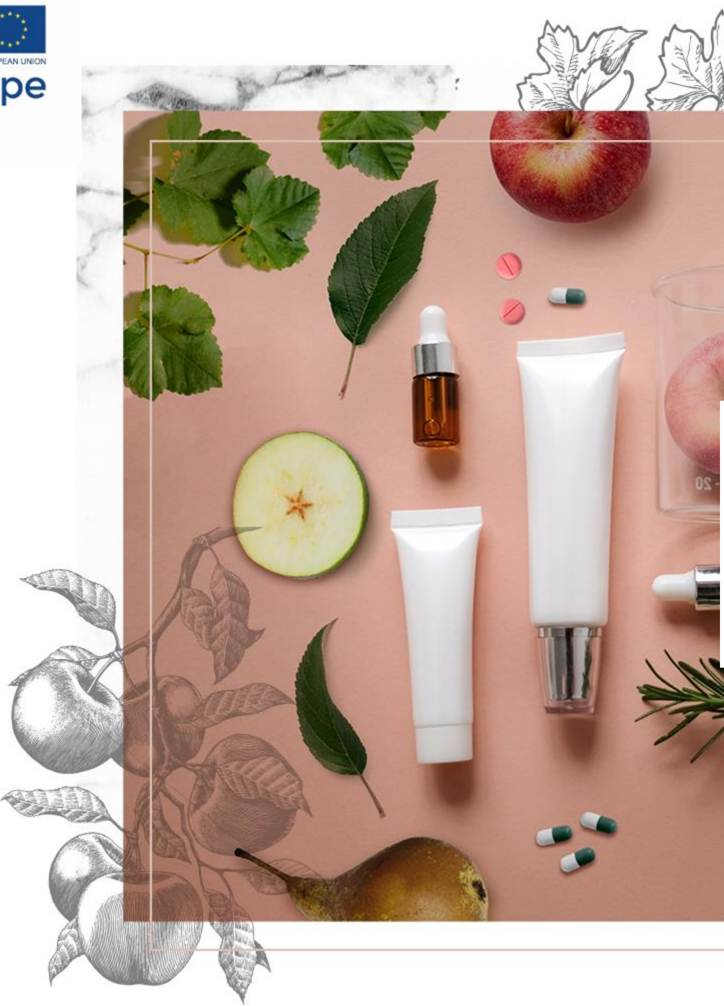
Interreg
North-West Europe
AgriWasteValue
European Regional Development Fund
EUROPEAN UNION



Agro-residues for feeding the Green Economy : framework conditions and implications

Mid-term event of the AgriWasteValue project

Elia Ruiz, Prasad Mandade & Edgard Gnansounou
Bioenergy and Energy Planning Research Group
EPFL

DID YOU KNOW ?

Agricultural residues are generated in high quantities after harvesting resulting often in wastes dumped in the agriculture fields or burnt.

These lignocellulosic waste material poorly exploited as feedstock could directly contribute to the bioeconomy development.

Agricultural residues are also a deep source of antioxidants, such as polyphenols, being highly demanded by Industry.

The production cost of the polyphenols obtained from agricultural residues is needed to evaluate the profitability of this process.

The environmental loads associated to this process are also assessed to contribute to the sustainable development of marketable products.

Methodology

Extraction mass balance given by Celabor based on bench scale experiments

Set of assumptions on the seize of the plant, lifetime, annual operating time, process design models

Calculation of mass and energy balances using Process Simulation (Aspen Plus Software)

