CORN STALKS AS A LIGNOCELLULOSE SUBSTRATE FOR BIOREFINERY APPLICATIONS

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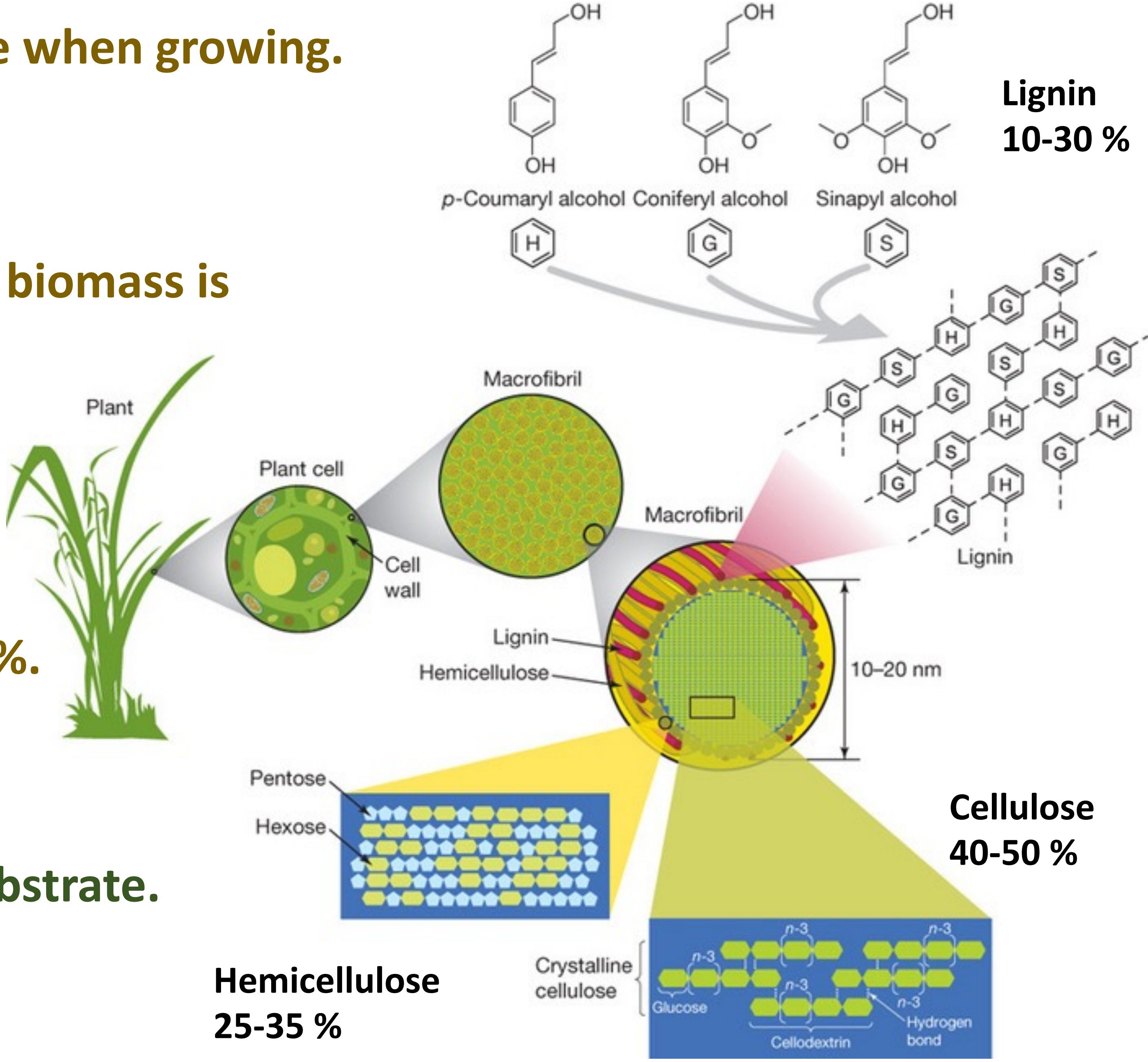
- **Plants capture CO_2 from the atmosphere when growing.**

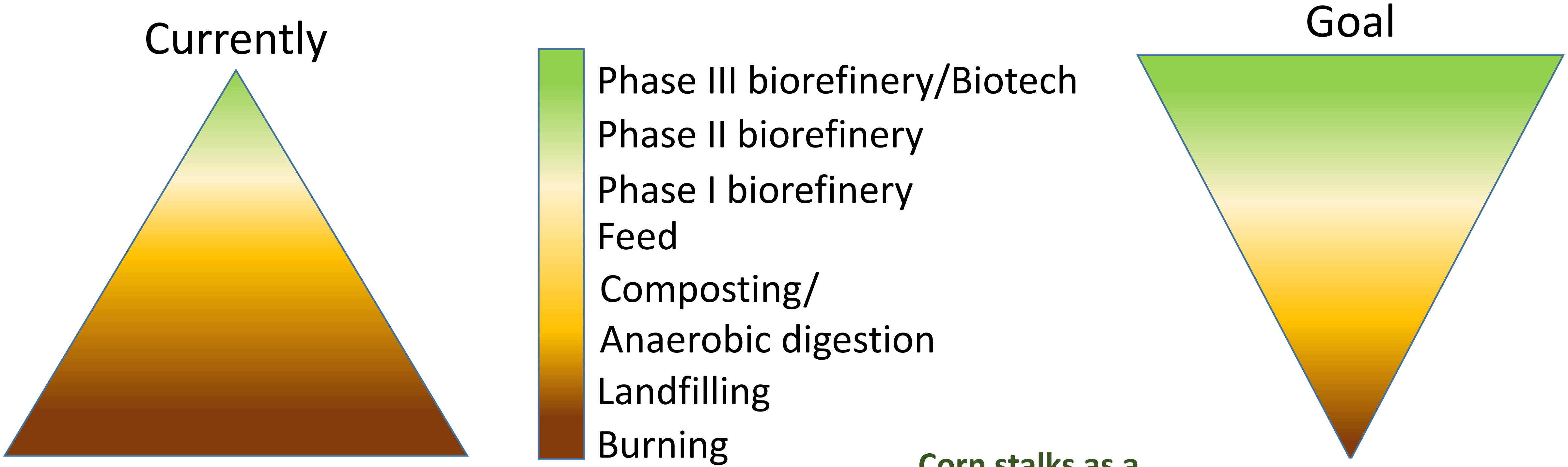
- **Estimate: 1,4 Gt of available renewable biomass is wasted, annually.**

- **Cereal straw wastes contribute with 66%.**

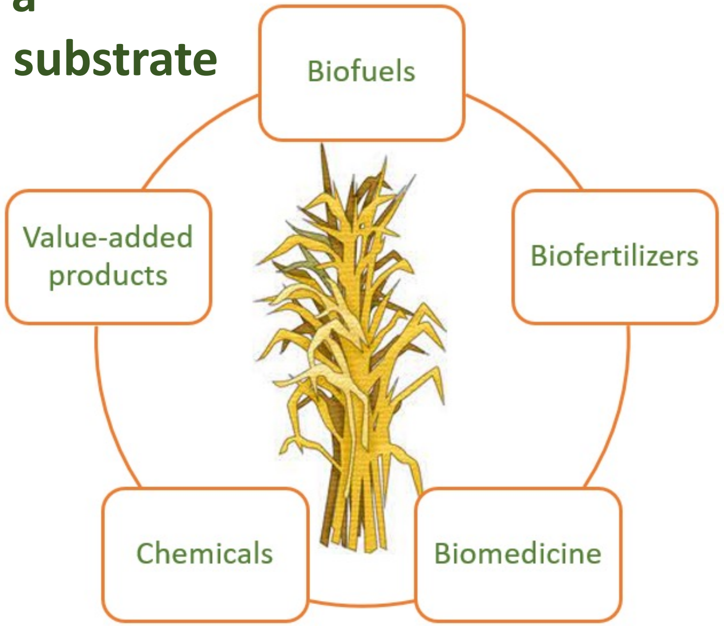
Lignocellulose is an abundant, cheap substrate.



