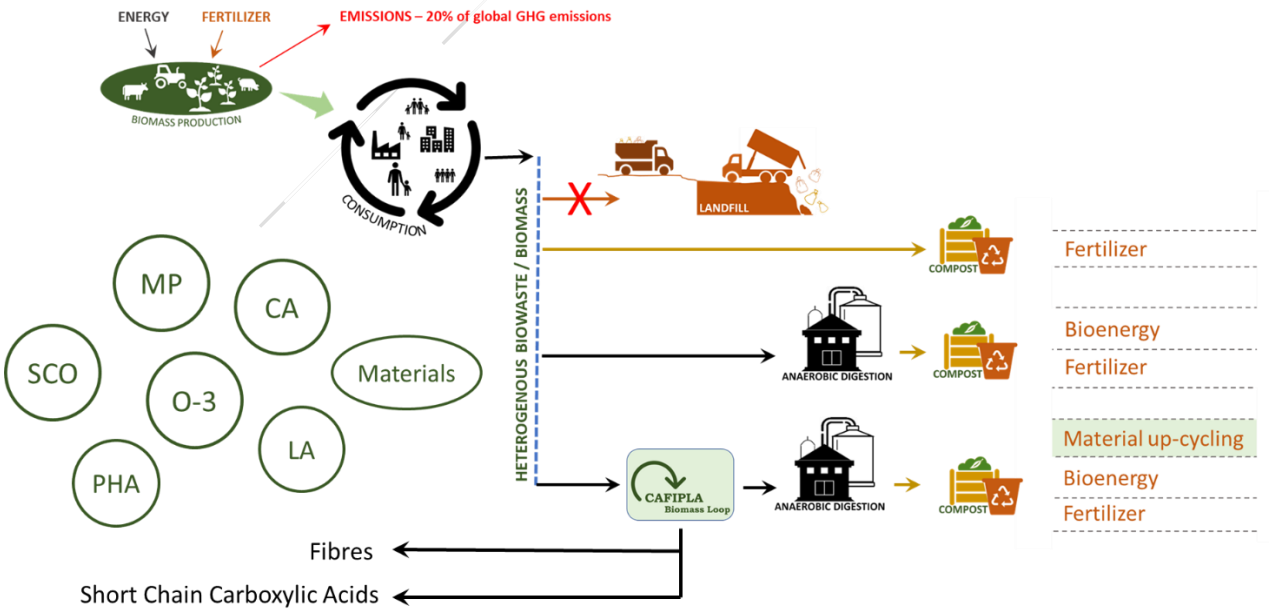
The implementation of the three years CAFIPLA project will radically alter the biomass pre-treatment approach for bioeconomy applications. Current biomass use comes at a high cost, either in terms of land-use (sugar/starch crops) or energy and chemical use (2nd generation biomass).

On the other hand, bio-waste is massively produced in urban or rural context but almost not valorised, or solely in low-value applications, in part due to its heterogenous nature.

The project CAFIPLA tackles both issues by developing an integrated biomass valorisation strategy that combines the carboxylic acid and fibre recovery platform (CAP/FRP). CAFIPLA optimises the platform approach and the transformation of easily biodegradable fraction as short chain carboxylic acids via the CAP as well as recalcitrant biomass, as input for the FRP. This allows the implementation of tailored valorisation strategies for both routes, which in turn allows the use of heterogeneous bio-waste as input, while still ensuring high overall yields. In the CAP, research focuses on process control strategies to obtain specific spectra of short chain carboxylic acids to feed into bioproduction of microbial protein, PHA or caproic acid bio-oil. In the FRP, fractionation into different fibre ranges results in intermediates that can be valorised as packaging material or insulation.

A TRL5 pilot demonstrated the CAFIPLA upscaling potential. The project represents a radically new approach for bio-economy applications by approaching biomass use more pragmatically. This approach, which centres on the integration of two platforms, allows tailor-made solutions. This improves the sustainability and cost-effectiveness of pre-treatment (ambient pressure/temperature, low chemical use, bio-waste as input material).

CAFIPLA furthermore studied the biomass supply chain and the business models for future implementation. The well-balanced CAFIPLA consortium, including 12 participants from 6 European countries, ensured successful research and impact on the bioeconomy well beyond the project consortium and timing.



