Alfalfa to get back into planetary boundaries

2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

Animal nutrition

Palmonari A. & Nalle M.

Parallel session 4

FROM 03 TO 06 nov. 2025

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2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

Variation of fresh alfalfa stem properties along its height: protein content, chemical composition and sorption behavior

Sarah Orbach,

Dr.Brahim Mazian, Pr.Pedro Augusto,
Pr.Patrick Perré




FROM 03 TO 06 nov. 2025

Context

Flax

Miscanthus

Hemp

Bamboo

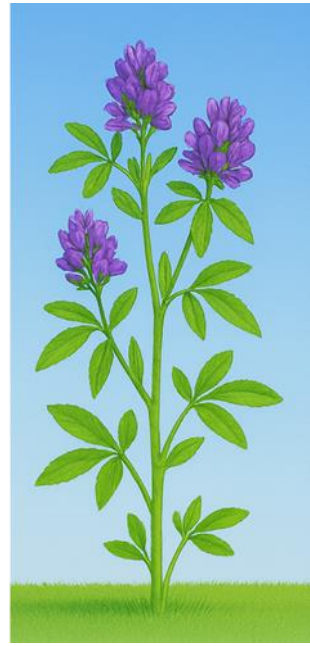
Coton

Jute

Sisal

Kenaf

Alfalfa



[1]Thygesen et al. 2007.

Context

Hemp

	Hemp[1]
Cellulose	64%
Hemicellulose	15%
Lignin	4%
Ash	4%

[1]Thygesen et al. 2007.

