Chemical composition of plant biomasses and impacts on their biofuel potentials

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Introduction

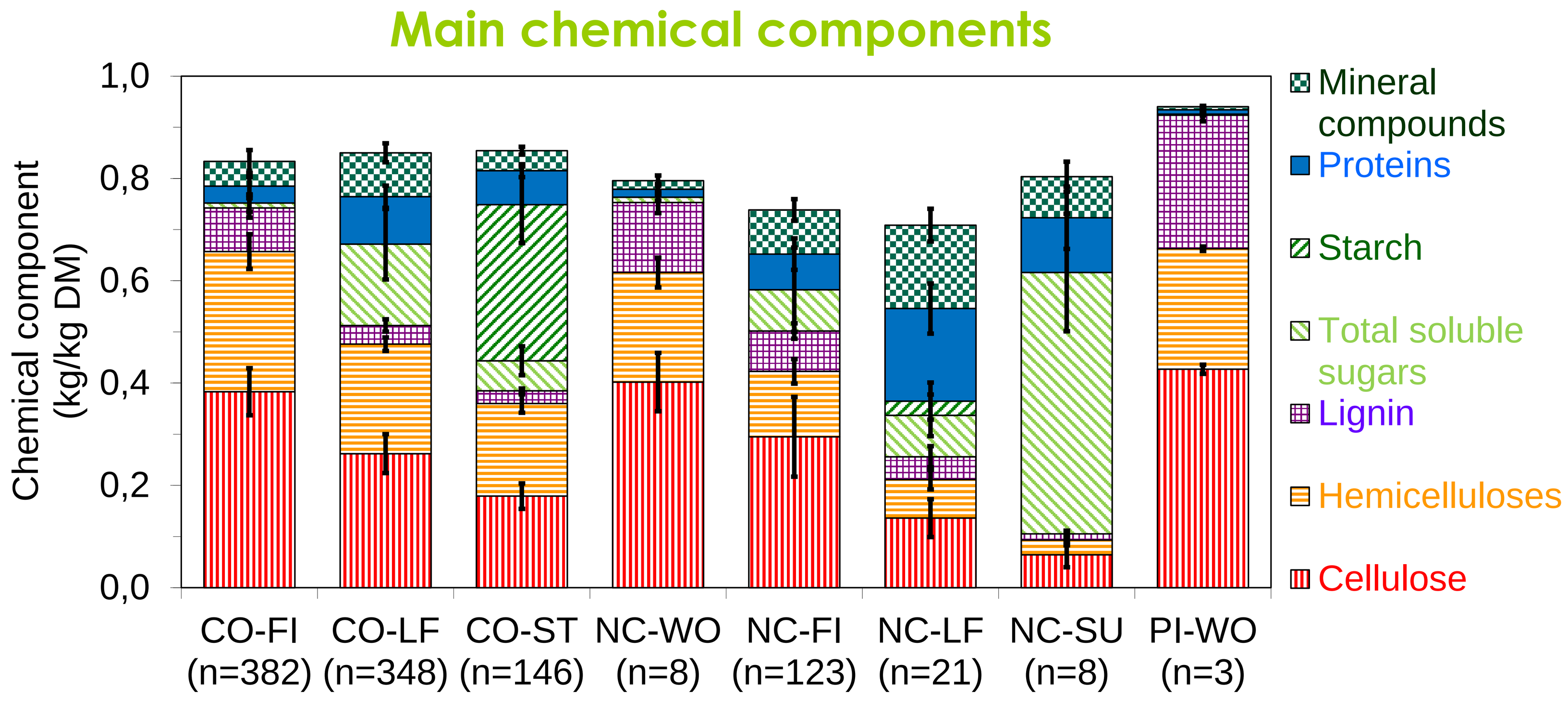
- **To reduce** simultaneously human induced **global warming** and the **depletion of fossil fuel resources**, alternative production chains are necessary. One of the promising sources of **renewable and sustainable energy** are **plant biomasses**. They represent a huge amount of renewable resource for the production of bioenergy. The **optimal valorization** of these biomasses in energy and green chemistry processes requires a **good knowledge** of their molecular chemical composition. Each biomass can indeed be better **suited to specific conversion processes**, depending on its composition.

Biomass suitability for energy conversion processes

- **Aim**: To **test the influence of the composition** of various biomasses on their respective **suitability for 3 main conversion processes**: anaerobic digestion, ethanolic fermentation and combustion.
- **Approach**: The main chemical components of 1049 samples from 49 plants species have been analyzed. Their **suitability** for **conversion processes** has been **assessed** with **3 fast approaches**:

i) the experimental **enzymatically digestible organic matter** (DOM) as a fast assessment of the **anaerobic digestibility** (biomethanation) ;
ii) the **theoretical bioethanol potential**, as a fast assessment of the **ethanolic fermentation** ;
iii) the experimental **higher heating values** (HHV), as a fast assessment for conversion by **combustion**.