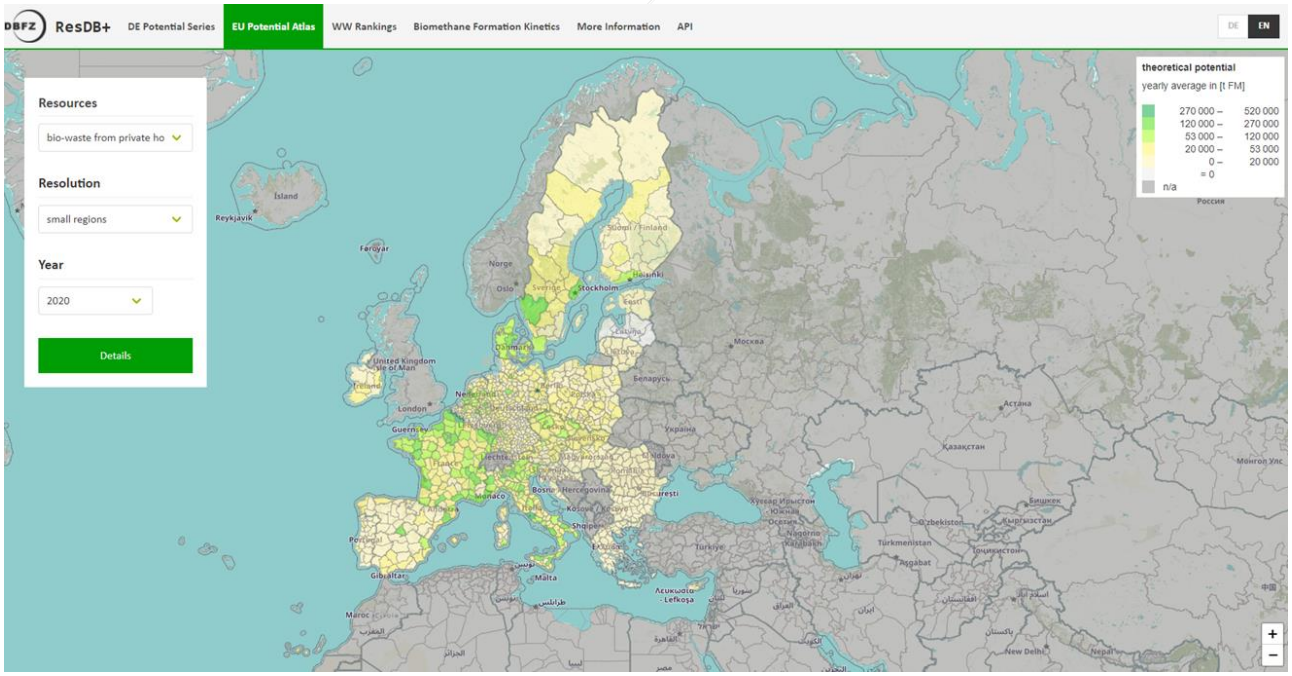
CA: Caproic acid; **LA**: Lactic acid; **MP**: Microbial protein; **PHA**: Polyhydroxyalkanoate; SCO: Single Cell Oil; **O-3**: Omega-3 fatty acids

Mapping of biogenic resource potentials across Europe – a test case for CAFIPLA transferability

Susann Günther – DBFZ Deutsches Biomasseforschungszentrum gGmbH (Germany)

With the increasing demand for biogenic resources, e.g. for energy or material use, it is important to estimate and understand the spatio-temporal variability and reliability of estimated biomass potentials. In particular, the establishment of new bio-based technologies requires this information to identify potential production locations. High-resolution spatial and temporal data on biogenic residues used in CAFIPLA are therefore a valuable source for identifying other areas with high theoretical biomass potential and their availability over time to extend the developed technology application and support the bioeconomy. The studied biogenic residues are produced in different sectors and there is no comprehensive database combining spatial and temporal time series of these different fractions.

As part of the Horizon 2020 BBI JU project “CAFIPLA” (GA. No.: 887115) the theoretical biomass potentials of 13 residues from agriculture (maize straw, wheat straw, rye straw, rapeseed straw, sugar beet leaves, sunflower straw, rice straw), municipal waste (biogenic municipal waste from households) and industry (beet pulp, molasses, brewer's spent grain, brewer's spent yeast, whey) are presented for all EU27 Member States on an annual basis from 2010 to 2020 with a spatial resolution from NUTS 0 to NUTS 3, where possible. The modelled and regionalised data are validated against national statistics. The resulting open access database is designed as an expandable tool to understand national and regional trends of theoretical biomass potentials in the European Union. As a further product of the project, all data is visualised within the interactive "EU Potential Atlas" dashboard, including time series and Europe wide rankings.



EU Potential Atlas - https://datalab.dbfz.de/resdb/maps

Impact and Market of Biowaste-derived Materials

Esther Hegel – DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V. (Germany)

In an expanding bioeconomy, demand, and competition for biomass as a feedstock will increase, making the efficient utilisation of biowaste, an abundant but currently underused resource, increasingly important. While the idea of using organic waste as renewable resource for bioproduction is not entirely new, the CAFIPLA approach is the first of its kind to integrate a carboxylic acid platform (CAP) for the conversion of easily degradable biomass with a fibre recovery platform (FRP) for the valorisation of fibrous biomass.

Within two **CAFIPLA Market assessments**, the potential of the obtained platform products as starting points for multiple valorisation routes was analysed. The CAFIPLA products include polyhydroxyalkanoates (PHA) which can be used as biobased and biodegradable plastics or bio-composites, medium chain carboxylic acid (MCCA)-based biooils to be used as antimicrobial feed additives as well as microbial proteins serving as slow-release fertilisers or food and feed additives. The simultaneously produced reinforced natural fibres have high environmental benefits and are relevant for the insulation and construction market segments. Selected CAFIPLA end products are showcased including information regarding production processes, product properties and targeted market applications. Further upscaling of the CAFIPLA concept and its transfer to further biowaste valorisation sites will be key to help unlock biowaste as a raw material for the European circular bioeconomy and help to ease trade-offs between industrial and environmental interests and the competition for increasingly scarce bioresources.