Potters, G., Van Goethem, D. & Schutte, F. (2010) *Nature Education* 3(9):14



Corn stalks as a lignocellulose substrate

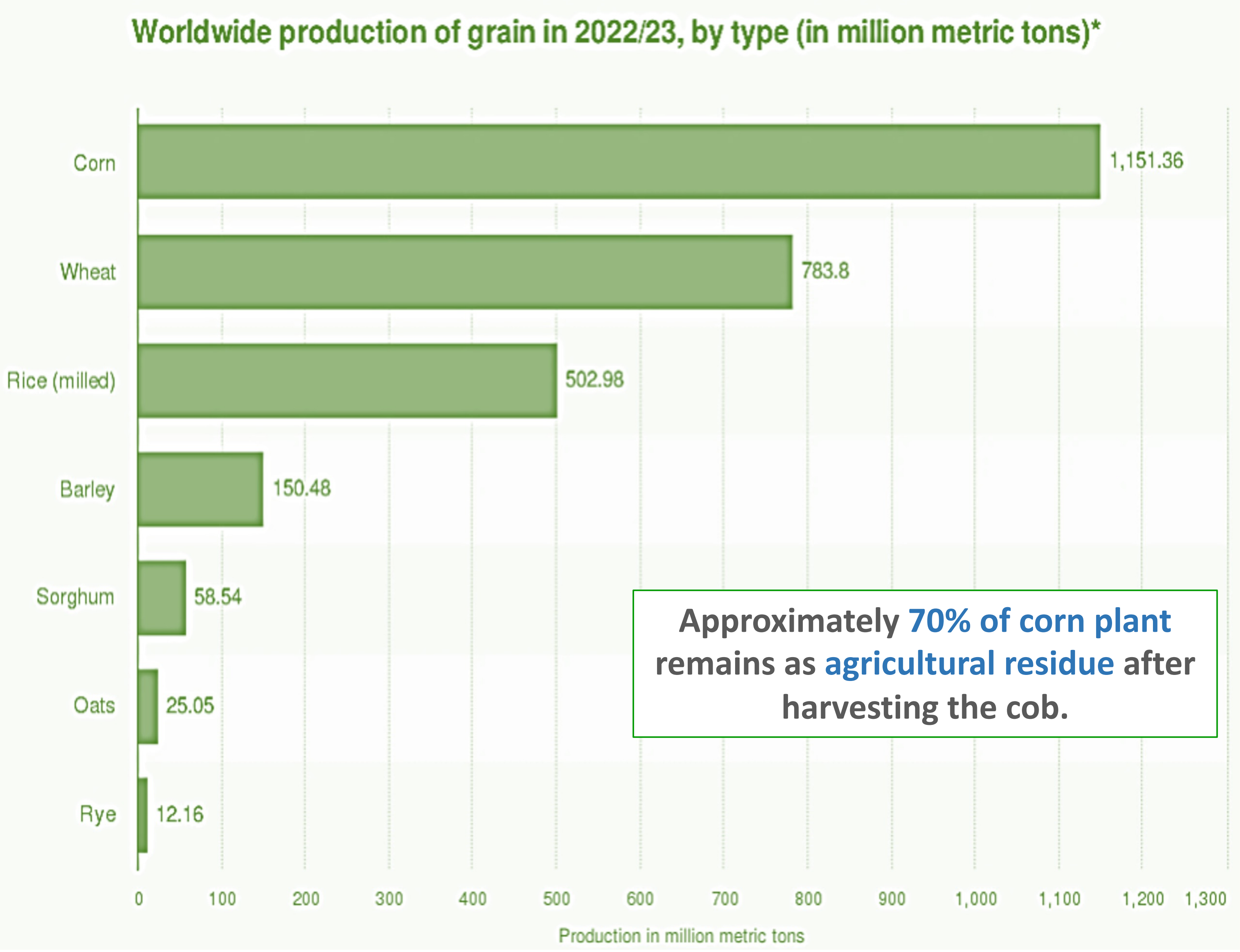


Challenges for better resource recovery:

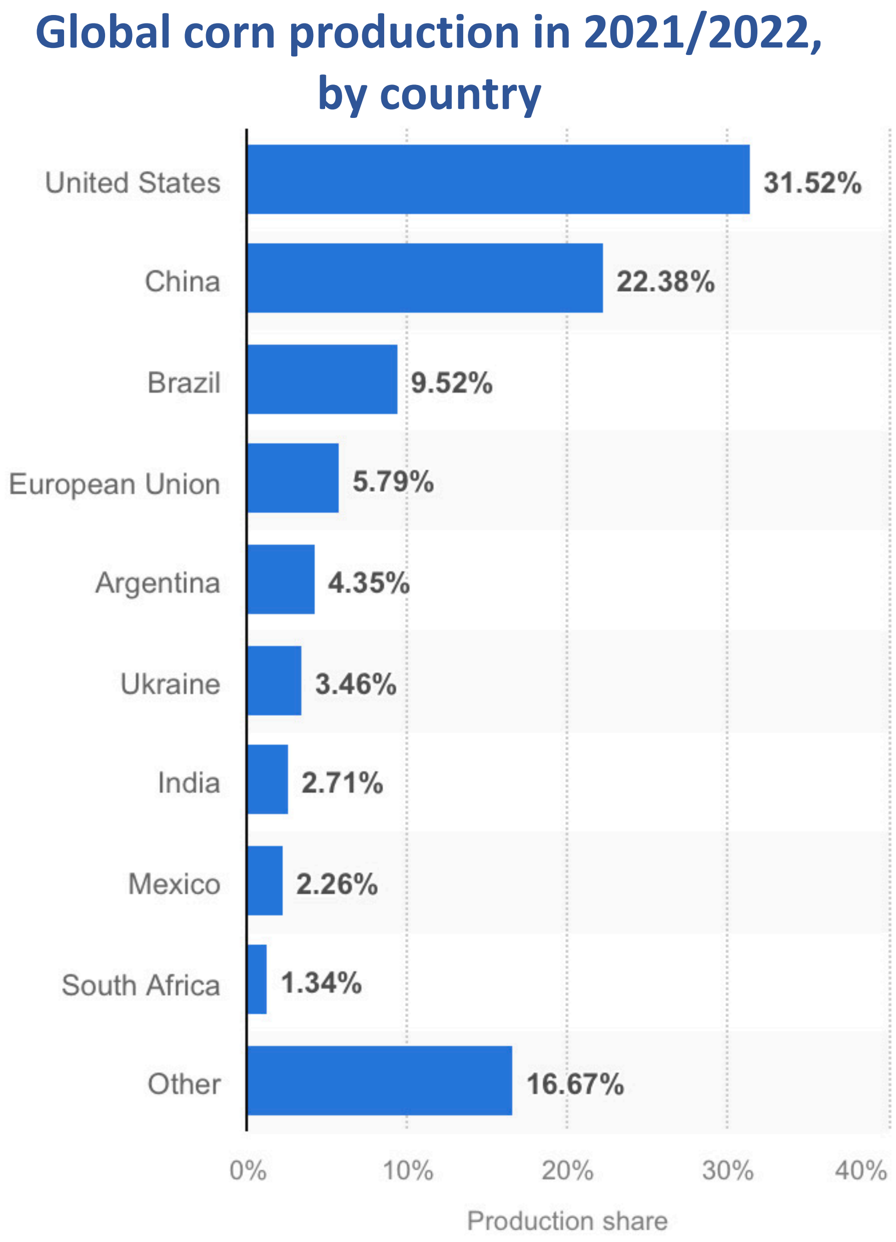
- **recalcitrant nature of dominantly present lignocellulose**
- **variability in biomass composition**

Treatments?