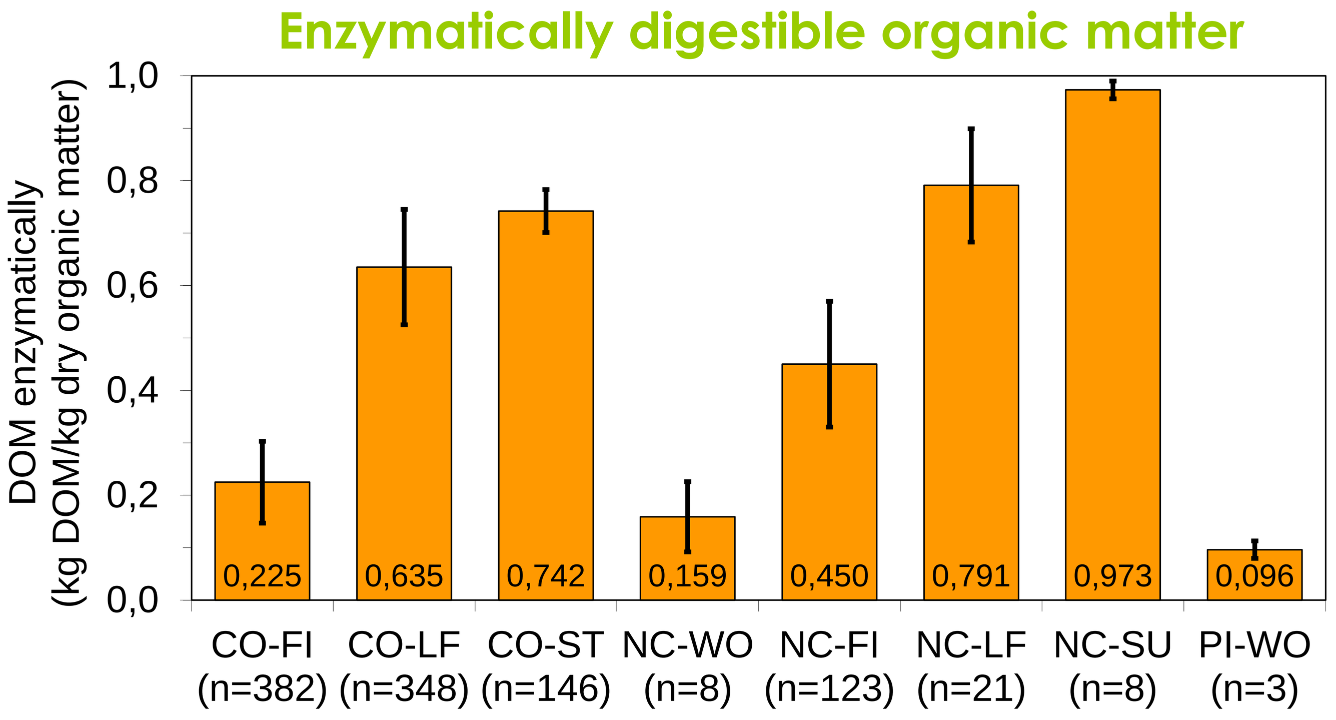
Main chemical components



- A **wide diversity of plant biomasses** revealed a **wide diversity of composition**
- The principal component analysis of the main chemical components led to cluster the biomasses as **8 distinctive groups:**

CO-FI: **Commelinid fibrous biomass** (e.g. miscanthus, switchgrass)
CO-LF: **Commelinid less fibrous biomass** (e.g. fiber sorghum, fescue)
CO-ST: **Commelinid high starch biomass** (e.g. fiber corn)
NC-WO: **Non-commelinid woody biomass** (e.g. willow, aspen, oak wood)
NC-FI: **Non-commelinid fibrous biomass** (e.g. hemp, sunflower stalk)
NC-LF: **Non-commelinid less fibrous biomass** (e.g. potato leaf, alfalfa)
NC-SU: **Non-commelinid high sugars biomass** (e.g. chicory tuber)
PI-WO: **Pinophyta woody biomass** (e.g. spruce, pine wood)