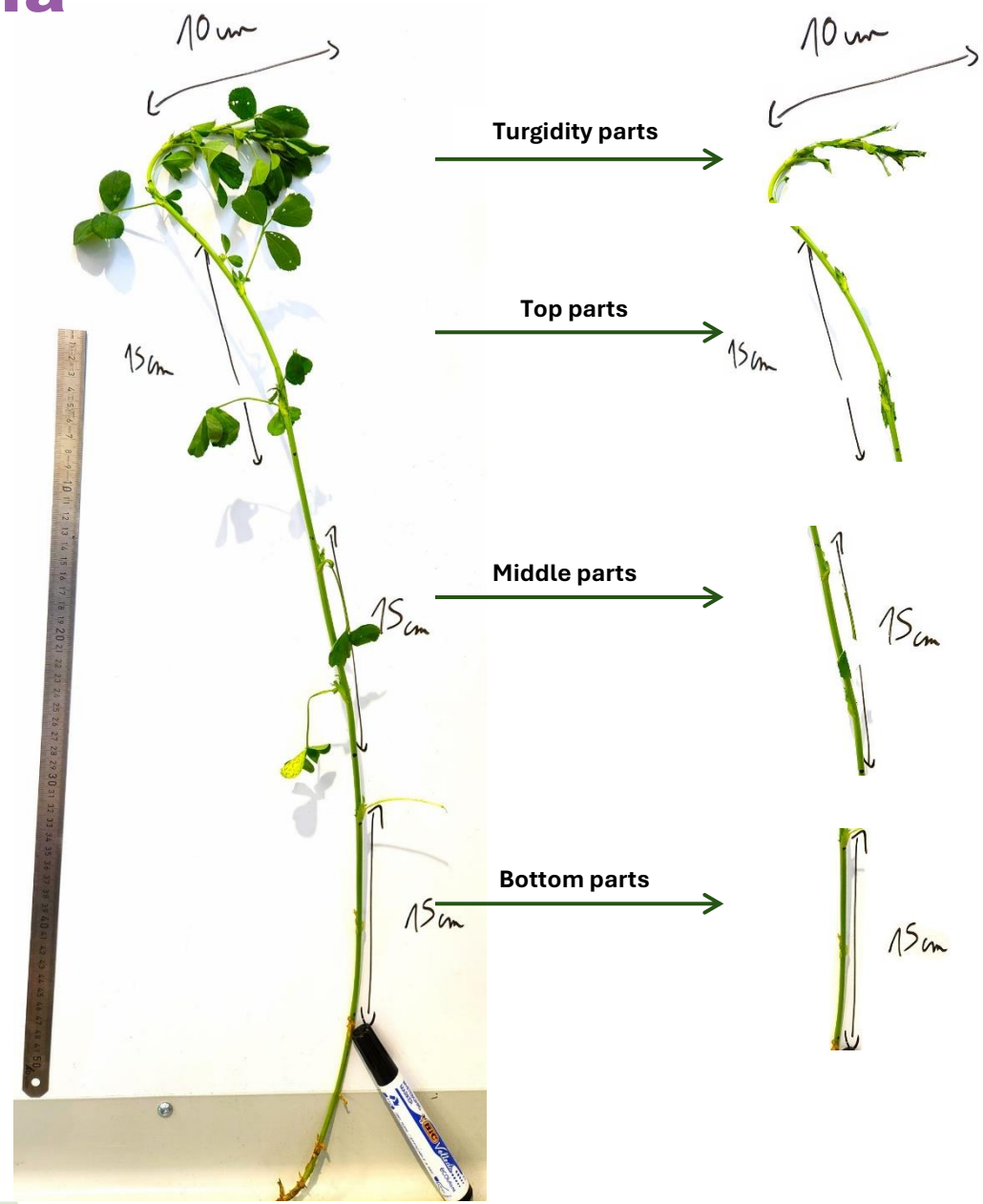
Context

Norway spruce (Wood)

	Hemp[1]	Norway spruce (Wood)[2]
Cellulose	64%	46%
Hemicellulose	15%	26%
Lignin	4%	28%
Ash	4%	<1%

[1]Thygesen et al. 2007,
[2] Bertaud et al. 2000.

Alfalfa



Morphological analysis : Tissu composition
➔ Nanotomography

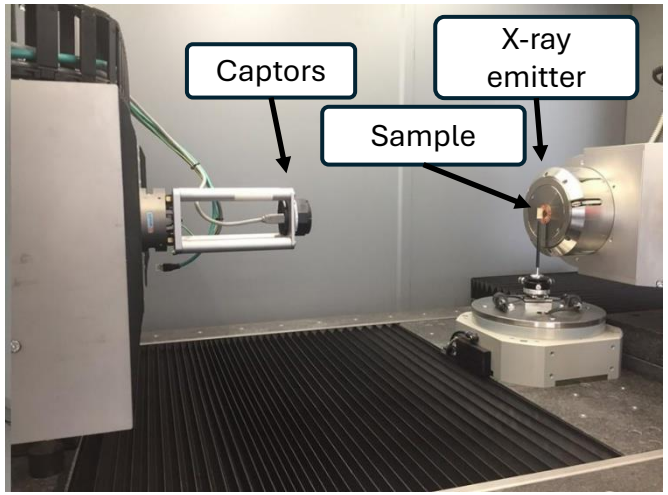
Protein evolution along the stem
➔ Kjeldahl devise

Evolution of global chemical composition
➔ Standards methods

Comparison with physical properties:
➔ DVS (Dynamic Vapor Sorption devise)

Methodology

Morphological Analysis



Nanotomography Ultratom from RX-solutions

- 3D images reconstruction,
- 3D images analysis: density, porosity, pore size,
- Data extraction for calculus and modeling.

[3]Amie Sluiter LAP/NREL 2008.

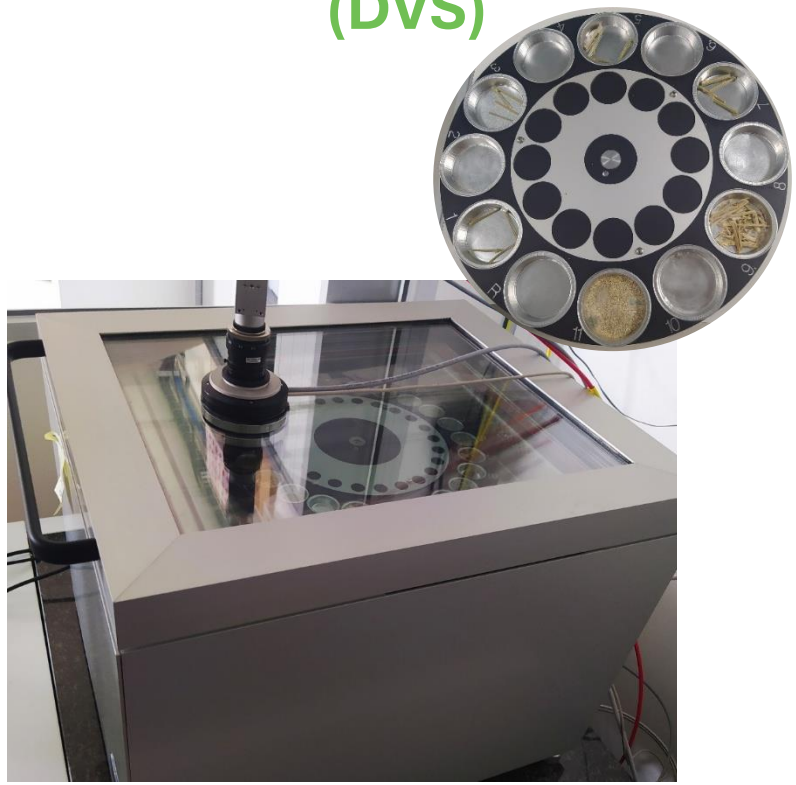
Chemical Composition[3]