Improved biocatalysts (enzymes and microorganisms)?



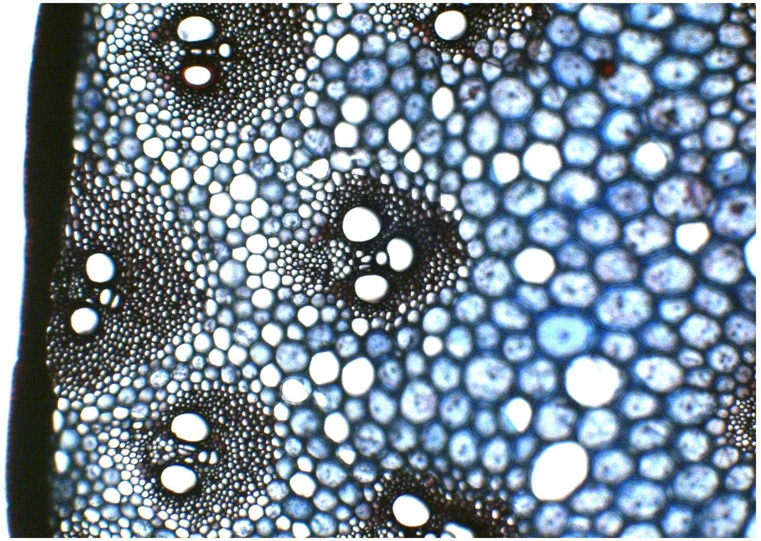
Approximately **70% of corn plant** remains as **agricultural residue** after harvesting the cob.

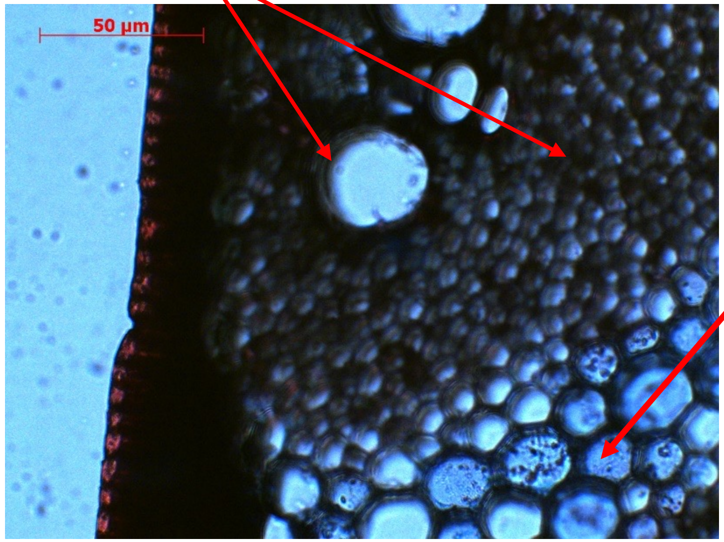


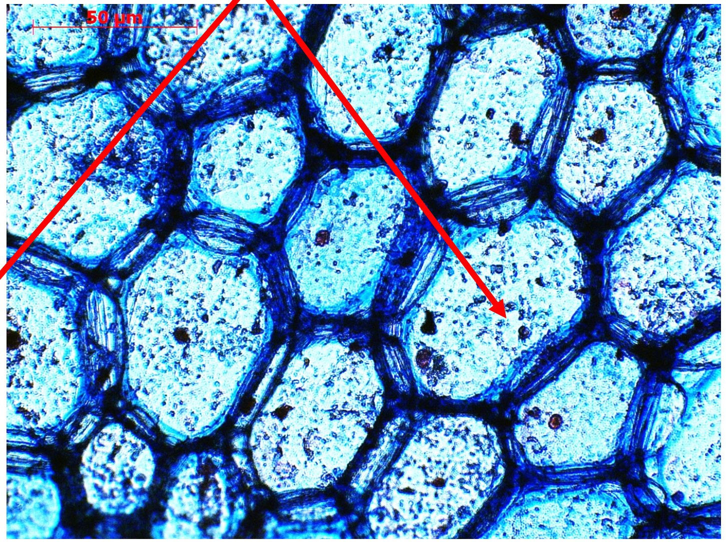
Corn stalks

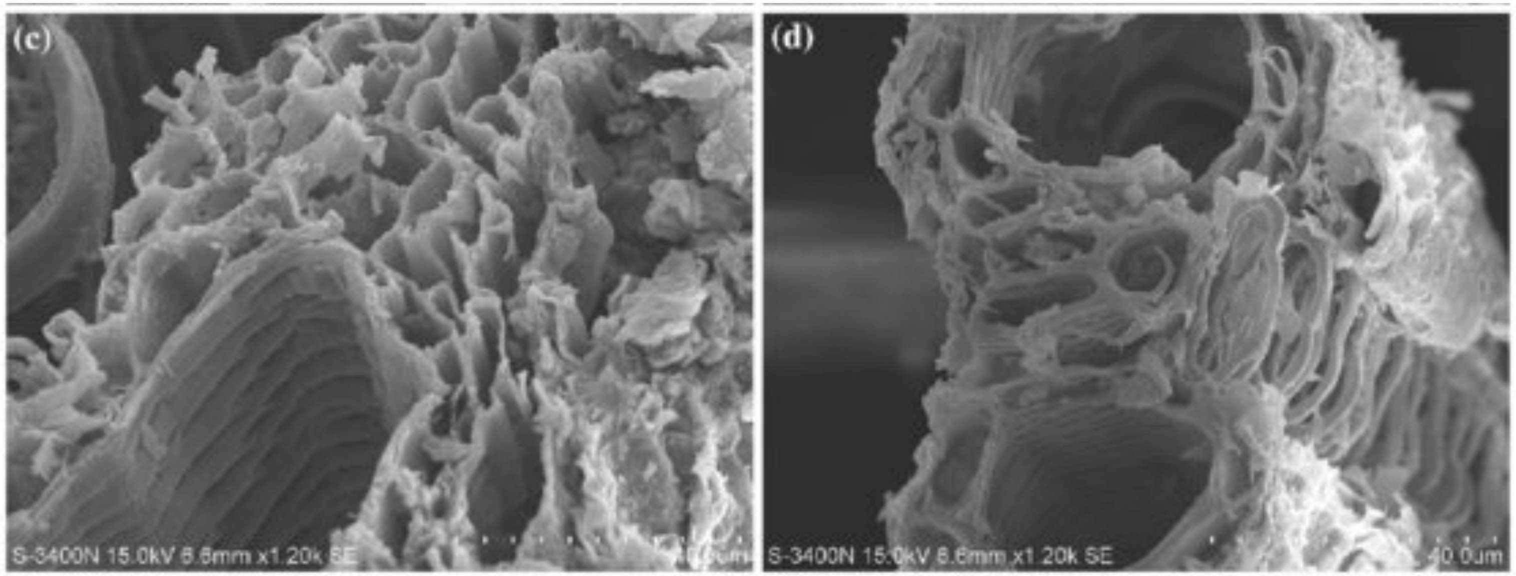
lignin rich xylem and phloem (vascular tissue)