The recently published ***CAFIPLA Implementation guideline*** outlines key factors to establish the highly flexible CAFIPLA technology and facilitate biowaste valorisation on a local level, considering feedstock supplies, stakeholders and markets. Different implementation routes are described, including an integration into existing biorefinery or waste treatment sites to complement existing biowaste utilisation approaches and the installation of stand-alone CAFIPLA biorefineries. Results obtained during multiple stakeholder workshops, interviews, survey, and conferences were used to provide clear recommendations in an overarching PESTEL analysis on how to accelerate biowaste valorisation and the European circular transition.

Key results are detailed in the following CAFIPLA reports:

- Initial Market Assessment
  https://cafipla.eu/wp-content/uploads/2021/08/D_01_01_Report-on-the-Initial-market-assessment-of-CAFIPLA-as-biowaste-valorisation-strategy.pdf
- Final Market Assessement
  https://cafipla.eu/wp-content/uploads/2023/02/D1.5_Final-Market-Assessment.pdf
- Implementation Guideline
  https://cafipla.eu/wp-content/uploads/2023/04/D7.12-Guideline-for-successful-integration-of-the-technology-platform_PU.pdf

Conversion Technologies – Tech4Biowaste

Stef Denayer – Bio Base Europe Pilot Plant (Belgium)

The Tech4Biowaste database: Getting biowaste conversion technologies out of the dark.

Tech4Biowaste provides the first an openly accessible dynamic open-source database of relevant technologies of biowaste conversion and utilisation (Tech4Biowaste). Stef Denayer will guide you through the database.

Who benefits from the Tech4Biowaste database?

Biowaste producers and converters can benefit from the database in four different ways:

1) **Finding new biowaste valorisation technologies**

The Tech4Biowaste database covers technology readiness levels four and higher, relevant feeds and products. The database contains up-to-date information, is user-friendly, well-maintained and accessible to everybody.

2) **Presenting technologies**

Biowaste valorisation technology providers can enter their company profile directly on the suitable technology page. Technology searchers will directly find the company profiles when looking for specific technologies.

3) **Finding technology providers**

Biowaste providers can find the right application for their feedstock and search for technologies and technology suppliers. Suppliers provide information and technical details about their technologies.

4) **Comparing technologies**

The one-stop and comprehensive biowaste technology overview is complemented by a technology comparison tool. The tool helps users to find the technology fit for their application.

Who is behind the Tech4Biowaste project?

The Tech4Biowaste consortium is led by BTG (Biomass Technology Group BV, The Netherlands, www.btgworld.com/en). The two other project partners are Bio Base Europe Pilot Plant (Belgium, www.bbeu.org) and nova-Institute (Germany, www.nova-institute.eu).

Tech4Biowaste is closely linked with two partner projects: Pilots4U, the Europe-wide network and database of open access multipurpose pilot and demo infrastructures for the European bio-economy (www.biopilots4u.eu) and the Renewable Carbon Initiative (RCI) which aims to support and speed up the transition from fossil carbon to renewable carbon for all organic chemicals and materials (www.renewable-carbon-initiative.com).

Funding

This project received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101023200. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Carboxylic Acid Platform: a new valorization approach

Thomas Willems – DRANCO NV (Belgium)

To increase the application of organic waste as input material for the bioeconomy, a completely novel approach for pre-treatment is required. One option represents the transformation of easy degradable organic material into carboxylic acids via a Carboxylic Acid Platform (CAP).

The CAP platform produces valuable short-chain fatty acids from organic municipal waste by promoting the acidogenesis reaction pathway, resulting in short-chain fatty acids that can be used as feedstock for various other applications. Batch tests were conducted to determine the potential of municipal household waste and other types of residual waste streams to produce short-chain fatty acids. The most promising waste streams were then used for lab-scale continuous reactor set-ups to test key physicochemical parameters with a view to scaling up to a pilot plant.

Once the continuous tests demonstrated stable short-chain fatty acid production, a pilot plant was constructed to achieve stable production of short-chain fatty acids for further applications within the project. The pilot plant, known as the loop, was chosen to maintain the tested physicochemical parameters. The biowaste is fed via a conveyor belt and homogeneously mixed by two screw conveyors. Temperature and pH are monitored closely, and after a set time, part of the reactor is emptied, and new material is introduced. The output of the reactor undergoes two downstream process steps: a pressing step and a decanting step. The output is separated into two fractions: dry press cake and press water. The decanter treats the press water further, resulting in clarified CAP water further purified via membrane filtration if needed and finally used as carbon source in added value fermentation processes. The solid fraction can used for fibre recovery via the FRP – Fibre Recovery Platform using NADES.

The pilot achieved a consistent production of 20 kg of SCCA per week. The residual press cake and solids still contain a significant biogas potential and can be further processed in the standard biogas digestion process. This pre-imposed CA platform is conclusive since every residual stream from the pre-treatment can be processed. The results of the pilot demonstrate that the new pre-processing approach adds value to the standard digestion process and is conclusive since all residual waste streams can still be treated using standard biogas fermentation.