Enzymatically digestible organic matter

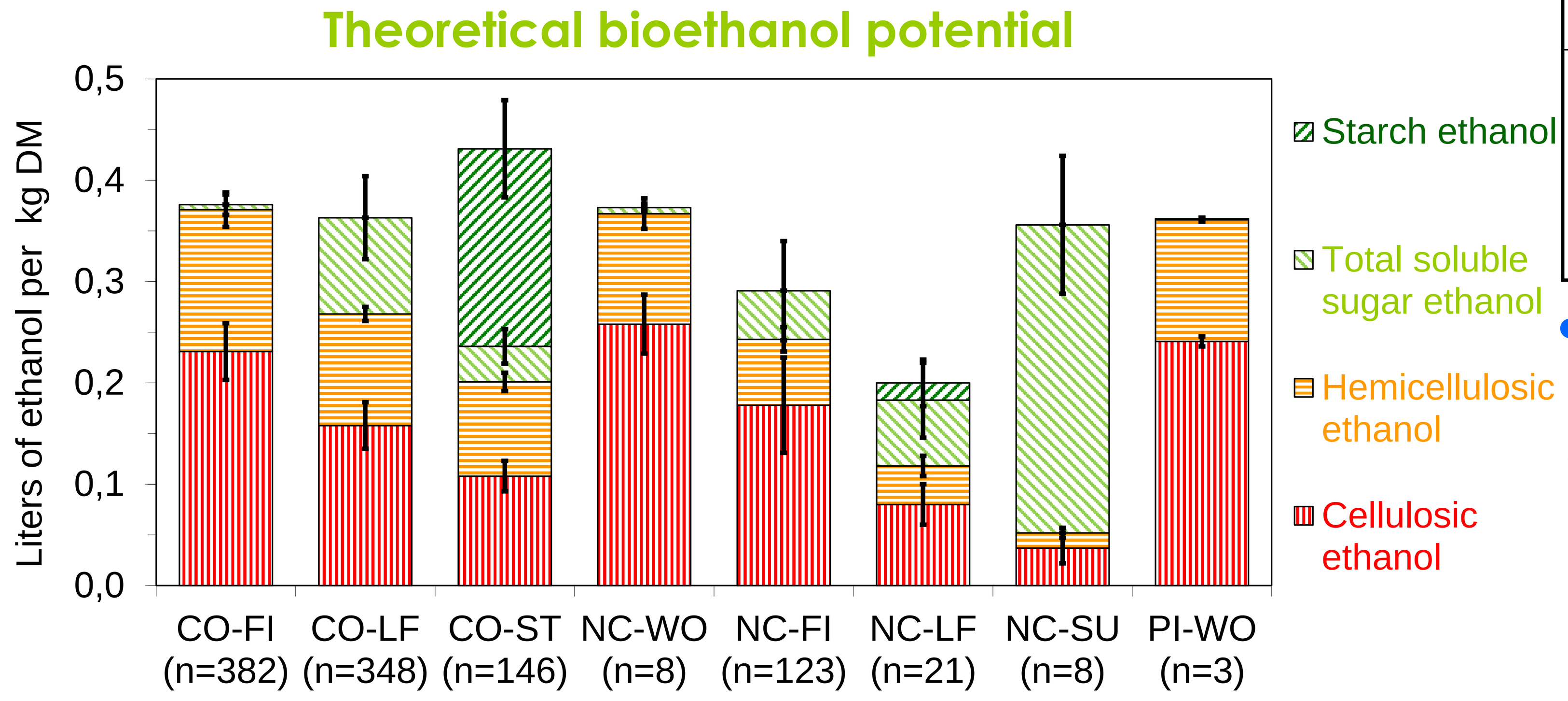


Biomass suitability for anaerobic digestion

Very suitable	Suitable	Unsuitable
CO-ST (high starch content) **NC-LF** (high protein content) **NC-SU** and **CO-LF** (high total soluble sugars content)	**NC-FI**	**CO-FI** and **NC-WO** (high fibers content) **PI-WO** (high fibers content ; very high lignin content)

- **Soluble sugars**, **starch** and **proteins** → **High enzymatic digestibility**
- **Fibers** (cellulose, hemicelluloses and lignin) → **Low enzymatic digestibility**

Theoretical bioethanol potential



Biomass suitability for ethanolic fermentation from structural carbohydrates

Very suitable	Suitable	Unsuitable
PI-WO, NC-WO and **CO-FI** (high cellulose and hemicelluloses contents ; low mineral compounds content)	**CO-LF, CO-ST** and **NC-FI**	**NC-LF** and **NC-SU** (very low cellulose and hemicelluloses contents)