- Proteins (Kjeldahl),
- Ethanol Extract
- Ashes

- Hemicellulose,
- Cellulose,
- Lignin.

[1]NREL standards

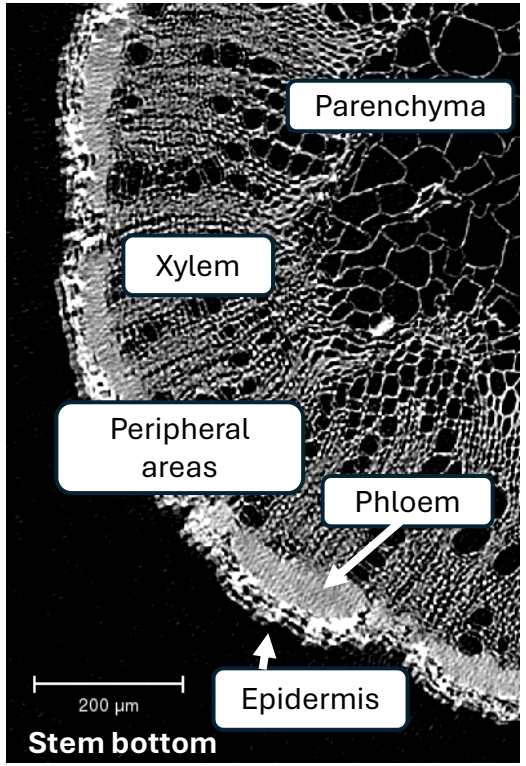
Dynamic Vapor Sorption (DVS)

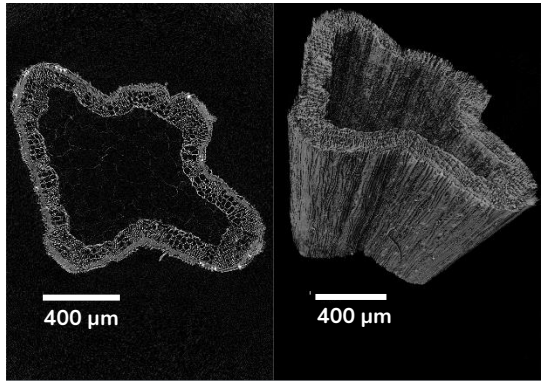


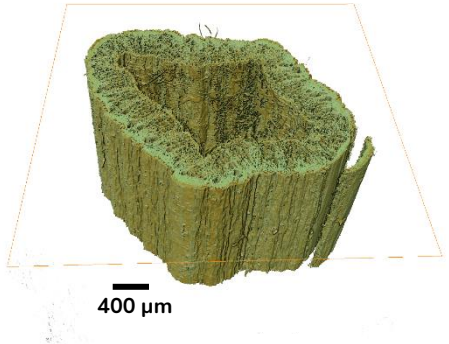
Conditions:

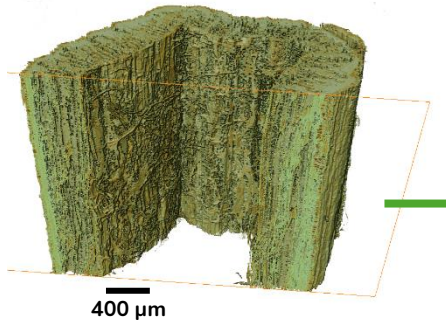
- 25°C
- From 0%RH to 90%RH.