Natural Deep Eutectic Solvents – an innovative solution for the recovery of fibres from municipal biowaste

Thomas Dietrich – TECNALIA Research & Innovation (Spain)

Municipal biowaste is in general a complex natural biomaterial composed of cellulose, hemicellulose, and lignin altogether with other substances as sugars, proteins, fat, minerals, etc. The crystalline cellulose is surrounded by the amorphous hemicellulose materials and embedded in the lignin matrix which act as an adhesive to bind the holocellulose components. Most of the biomass processing technologies such as acid or basic hydrolysis as well as Ionic Liquids processes utilize toxic raw materials which generates hazardous effluent streams and/or are energy-intensive processes because they require high temperature and pressure to separate or isolate specific components.

Therefore, the project CAFIPLA developed an innovative approach to use natural deep eutectic solvents, mixtures containing an hydrogen bond donor and acceptor formed by cellular metabolites such as alcohols, amino acids, organic acids, and sugars. The appropriate combination of these compounds leads to an eutectic mixture with a melting point depression.

The resulting NADES can be used to recover and purify lignocellulosic fibres from municipal biowaste. The fibres have a wide application potential such in films or bio composites.

PHB composites with incorporated fibres extracted from municipal biowaste

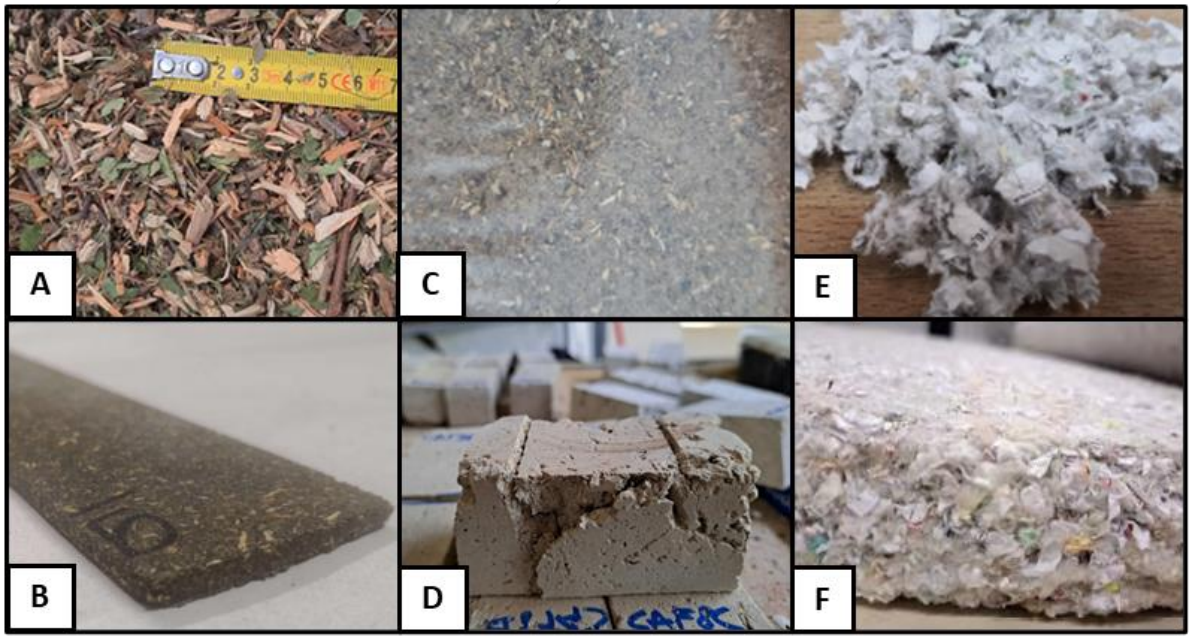
Recovery of fibres from biowaste streams via dry process, and potential in industrial applications

Thibault Lerouge – FRD Fibres Recherche Developpement (France)

The CAFIPLA method aims at valorising in a circular economy all insoluble fibres from biowaste streams accessible in the sorting centre. FRD has investigated and optimised the process of fibre recovery via a dry road with an in-depth characterisation of obtained fibres. Both organic fibres from kitchen wastes after the innovative LOOP process, as well as paper scraps and green wastes were studied. The specifications expected from these fibres were obtained after discussions with several industrialists.

The dry recovery road is composed of successive steps applied if needed. The wastes are firstly dried for stability (prevent biodegradation by bacteria and/or fungi growth). Then the wastes are depolluted (from stones, metal, or plastics) following technical specifications or industrial needs. Size reduction and fibre opening are performed with shredding and/or milling operations to reach specific sizes, from 8 mm to 500 µm maximum. Finally, a final sieving can be realised in case of specific industrial needs to remove fine dust or longest thin fibres.

The potential of the fibres was identified with an intensive prospection of several markets. First, the use of recycled biomass was validated in terms of legislation, by interviewing recycling actors and analysing the regulation. Simultaneously, the fibres were tested by FRD and TECNALIA in different applications and have presented interesting results in formulation and properties at pilot scale. Finally, numerous industrialists from several markets were prospected to obtain specifications and feedback on the fibres thanks to internal tests. The markets presenting the most potential are Plastics, thermal insulation and building applications.