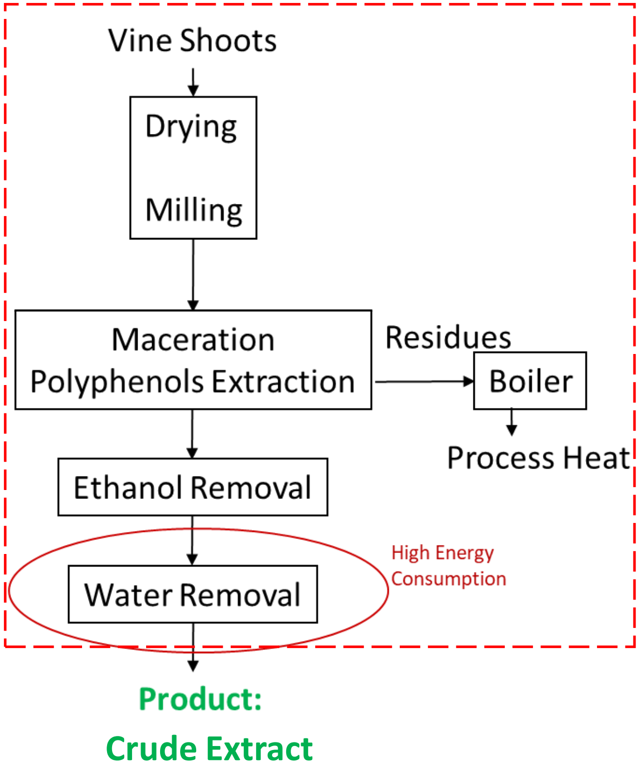
Techno-economic assessment based on economic data from the literature adjusted to the scale of the process

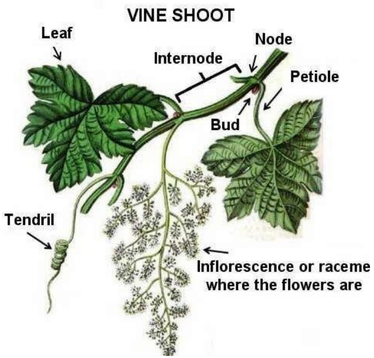
Production Cost

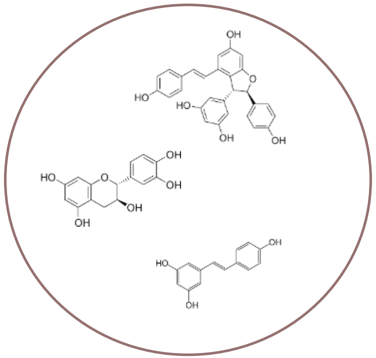
Goal: Estimating the cost of producing polyphenols using residues, and compare it with the polyphenols market price

