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PhD topic: Circular bioeconomy: Increasing the Value in Food Waste Based Biorefineries for Future Business Expansion.

Background and objectives

The growing attractiveness of sustainable production leads to increasing interest of using waste as a secondary resource. Food waste is a valuable feedstock (e.g. energy, protein, enzymes production etc.) that can be used in climate resilient bio-based economy. Further development and expansion of circular bioeconomy is a top priority for the future research and technology promotion in Europe.

The PhD is partially funded by the H2020 project DECISIVE (DECentralIzed management Scheme for Innovative Valorization of urban biowaste), which focuses on sustainable development of urban organic material fluxes from a linear paradigm (import of goods without thoughtful interaction between external, peri- and intra-urban areas, consumption, and external disposal of waste) to a circular paradigm (responsible production and consumption, and return of materials and energy to the production areas). The project is expected to develop and demonstrate eco-innovative solution for decentralized urban waste management systems, including new marketable eco-designed solid-state fermentation technologies for bioproducts.

The PhD research focuses on opportunities for business expansion within food waste sector and on integration of higher value into Danish biogas sector using food waste as a substrate for value chain expansion comparing different biorefinery pathways. The objectives are as follows:

1. The main objective is to contribute to the development of database that gather data on biorefinery state-of-art and emerging technologies, feedstock, and low to high-value production of ingredients via sustainable conversion pathways.
   1a. Clarify and synthetize definitions of ‘food’ and ‘food waste’ according to fit into circular economy and strong sustainability concepts.
   1b. Develop guiding criteria for the aforementioned feedstock in order to support circular economy (to avoid rebound effect, minimize deforestation etc)

1c. Address challenges of food waste regulatory framework in EU and to some extend on global scale (like UN framework and overall definition usage for national reporting etc.)

2. Establish collaboration with the industry e.g. Danish biogas sector. Through the collaboration and extensive literature research.

   2a. Map potential partners that use food waste and local resources, including biogas producers

   2b. Use questionnaires for identified potential partners to recognize collaboration and/or data sharing partners → *(I am currently here! While working parallel on previous objectives e.g. finishing)*

3. Model business expansion scenarios of food waste biorefineries and biogas production in Denmark and its integration to Danish biogas industry.

   3a. Upscalling scenario of gather-up data on Danish Study Cases picked in point 2. – Research stay and exchange in INRA, Toulouse, collaboration on Make Planet Great Again project CAMBIOSCOPE- Carbon Management & Bioressources Strategies for Scoping the Transition towards low fossil Carbon, by Lorie Hamelin.

   3b. Finally, by means of comparative Life Cycle Assessment (LCA) chosen pilot cases or circular economy scenarios will be compared to conventional scenarios.

Abstract of submitted review article (objective 1): Review of high-value food waste and food residues biorefineries with focus on unavoidable wastes from processing

Processing of food is linked to unavoidable and inedible food waste that, despite the efforts to minimize waste, will persevere. It represents a stable feedstock for the future bioeconomy value chains and products. This study presents a systematic review of 148 examples from the scientific literature using inedible, unavoidable food residues and wastes for the production of value-added bio-based compounds that could substitute synthetic chemicals production. The main high-value products investigated are acids, bioplastics, colorants, enzymes and other platform chemicals. We found 43 examples of acid production with high variability in output (from 43.2 g.kg-1 to 640 g.kg-1), 9 examples of bioplastic (from 0.28 g.L-1 to 49.4 g.L-1), 26 examples related to colorants (from 0.04 mg per 100 g to 463 mg per 100g), 22 cases of enzyme production (from 6.8 U.g-1 to 34,000 U.g-1), 4 examples of protein (23.6 % wt DM to 38.5 %wt DM) and 44 cases of other high-value molecules such as pectin and single cell oils. Our findings highlight fermentation as a key technology for the valorization of the

studied feedstock, with 75 examples out of the 148 reviewed. The review process also uncovered important limitations related to the lack of standardized food waste definitions, a barrier that is discussed and for which solutions are proposed. At the light of our findings, we further proposed guiding criteria towards the sustainable development of future biorefineries based on food waste. This work is coherent with several Sustainable Development Goals, such as 8.2, 9.5, and 12.3.