(**A**) Raw green waste (GW) shredded at 8mm, and (**B**) panels with GW grinded at 2 mm; (**C**) Dry organic waste and (**D**) mortars with it; (**E**) Paper scraps grinded at 5 mm and (**F**) thermal insulation panels.

Biowaste as feedstock for lactic acid fermentation

Joachim Venus – ATB Leibniz-Institut für Agrartechnik und Bioökonomie e.V. (Germany)

Introduction: Among the 17 sustainable development goals (SDG) SDG7 “Ensure access to affordable, reliable, sustainable, and modern energy for all”, SDG12 “Ensure sustainable consumption and production patterns” and SDG13 “Urgent action to combat climate change” are interrelated and have become a high priority on the research agenda. Especially for biotechnological processes, in which the carbon of various substrates should be converted into microbial products, there is an increasing interest in the use of cheap raw materials, biogenic residues and wastes.

Aims: The goal is to develop high performance fermentation processes based on the substitution of expensive substrates and nutrients by cheaper materials from biomass and residues due to their main proportion of the whole costs.

Materials and Methods: Many feedstocks cannot be used normally for fermentation directly because the fermentable sugars are bound in the structure especially as cellulose and several types of hemicelluloses. A pre-treatment of agricultural residues is required when enzymes are used for hydrolysis in an enzymatic approach. Possible disturbing impurities and inhibitors (e.g. phenolic components from lignocellulosics, heavy metals in municipal waste or recycled paper), difficult to use components (e.g. pentoses) and partly fluctuating or relatively low concentrations of bio-available carbon sources in these materials should be considered. Special detoxification steps can help to improve the fermentability and con-version efficiency of such lignocellulosic hydrolysates. According to the difficulties mentioned in the mobilization of fermentable sugars a range of other, easily accessible substrates are suitable for fermentation processes (such as residues from fruit and vegetable processing, by-products from starch and sugar factories or from the baking industry).

Results: The viability of the production of organic acids from several residues has been demonstrated from laboratory up to pilot scale including the entire value chain starting from the raw material and resulting with a polymer-grade product (in case of subsequent bioplastic production). Pre-treatment methods are energy-intensive, and the selection of an efficient method is crucial for the overall economy of a biotechnological process. As a result of the achievements so far, the optimization of pre-treatment, hydrolysis, fermentation, and downstream processing steps in parallel together with the screening of suitable bacteria have been performed.

Conclusion: The entire processing chain has been implemented to generate lactic of high purity and quality. Exploitation of these monomers to produce biopolymers is one of the recent applications.

It is likely that one of the future trends in biochemical production will end up in mixtures of different low-cost raw materials to avoid the use of expensive complex supplements.

MCCA production from LA rich waste streams

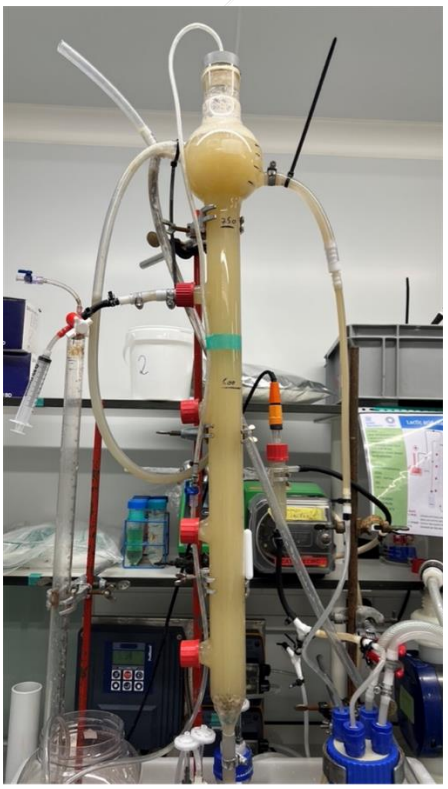
Kevin Sabbe – Universiteit Gent

The CAFIPLA project aims to produce a bio-oil rich in medium-chain carboxylic acids (MCCA), specifically targeting caproic acid (C6), a six-carbon MCCA with numerous applications in the chemical, feed, and energy sectors. In keeping with the principles of a circular bioeconomy, the project is investigating green technologies to increase the sustainability of C6 production, as well as the C6-utilising industries.

One promising approach is microbial chain elongation, using lactic acid (LA)-rich organic waste streams as a substrate. To optimize this process, we studied various process parameters such as feedstock composition, pH, hydraulic retention time, and temperature in continuous stirred tank reactors, using a synthetic feed that mimics the waste stream produced in the project. Our findings indicated that the presence of acetic acid (AA) as an electron acceptor is crucial for achieving stable LA-chain elongation, which significantly enhanced the production rate and selectivity of C6.

We then improved the process further in an extended granular sludge bed reactor (EGSB) system with in-line product extraction to retain active biomass and avoid product toxicity. With a selectivity of up to 93%, C6 was efficiently extracted from the system. We then validated the reactor configuration using a mixture of LA-rich and AA-rich broths produced by CAFIPLA project partners and the LOOP pilot plant. The results showed that the production selectivity of CA increased from 31% ± 15% to 82% ± 13%, resulting in a bio-oil containing 220 g/L CA.