cellulose rich parenchyma

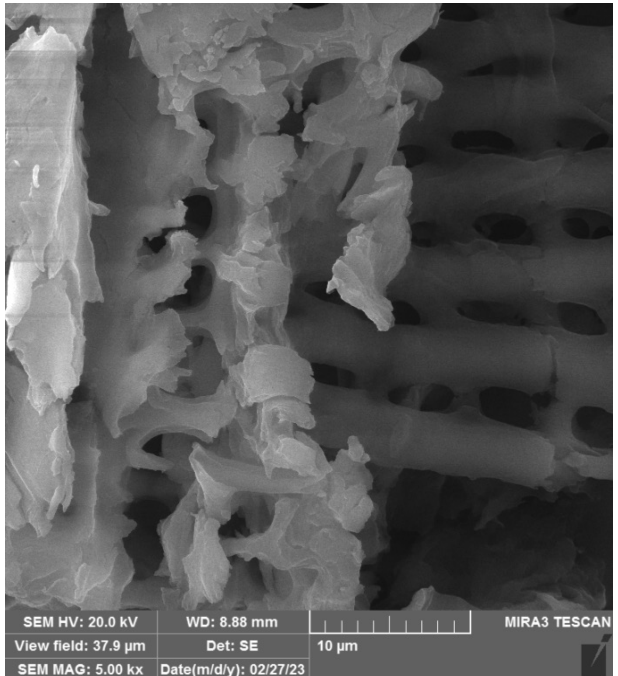




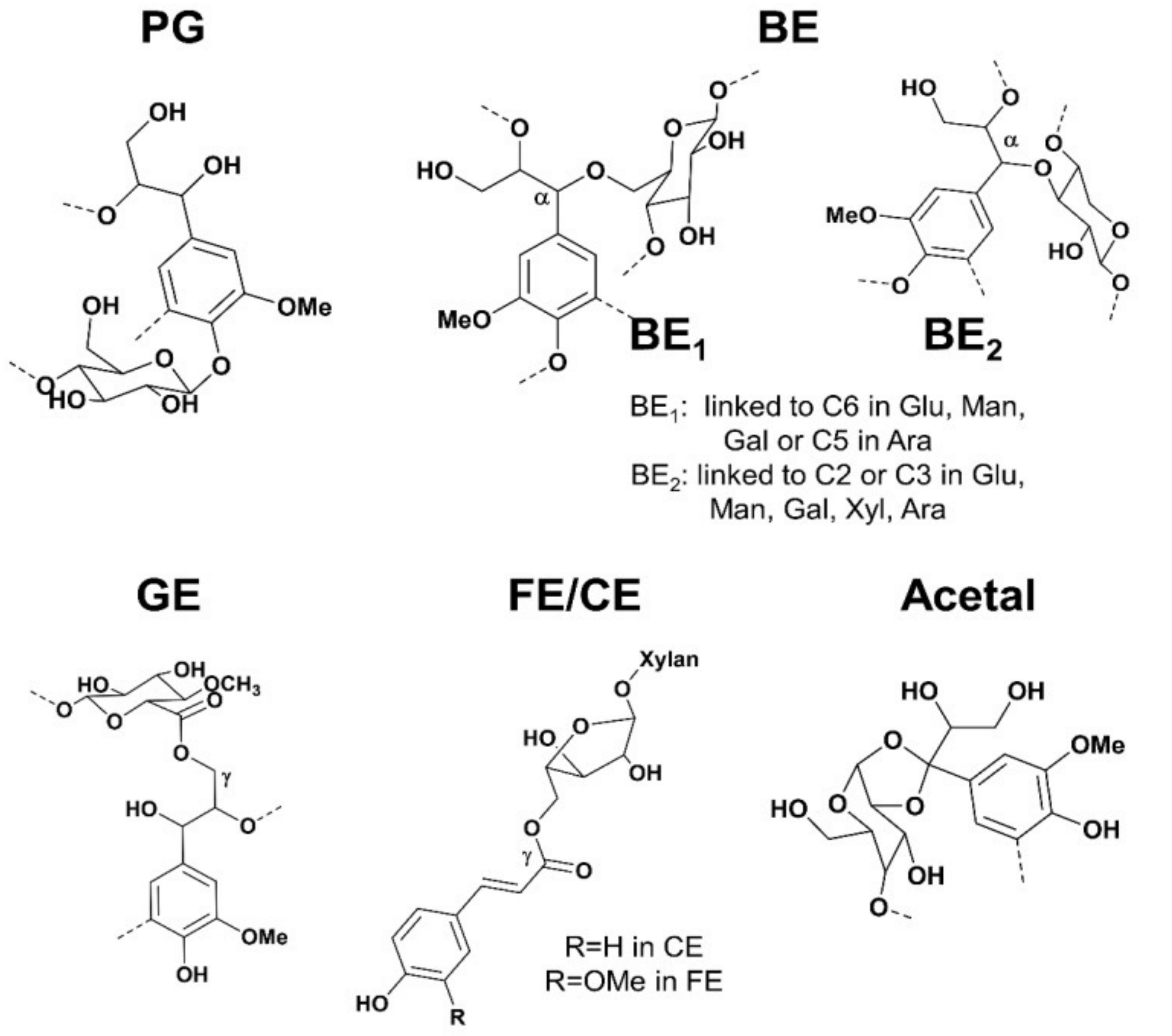




Li, H., Ye, C., Liu, K., Gu, H., Du, W., & Bao, J. (2015). *Bioprocess and biosystems engineering*, *38*, 149-154.



Proposed lignin-carbohydrate (LC) bonds in wood and grass biomass



PG=phenyl glycosides,
BE=benzyl ethers;
GE=γ-esters;
FE=ferulate esters;
CE=coumarate esters.