Polyphenols from Vine Shoots

Case 1

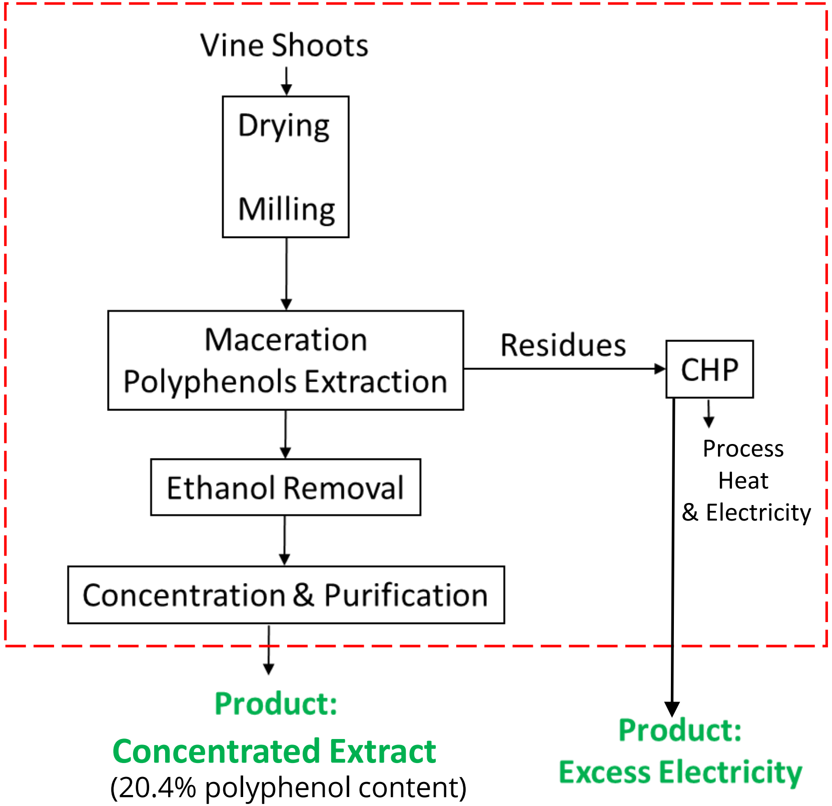






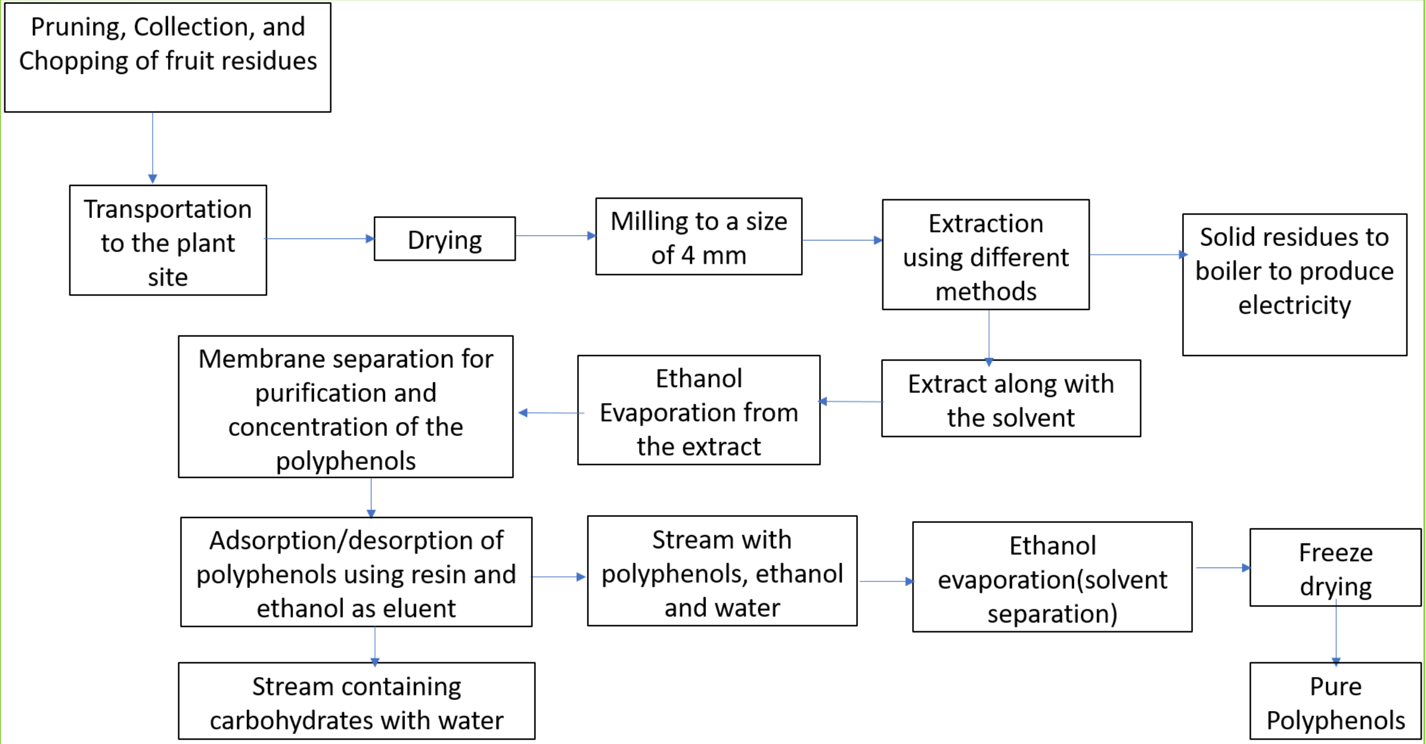
Polyphenols

Case 2



What is the Production Cost?