These findings demonstrate that waste-derived LA and AA can be effectively converted into MCCA-rich bio-oil using microbial chain elongation. This technology has the potential to promote the sustainable production of caproic acid and thus, the greening of industries that utilize it.



EGSB (expanded granular sludge bed) reactor

Side stream derived biopolymers

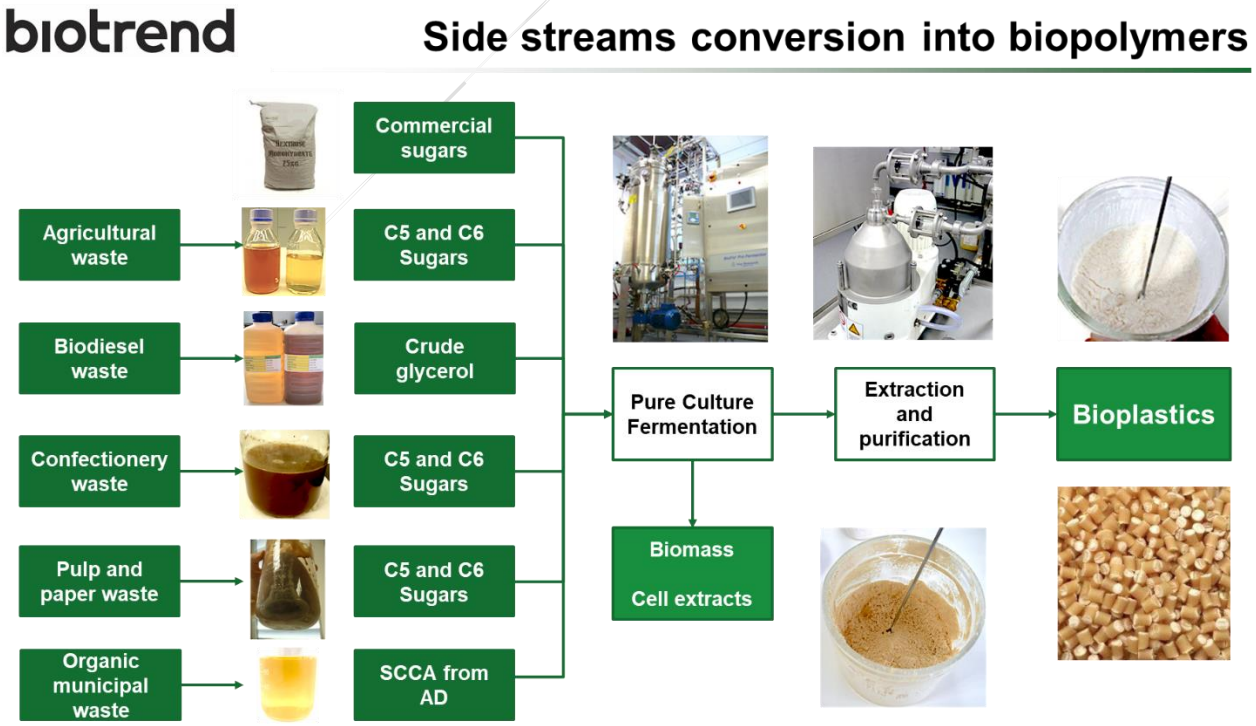
Ana Carolas – BIOTREND Inovacao e Engenharia em Biotecnología SA (Portugal)

Most plastics used worldwide are derived from fossil fuel hydrocarbons which, in one hand, are a non-renewable carbon source with significant CO_2 footprint. Further, the vast majority or existing plastics are not biodegradable, which accumulate in the environment after reaching their end of life. The negative repercussions of it are already well known and, because of that, the search for alternative solutions has resulted in extensive research and development.

Biotechnological solutions have been developed for decades now, in which bioplastics such as polyhydroxyalkanoates (PHAs) are produced using naturally producing bacteria. However, current carbon sources for bacterial growth comes at a high cost, either in terms of land use (sugar/starch crops) or energy and chemical use (2nd generation carbon sources).

Valorisation of side streams of industries to produce biopolymers such as agroindustry, paper and pulp industry and food industry, not only will contribute for the reduction of waste generated in those industries but will also contribute for the essential transition from a linear to a circular bio-economy system. This, in turn, will reduce the cost of raw materials to produce bioplastics, essential to obtain a cost-competitive alternative to the fossil fuel counterparts. More importantly, the bio-waste massively produced in urban or rural context is not yet significantly valorised, or solely in low-value applications. These can however be a source of raw materials to produce biopolymers by bacterial fermentation. Their heterogeneous nature constitutes a challenge but also an opportunity for tailor-made biopolymers with differentiated mechanical properties.

An introduction to the biopolymer's properties, fermentation technology and extraction and purification of PHA will be presented, focusing on the use of carboxylic acids as carbon source, produced by anaerobic digestion of bio-waste.