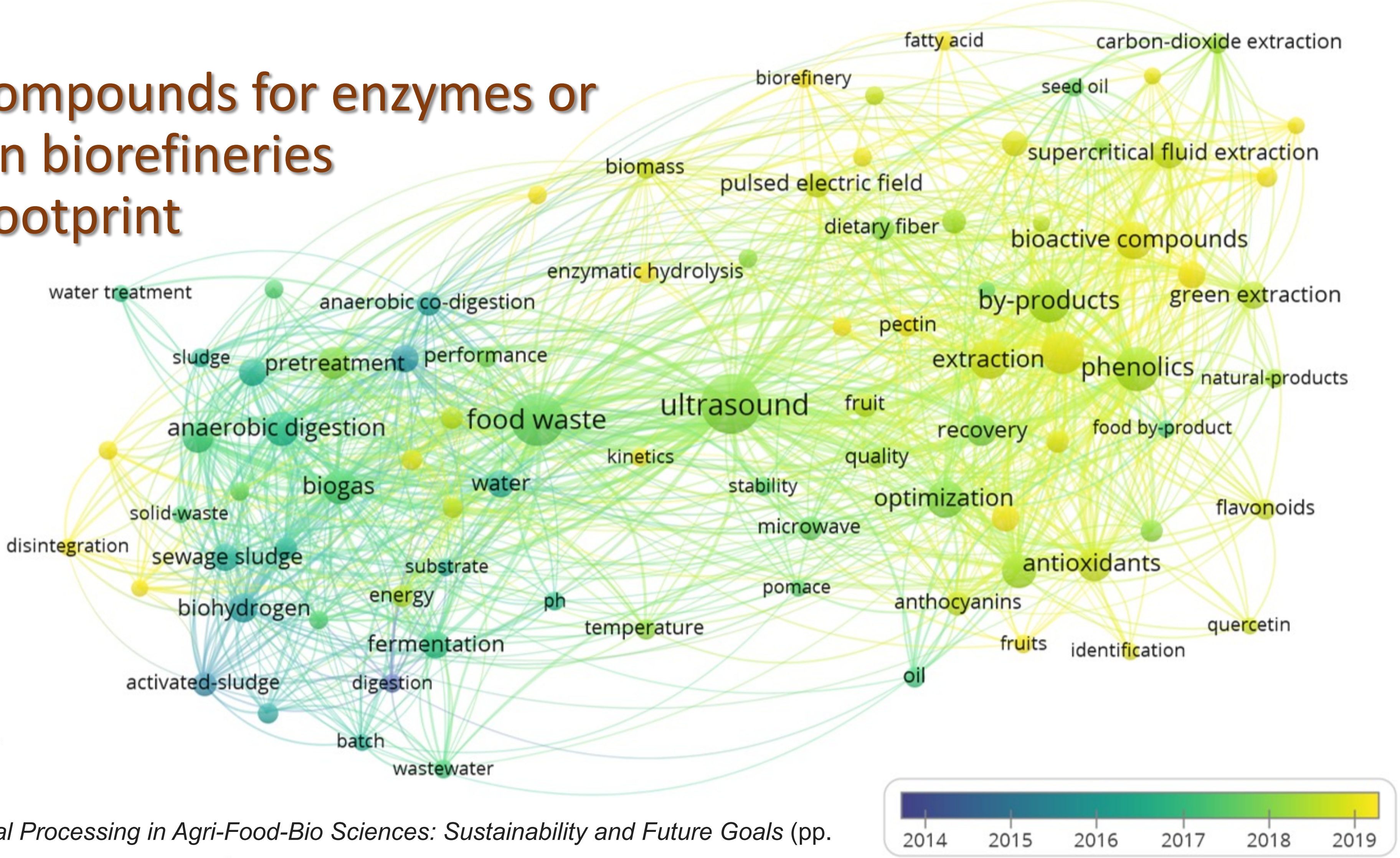
Challange: To separate carbohydrate and lignin fractions in order to valorize both in the best possible way

Giummarella, N., Pu, Y., Ragauskas, A. J., & Lawoko, M. (2019). *Green Chemistry*, *21*(7), 1573-1595.

Conventional treatments:

- Acid/Alkaline/Oxidation treatments
- Thermal treatments

- low selectivity
- generate inhibitory compounds for enzymes or microorganisms used in biorefineries
- high environmental footprint



Timescaled co-occurence network - bibliometric map of research on food waste, by-products and non-thermal processing (Scopus)

Djukić-Vuković, A. P., et al. (2022). In *Nonthermal Processing in Agri-Food-Bio Sciences: Sustainability and Future Goals* (pp. 687-709). Springer

Fenton reaction

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + \cdot OH + -OH$$

k_1=63-76 $M^{-1}\ s^{-1}$

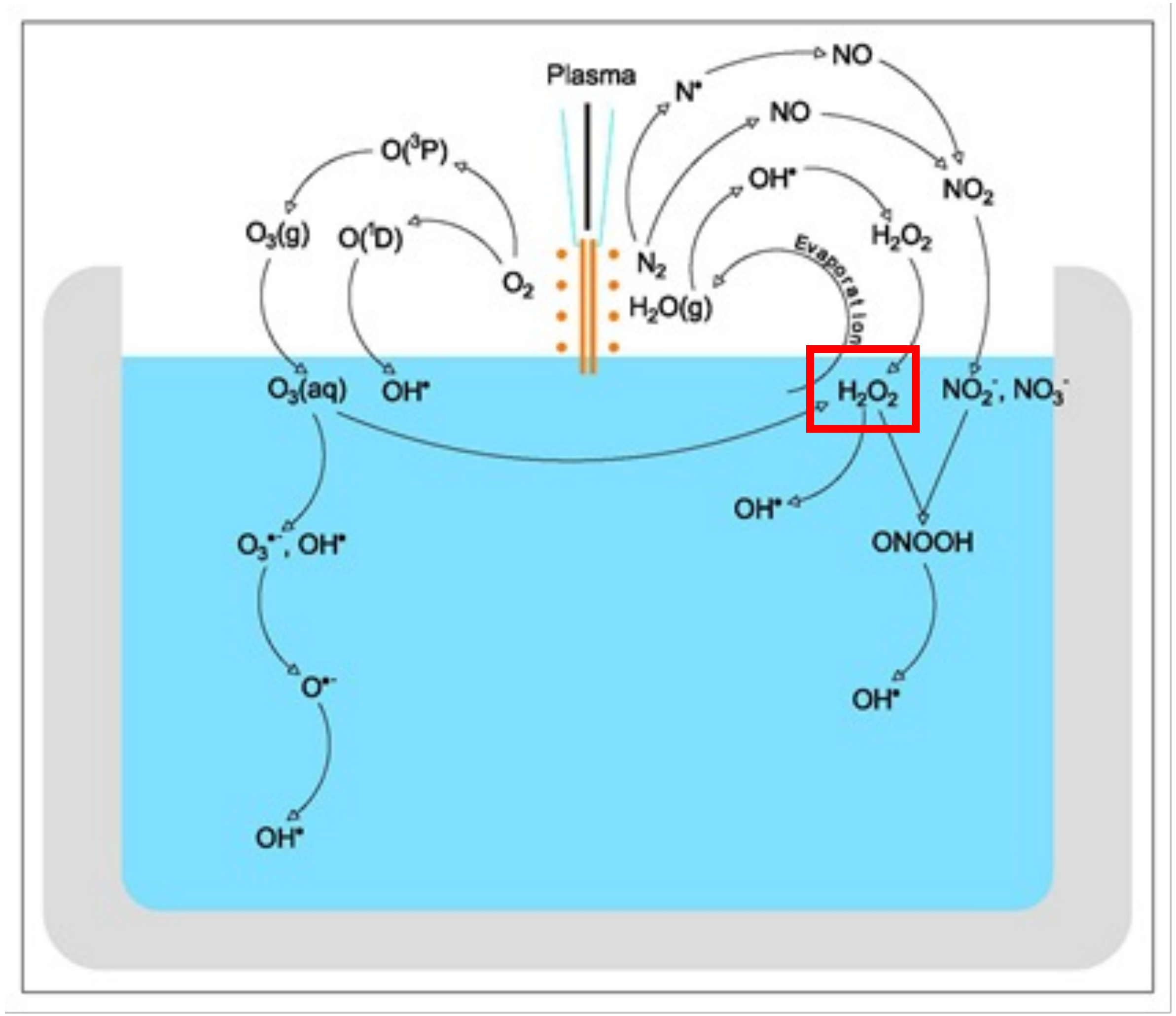
$$H_2O_2 + Fe^{3+} \rightarrow HO_2\cdot + Fe^{2+} + H^+$$