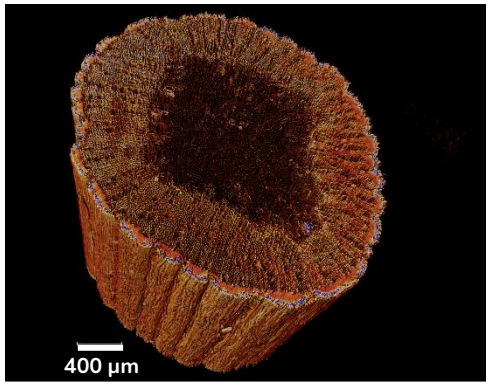
Results : Morphological analysis

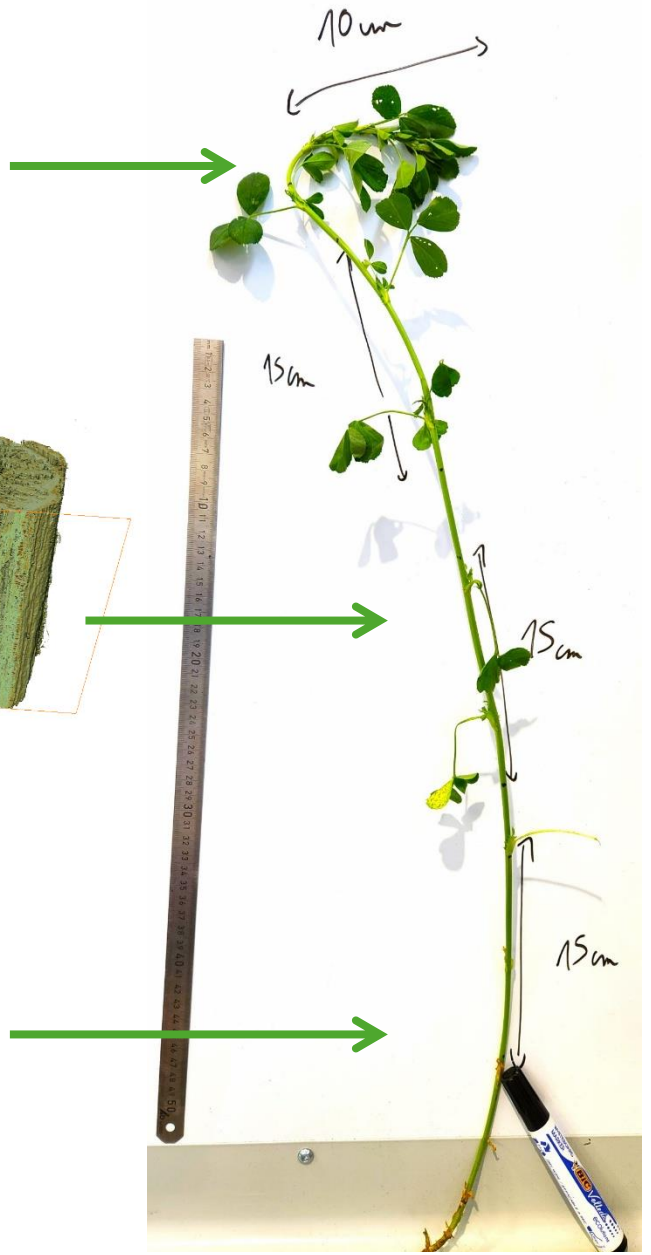