Development and technical scale evaluation of microbial protein production from CAP waters

Michael Pil – AVECOM (Belgium)

Feeding the world's population is one of the greatest challenges of our time. With the global population projected to reach 9.7 billion by 2050, it is estimated that food production will need to increase by 70% to meet this demand. It is clear, that there is a need for more sustainable alternative protein sources to cope with this problem. A possible alternative protein source is microbial protein (MP), which has several advantages over conventional protein sources. For one, it can be produced using a fraction of the land, water, and energy required. Additionally, it has a lower environmental impact, producing fewer greenhouse gas emissions and generating less waste.

In the CAFIPLA project, a development and technical scale evaluation of microbial protein production from CAP (Carboxylic Acid Platform) waters was performed. The CAP solutions are produced by OWS RF by anaerobically digesting municipal waste streams. The carbon and nutrients of this CAP water are subsequently converted into protein-rich microbial biomass by means of a mixed-culture aerobic fermentation process. Hereafter the MP is dewatered and finally dried to a powder.

A total of 10 lab-scale fermentation tests were performed with CAP waters derived from Idelux biowaste, with or without co-substrates. In all these fermentations, a very high COD conversion percentage (>95%) and relatively high protein percentage (66-75%) were achieved. An important finding here was to avoid the use of calcium hydroxide as a pH-controlling agent in the pre-treatment since this results in high calcium concentrations in the CAP waters and creates severe calcium precipitation in the MP reactor. This subsequently leads to a high ash and lower protein content. In general, the results of the lab-scale tests indicate that the CAP samples from the Idelux biowaste are well-suited for MP production. Furthermore, the best results of MP production were achieved with brewery yeast as a co-substrate.

Finally, a small pilot-scale MP fermentation reactor (10 L) was operated to validate the MP production using effluent from the CAP demonstration pilot on the Idelux site. In general, the results of the small pilot-scale MP fermentation reactor confirmed the findings of the previously performed lab-scale tests. However, even though sodium hydroxide was applied for pH control in the CAP treatment, analyses of influent and effluent of the MP fermentation showed the presence of relatively high calcium concentrations in the treated biowaste and again important precipitation of calcium salts in the MP reactor. This, in turn, resulted in a lower quality of the MP biomass produced (45-55% protein). The best results of the pilot-scale MP test were obtained with a post-treated CAP sample, originating from a mixture of biowaste and a co-substrate (milk powder).

In general, the results of the lab-scale MP fermentation tests and of the small pilot-scale MP fermentation test show that pre-treated biowaste or CAP water can be used for microbial protein production. However, to obtain a high protein content in the biomass, there are three main requirements for the CAP treatment. First of all, the application of calcium hydroxide for pH control is not allowed. Secondly, the addition of a carbon-rich co-substrate to the biowaste is strongly advised to enhance the MP quality. Finally, a very efficient liquid-solid separation step is needed after the anaerobic CAP treatment.

Production of Single Cell Oils from Volatile Fatty Acids – Recent developments and future perspectives

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While there is a growing demand for bio-based materials and fuels, the available land for biomass cultivation is limited and competition with food and feed production is an increasing concern. The use of volatile fatty acids (VFA) produced by acidification from biogenic waste or wastewater could help to bridge this gap. As part of the Horizon 2020 project VOLATILE it was studied how VFA from the carboxylic acid platform could be used towards single cell oil (SCO). SCO are lipids produced by single cell organisms such as yeasts and microalgae. Oleaginous yeasts are able to accumulate triacylglycerides (TAG) as storage lipids when there is a carbon oversupply while essential nutrients like nitrogen or phosphorous are limited. Lipid concentrations can reach up to 70% of the dry cell weight (DCW). The single cell oil can be extracted from the biomass and subsequently used for fuel applications or for chemical synthesis and material use.

Within the VOLATILE project, two yeast strains, Pichia kudriavzevii V194 and Apiotrichum brassicae V134, were identified as suitable SCO producers during a screening process. Both strains could be cultivated in a pH-stat fed-batch system, where a VFA mixture serves both as a feed solution for the carbon source and as a neutralizing agent. The process gave comparable results at laboratory scale, as well as at 50 L- and 500 L-scale with a synthetic mixture of acetic and propionic acid as feed solution. Biomass concentration (DCW) was typically within the range of 31–37 g/L, with a SCO content between 55 and 60 g/100 g DCW. The produced amounts of biomass were used for evaluating and optimizing the lipid extraction. It could be further demonstrated that the process also works with a purified and concentrated VFA mixture obtained from the acidification of biogenic waste.

While the results confirm a general feasibility and scalability of the production of SCO from VFA, there is still potential for further improvement. Suggested approaches are the optimization of the nutrient composition in the medium, as well as the development of a process design that also allows the use of lower concentrated VFA feed solutions.