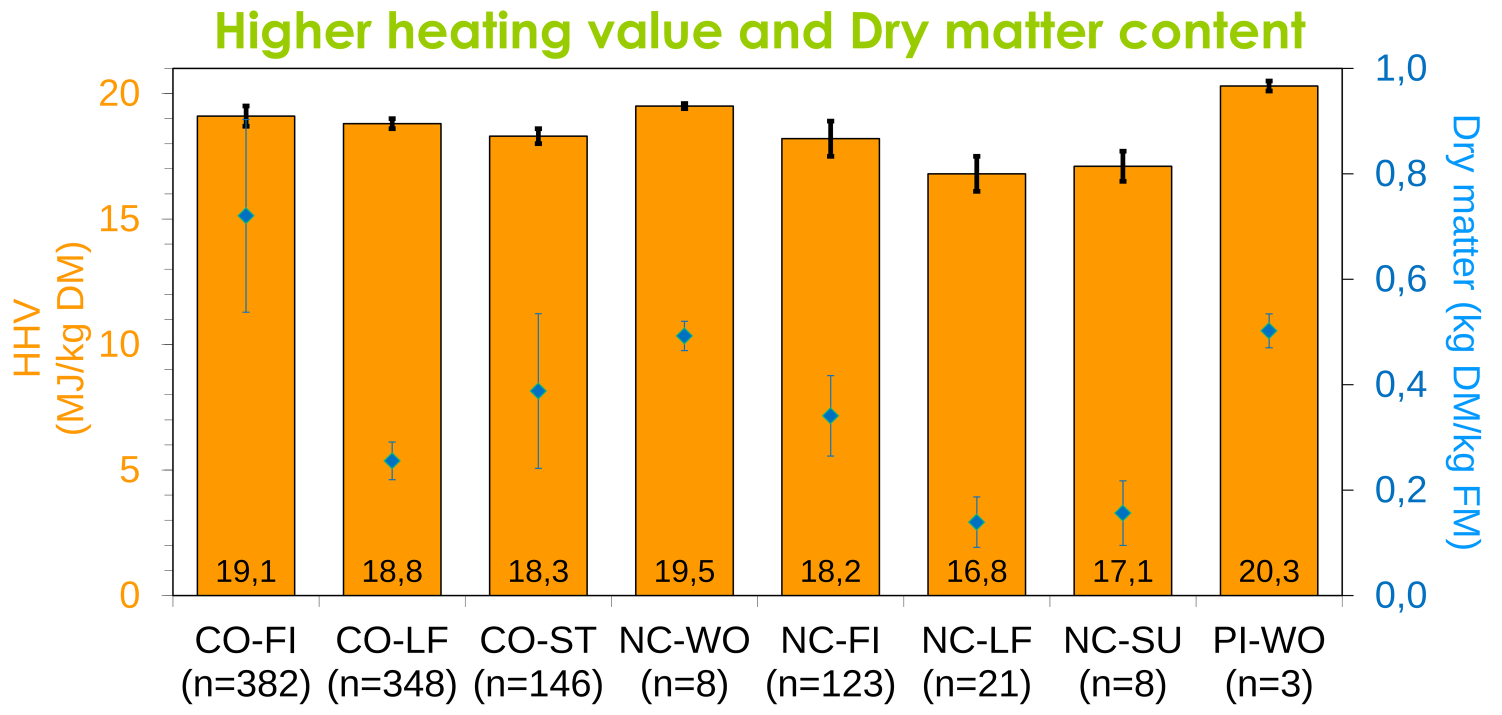
- **High cellulose and hemicelluloses** contents → **High structural ethanolic potential**

Biomass suitability for ethanolic fermentation from non-structural carbohydrates

Very suitable	Suitable	Unsuitable
CO-ST (high starch content) **NC-SU** (high total soluble sugars content)	**CO-LF**	**CO-FI, NC-WO, NC-FI, NC-LF** and **PI-WO** (high cellulose and hemicelluloses contents)

- **High starch or total soluble sugars** contents → **High non-structural ethanolic potential**

Higher heating value and Dry matter content



Biomass suitability for combustion

Very suitable	Suitable	Unsuitable
PI-WO, NC-WO and **the most fibrous CO-FI** (low mineral compounds and water contents)	**CO-FI**	**CO-LF, CO-ST, NC-FI, NC-LF** and **NC-SU** (high mineral compounds and water contents)

- **Less fibrous** biomasses → **High water and mineral** contents → **Low HHV**

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Conclusion

- The **enzymatically DOM** and the **bioethanol potential** of biomasses expand on **wide ranges** and are **highly dependent on the chemical composition**. Whereas, the **HHV** is **stable** and **linked** to the content of **mineral compounds** and the **water** content. The **suitability** of being converted by **anaerobic digestion** is **opposite** to be one of being converted by **combustion**. **All biomasses** are generally **suitable** to be transformed by **ethanolic fermentation** except for non-commelinid less fibrous biomasses.

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