k_2=0.001-0.01 $M^{-1}\ s^{-1}$

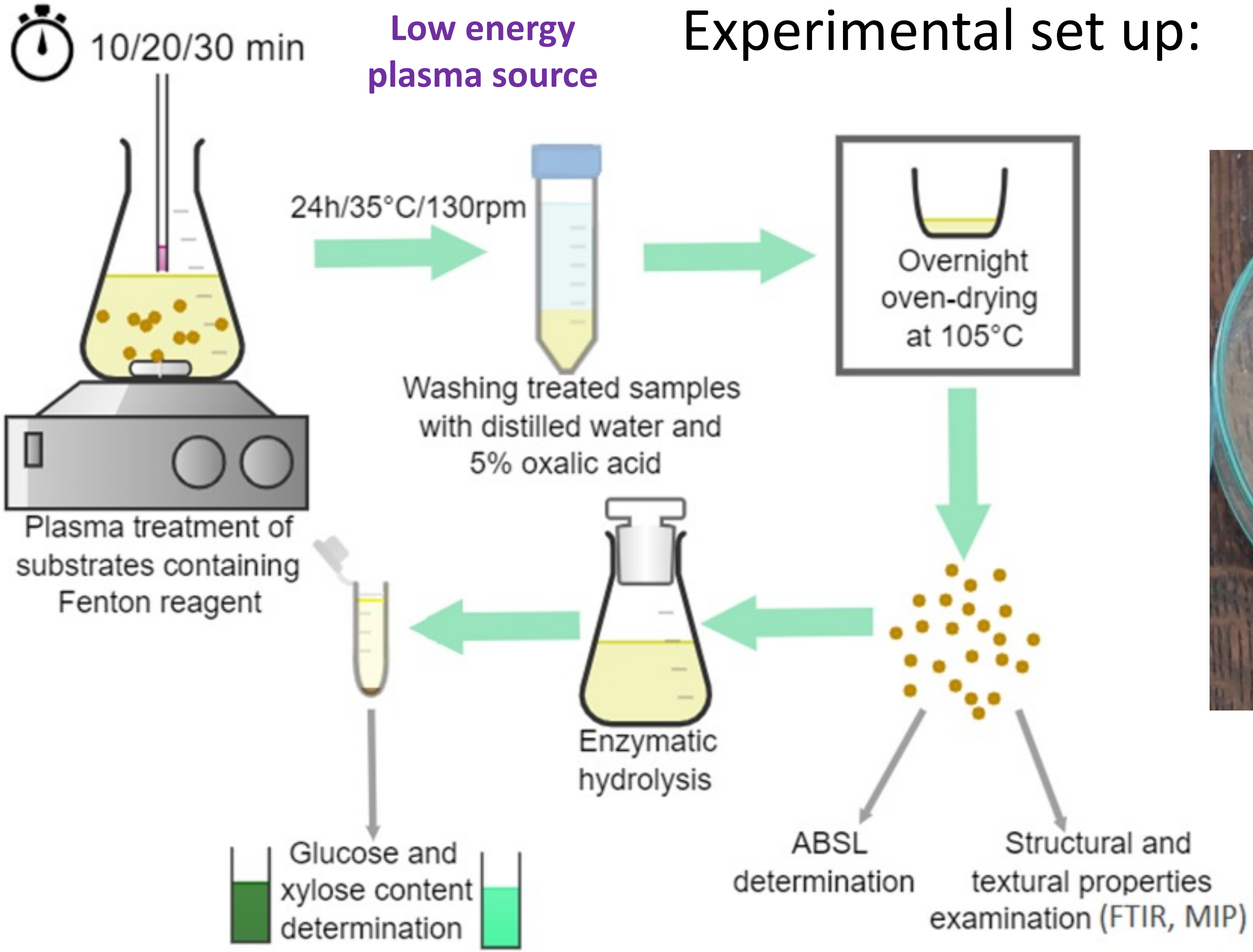
Fenton-based pretreatment is low energy and mild treatment, it is **very time-consuming**

- due to **low concentration of hydroxyl radicals** generated during the pretreatment process

+ Cold atmospheric plasma treatment

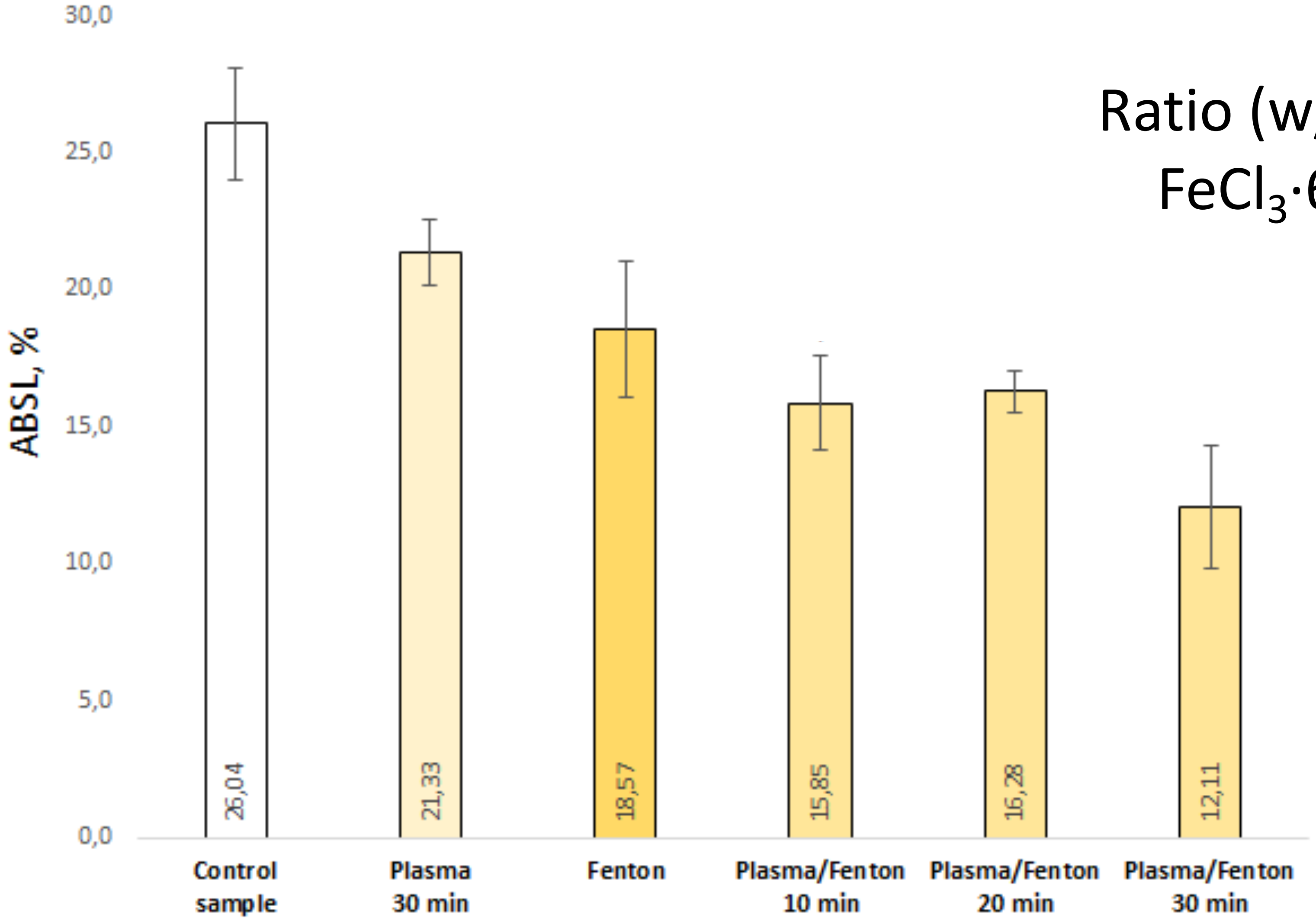


Experimental set up:



Grbić et al., (2023) *Advanced oxidation processes in the treatment of corn stalks*, Sust. Chem. Pharm., 32

Acetyl Bromid Soluble Lignin

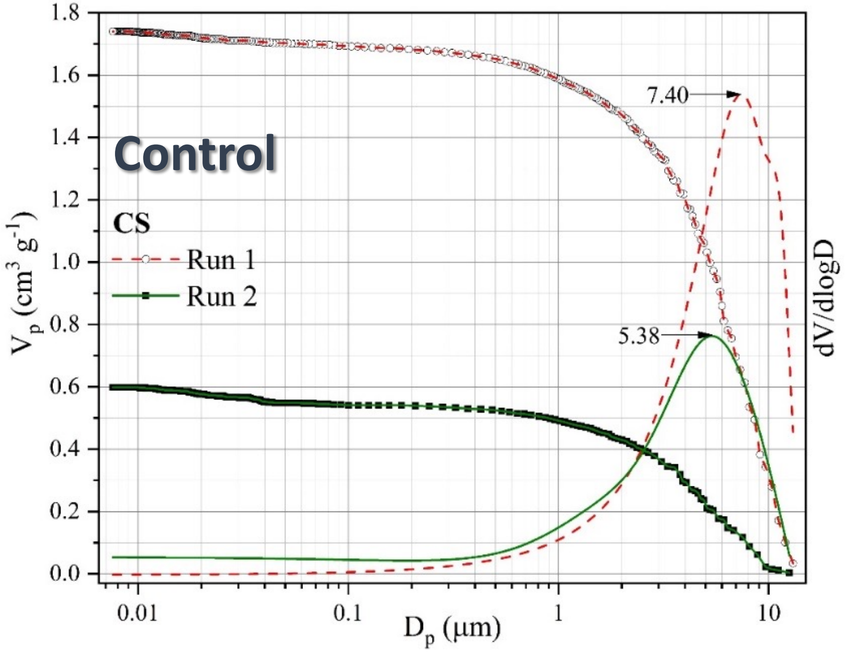


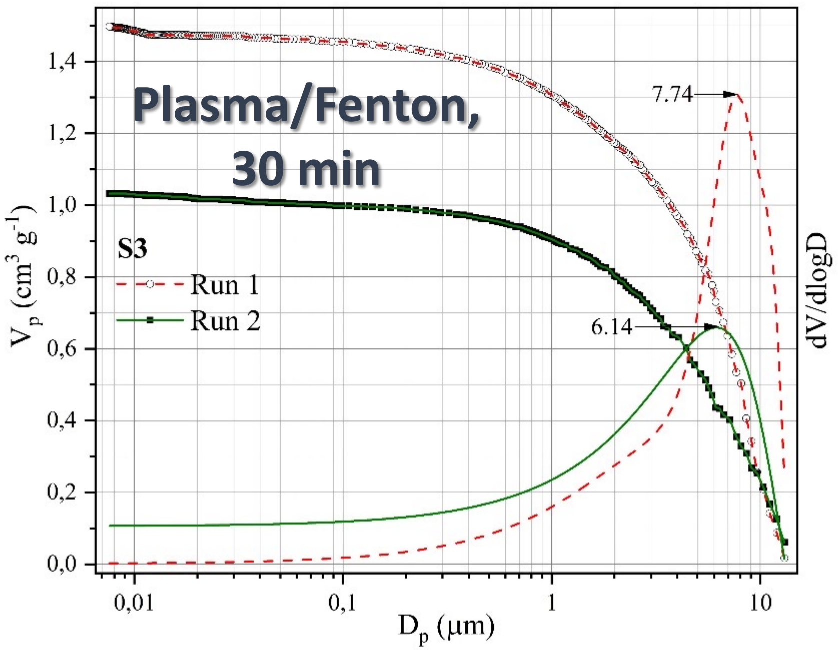
Ratio (w/w) (ferric chloride)

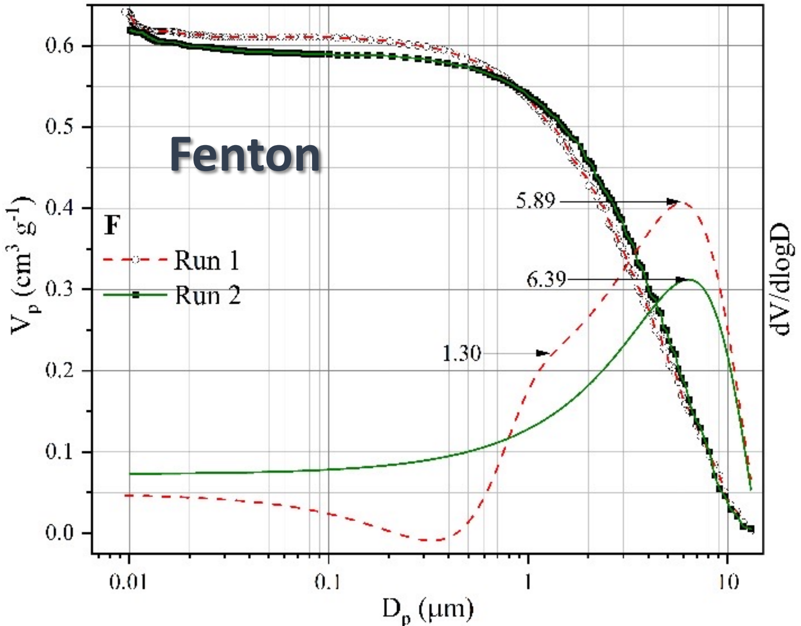
$FeCl_3 \cdot 6H_2O : H_2O_2 = 1:25$

Grbić et al., (2023) *Advanced oxidation processes in the treatment of corn stalks*, Sust. Chem. Pharm., 32

Textural properties determined by mercury intrusion porosimetry







Sample	Run	Porosity (%)
CS	I	71.36
	II	24.55
S1	I	65.46
	II	47.04
S2	I	61.14
	II	26.20
S3	I	76.37
	II	52.63