Techno-Economic Analysis (TEA)



System boundary for TEA of polyphenol production

Basis of TEA : Operational capacity 1000 t (d.b.) / y

Plant operating duration : 200 days/year (considering 2018 as base year)

What is the Production Cost?

Techno-Economic Analysis (TEA)

CASE 1

Product: crude extract

Cost of biomass raw material (farm gate price)	0.7	$/kg
Transportation of biomass to site	0.4	$/kg
Fixed capital cost	14.9	$/kg
Fixed operating cost	6.6	$/kg
Variable operating cost	1.5	$/kg

- Operating capacity =1000 t (d.b)/y.
- Plant operation = 200 days/y
- **Crude extract expenditures = 2051836.9 $/y.**
- Crude extract production = 84960 kg/y.
- **Crude extract production cost** = **24.15 $/kg**

What is the Production Cost?

Techno-Economic Analysis (TEA)

CASE 2

Products: concentrated extract and electricity

(20.4% polyphenol content)

Cost of biomass raw material (farm gate price)	118.9	$/kg
Transportation of biomass to site	11.5	$/kg
Fixed capital cost	585.9	$/kg
Fixed operating cost	255.0	$/kg
Variable operating cost	71.7	$/kg
Excess electricity credit	-27.6	$/kg

- Operating capacity =1000 t (d.b)/y.
- Plant operation = 200 days/y
- **Concentrated extract expenditures = 2680675 $/y.**
- Concentrated extract production = 12960 kg/y.
- **Concentrated extract production cost** = **206.84 $/kg**

Interreg North-West Europe
AgriWasteValue

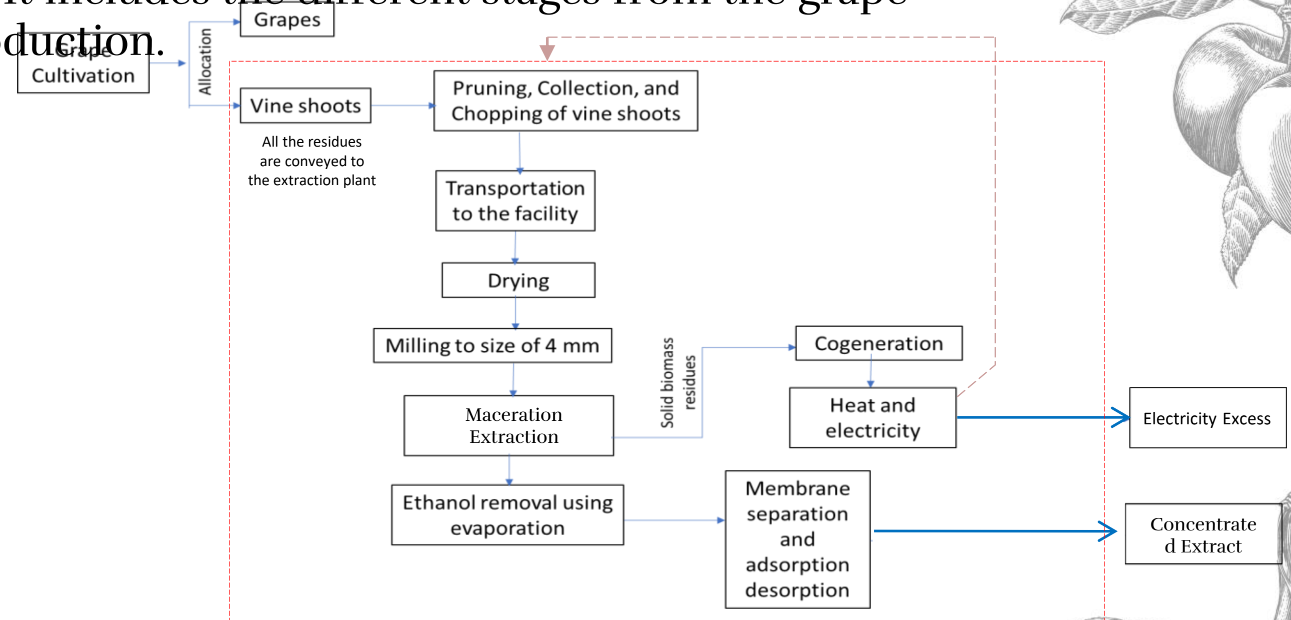
Life Cycle Assessment (LCA)