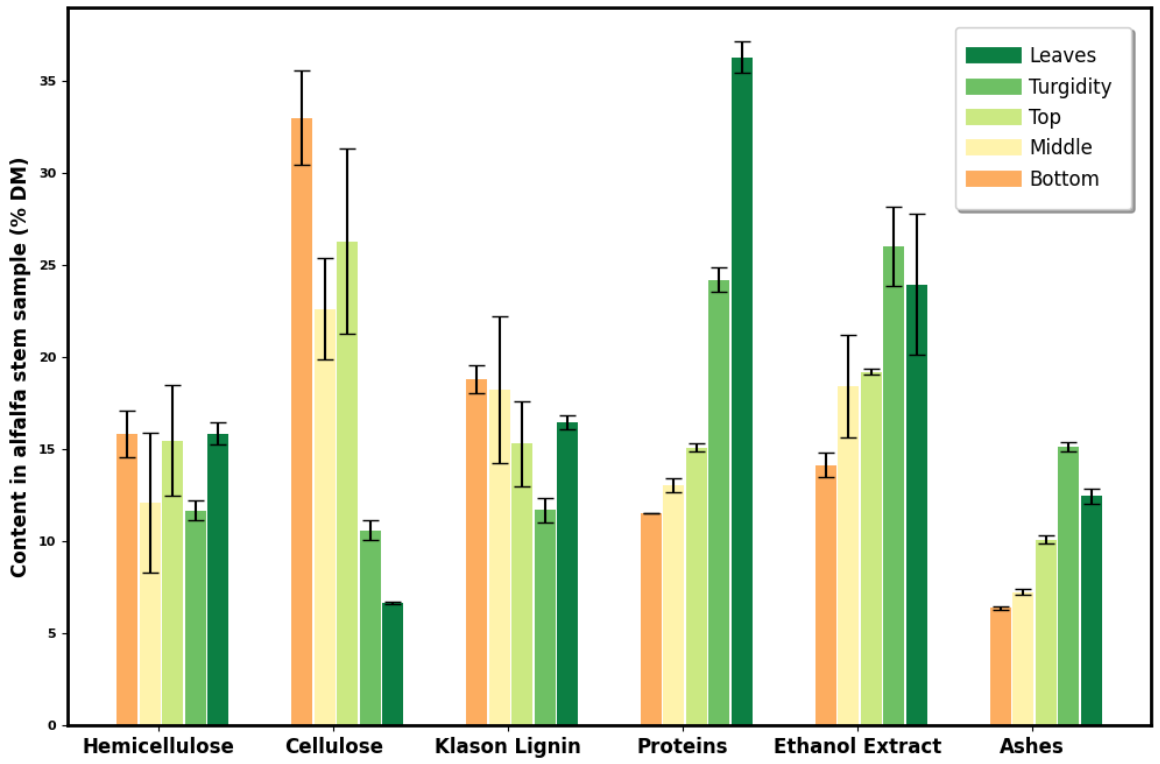


Data:

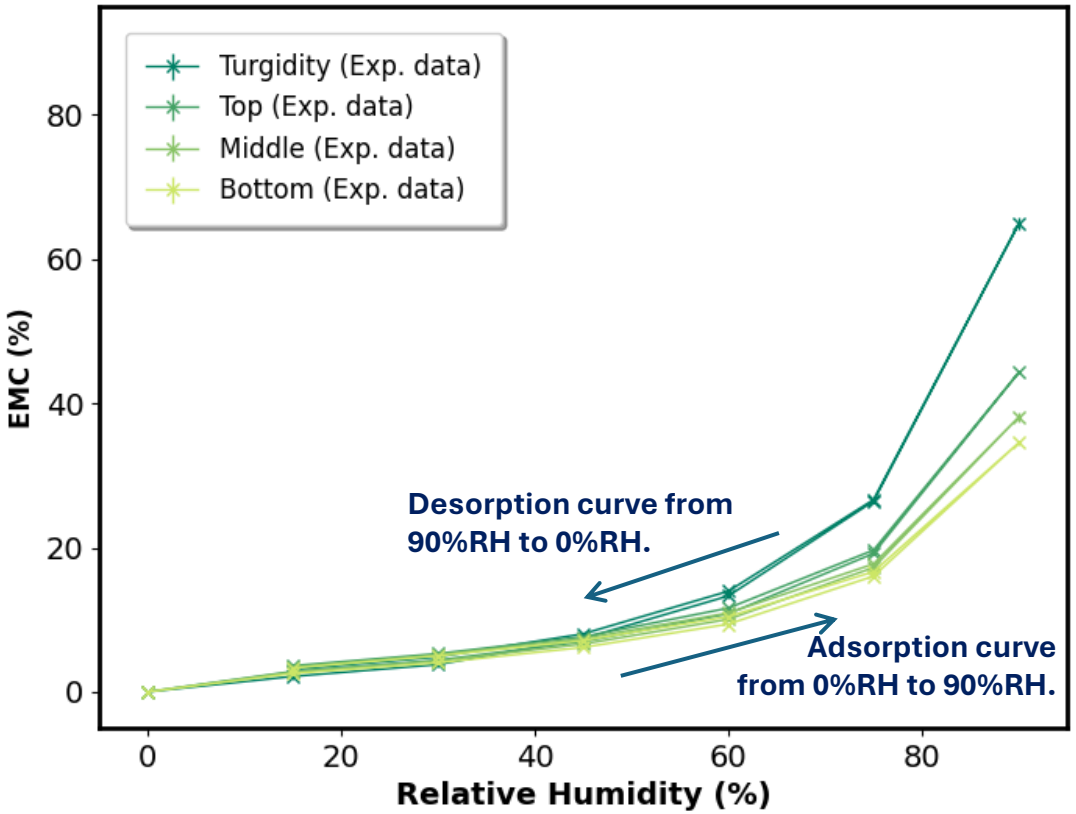
- 2 samples Top,
- 2 samples Middle,
- 2 samples Bottom.