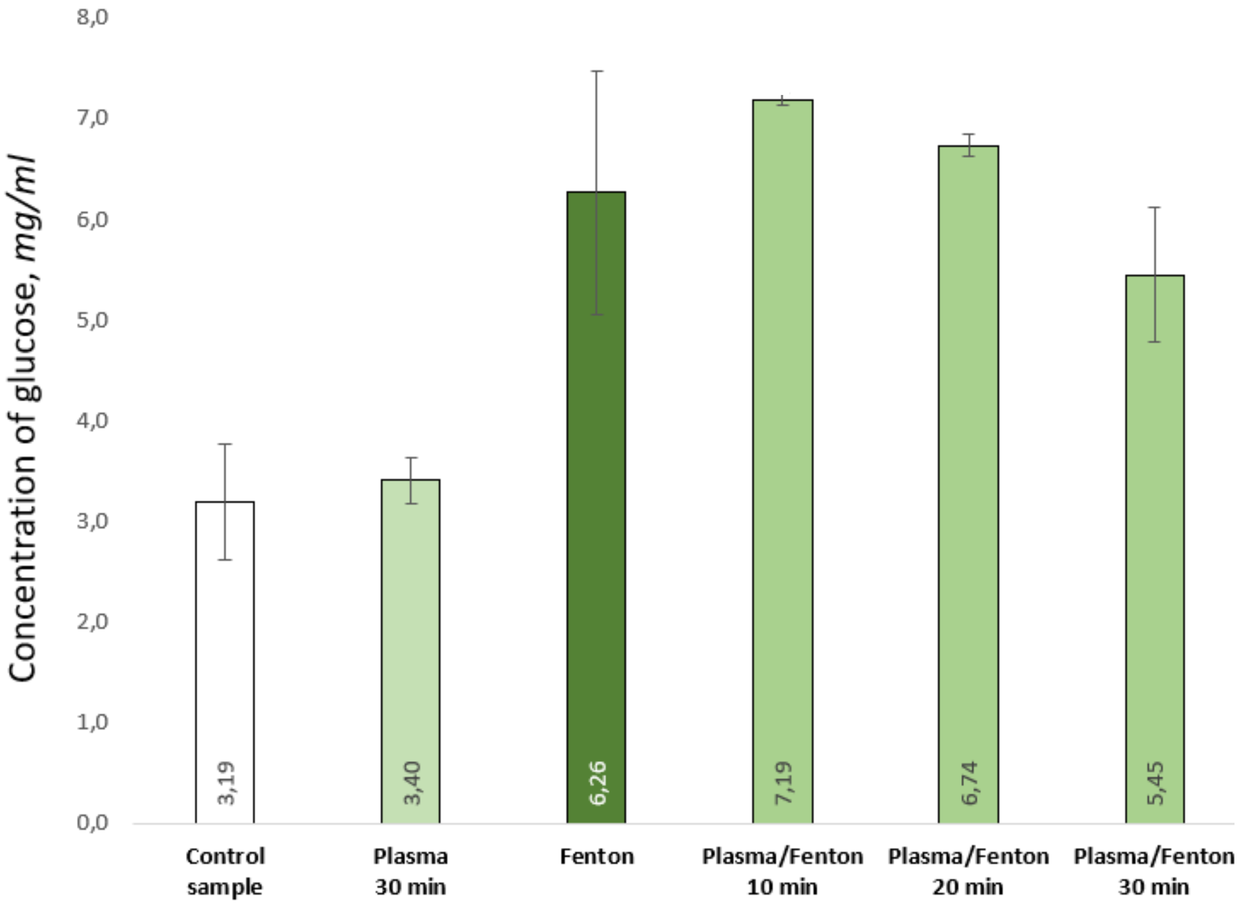
PSD curves

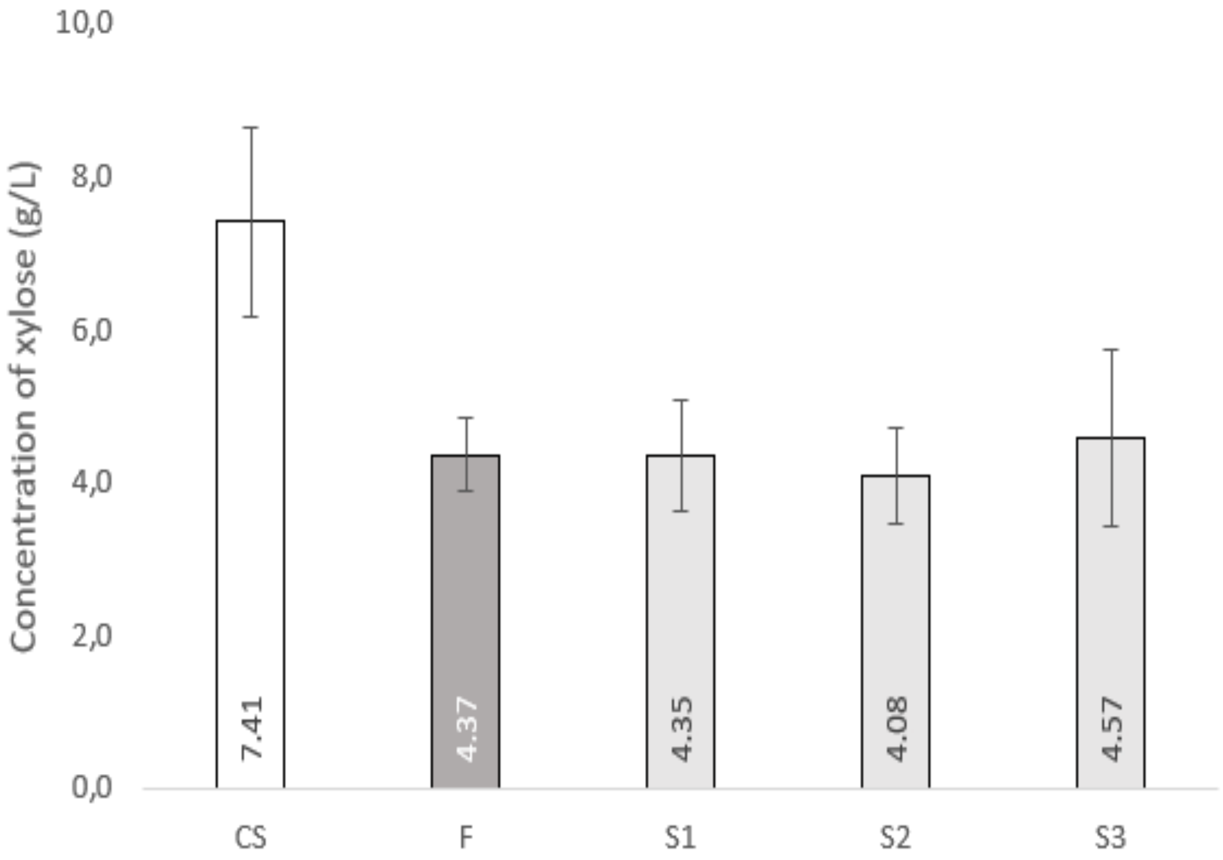
As the treatment time increases:

- Stabilization of the porous structure and uniform distribution of pores occur.
- This stability is confirmed by the decreasing difference between two consecutive intrusion cycles (Run 1 and Run 2), higher porosity and larger pore volume compared to the samples that were treated for a shorter time.

Grbić et al., (2023) *Advanced oxidation processes in the treatment of corn stalks*, Sust. Chem. Pharm., 32

Enzymatic hydrolysis of delignified biomass – sugars concentration





- ✓ **It is important to examine kinetics of delignification by plasma and to optimise hydrolysis conditions.**
- ✓ **Stressors or inhibitors present in these type of media could affect kinetics of microbial and enzymatic biotransformations**

Grbić et al., (2023) *Advanced oxidation processes in the treatment of corn stalks*, Sust. Chem. Pharm., 32

Conclusions

- The combination of plasma and Fenton reagent results in better delignification and it shortens Fenton reaction time affecting the textural properties of samples – kinetics*

- Recovery of hexoses is significantly improved by Fenton/cold plasma assisted treatment while recovery of pentose sugars is lower in current set up in comparison to control, untreated sample

- Selectivity is an issue – separation/extraction prior to treatment* - breaking of bonds between sugars and lignin

Our team at Faculty of Technology and Metallurgy, University of Belgrade, Serbia

- Dr Ljiljana Mojović, Professor Emeritus
- Dr Dragana Mladenović, Assistant research professor
- Jovana Grbić, PhD student
- Mihajlo Bogdanović, PhD student
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Alliance of International Science Organizations

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National Technical University of Athens

SparkGREEN project: Cold plasma assisted resource recovery from agri-food industry wastes

Thank you for your attention!

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