Laboratory Scale:
0.4 – 0.5 L working volume

Small Pilot Scale:
50 – 60 L working volume

Pilot Scale:
600 L working volume

Cultivation of Oleaginous Yeasts – Practical Implementation – Scale-up

Funding:
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Production of health-promoting Omega-3 fatty acids from Volatile Fatty Acids

Laura Oliver – TECNALIA Research & Innovation (Spain)

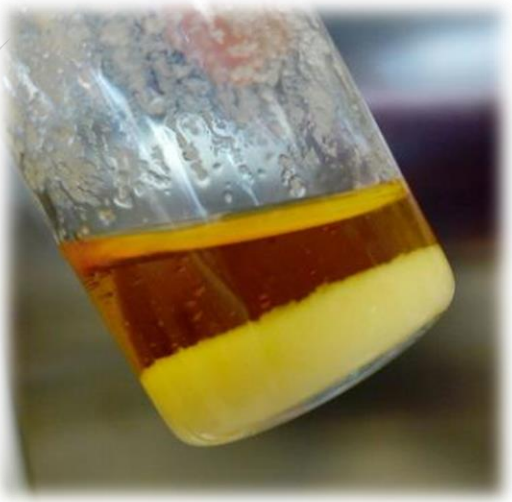
The progressive increase in population, together with the effects of climate change, has led to an imbalance in recent decades between the availability and demand for food at a global level. The need to respond to this demand puts great pressure on available natural resources, which are already showing signs of depletion.

The population also has a greater understanding of the effect of diet on health and is aware of the impact of maintaining healthy eating habits. This translates into a growing demand for foods and food supplements capable of providing beneficial effects on health.

Microalgae can be an interesting source of numerous bioactive compounds as they are very diverse and heterogeneous unicellular organisms. However, there are still major challenges in establishing economically viable production processes for heterotrophic microalgae. The main drawback lies in the cost associated with the carbon source, glucose, a nutrient required in the medium for the growth of microalgae in heterotrophic systems.

It is therefore necessary to find alternative sources of glucose for the development of viable and sustainable processes for obtaining bioactive compounds, in particular Omega-3 PUFA, from microalgae produced under heterotrophic conditions. An alternative source of glucose is volatile fatty acids generated in a controlled process of anaerobic digestion of organic by-products. Following the principle of circular bioeconomy, by-products and wastes from industry or from human consumption should be considered as feedstock for other industrial processes. Volatile fatty acids can be recovered from the anaerobic digestion processes that take place in plants treating the organic fraction of municipal solid waste and used as a carbon source to produce Omega-3 PUFA and other bioactive compounds from heterotrophic microalgae.

The results obtained have shown the capacity of the microalga *Schizochytrium limacinum* to use volatile fatty acids from anaerobic digestion processes and produce not only Omega 3 but also other interesting compounds such as C15:0 and C17:0 with potential application in food and health.



Funding:
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Vitalise Europe's Urban Bioeconomy: The HOOP Project

Martin Soriano – CETENMA Centro Tecnológico Energía y Medio Ambiente (Spain)

Under a context of scarcity of resources and inefficient biowaste management, the EU Bioeconomy Strategy and other related policies see cities and regions (C&R) becoming major circular bioeconomy hubs, where biowaste/wastewater are feedstock for safe and sustainable bio-based products. Cities and regions are important because 1) Concentrate most of the world's population, the energy/natural resources consumption and the production of waste and emissions, and 2) play an instrumental role in most of the sustainable development goals. However, up to now very few C&R have developed urban circular bioeconomy (UCBE) strategies or projects for the production of innovative biobased products. This is due to the existence of numerous barriers that hinder investments and the true deployment of local bioeconomies.

The Horizon 2020 project HOOP aims to tackle barriers and unlocking UCBE projects by providing the necessary technical, economic, financial and legal expertise through a project development assistance (PDA) scheme to 8 European C&R, known as Lighthouses: Albano-Laziale (IT), Almere (NL), Bergen (NO), Kuopio (FI), Münster (DE), Murcia (ES), Greater Porto (PO), and Western Macedonia (GR). In this context, it is the objective of this presentation to share our experience and main lessons learnt after 32 (out of 48) months of project implementation.

The work done so far allows us to extract very useful information at two levels. One is specific for each HOOP C&R, and includes the UCBE projects identified, together with a deep understanding of advantages, barriers and solutions, and the actual PDA offered, which is an always evolving process. With all this background and an eye on replication, we have developed a more general understanding of the needs of cities and regions at a European level. Some recommendations/observations come as a result: 1) we need tailor-made assistance; 2) public or private investment come with high techno-economic feasibility (high TRL); 3) changes in local governance affect UCBE project development; 4) urban biowaste's quality is not suitable for most valorisation routes; 5) C&R are at different development status and advance at different speeds; 6) market and regulation might act as important barriers even for mature technologies; 7) stakeholder engagement and industrial symbiosis is paramount. Linked to replication, which is crucial in HOOP, an online platform (The HOOP Urban Circular Bioeconomy Hub) has been created to foster knowledge exchange in our HOOP Network of cities and regions . All this information, and much more, will be covered by the presentation, allowing attendants to get a European perspective of what is going on in our 8 frontrunner C&R, and how HOOP is helping them on the path towards a more sustainable and circular future.

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Roundtable: Why urban biowaste is still waste? What are we doing with our biowaste? How can biowaste become “money”?

Moderator: Mª Carmen Villaran – TECNALIA (Spain)
Participants: Bruno Ferreira – BIOTREND (Portugal)
Marie Aline Pierrard – IDELUX Environnement (Belgium)
Martin Soriano – CETENMA (Spain)