Goal : Analyze the life cycle environmental impact of polyphenol production (production of 1kg of product) polyphenolic crude extract (case 1) and concentrated extract (case 2)

Boundary of the assessment: It includes the different stages from the grape cultivation to polyphenol production.

- Case 1 includes the production of crude extract.

- Case 2 includes the additional steps of concentration and purification of polyphenols using membrane filtration and adsorption/desorption process.



System boundary in Case 2: production of concentrated and purified polyphenols (20.4% polyphenol content)

Life Cycle Inventory (LCI) for the assessment

- The inventory of the polyphenol production process is based on process simulation using Aspen Plus v. 11, Ecoinvent 3.5 database and literature.
- The inventory data for the agricultural stage were based on grape production from the Ecoinvent database, using economic allocation for grapes and vine shoots.

Data origin used in this work

Process	Source
Grape Production	Ecoinvent database
Vineshoot composition	Data from Partners
Maceration Extraction	Data from Celabor
Concentration & Purification	Data from Literature[1]
Mass and Energy balances for the whole process	Aspen Plus V11 simulations
Transportation of vineshoot to biorefinery	Assumption of 100km two-way distance from site to extraction unit

[1] Zagklis, D. P., & Paraskeva, C. A. (2020). Preliminary design of a phenols purification plant. Journal of Chemical Technology & Biotechnology, 95(2), 373-383.

Life Cycle Impact Assessment (LCIA) polyphenol production

- Software package SimaPro v9.0 and Recipe midpoint (E) methodology were used to perform the environmental impact assessment
- LCIA results estimated for the two cases for the production of 1kg of product i.e. polyphenolic crude extract (Case 1) and concentrated extract (Case 2)

Impact category	Unit	Case 1	Case 2
Climate change	kg CO_2 eq	4.165	31.682
Fossil depletion	kg oil eq	2.529	22.104
Freshwater ecotoxicity	kg 1,4-DB eq	0.0051	0.0331
Freshwater eutrophicatio n	kg P eq	0.0028	0.0259

Interreg North-West Europe AgriWasteValue

Concluding remarks and future goals

- Seemingly, producing a concentrated mixture of polyphenols is more expensive and less environmentally sustainable than producing crude extract.
- However, using value-based approach[2], results can be directly affected by the market value of both products.
- Assuming that the market price of both products are known, the LCA results can be expressed using 1$ of gross margin as functional unit, allowing a fair comparison of the two cases based on their gross margin.
- The market value of both products must be included in the assessment in order to choose the best configuration according to economic profitability and environmental benefits.

[2] Edgard Gnansounou, 2019. Economic Assessment of Biofuels, In "Biofuels: Alternative Feedstocks and Conversion processes for the Production of Liquid and Gaseous Biofuels, Second Edition", chap. 4, pp. 95-121, eds Pandey et- al., Elsevier.

Project under the program

With the financial support of the European Regional Development Fund and Wallonia

Thank you very much for your attention

Elia Ruiz, Prasad Mandade & Edgard Gnansounou (EPFL)
www.epfl.ch/labs/bpe/