Results: Protein and Chemical composition Sorption behavior

NDF = Hemicellulose + Cellulose + Lignin
ADF = Cellulose + Lignin



Alfalfa chemical composition variation along the stem



Alfalfa sorption curve depending on the sample position of the stem

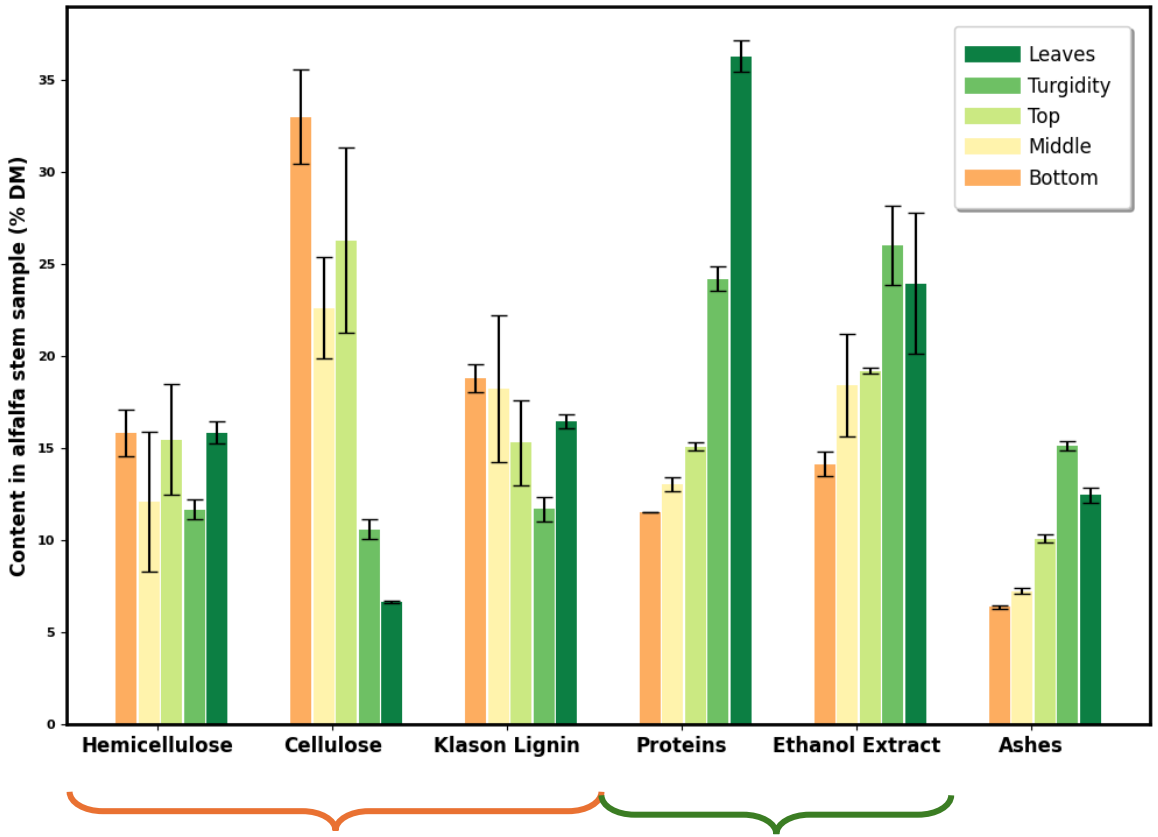
Results: interaction with water vapor: GAB Model

$$EMC = \frac{M_m C K a_w}{(1 - K a_w)(1 - K a_w + C K a_w)}$$

M_m: monolayer moisture content,

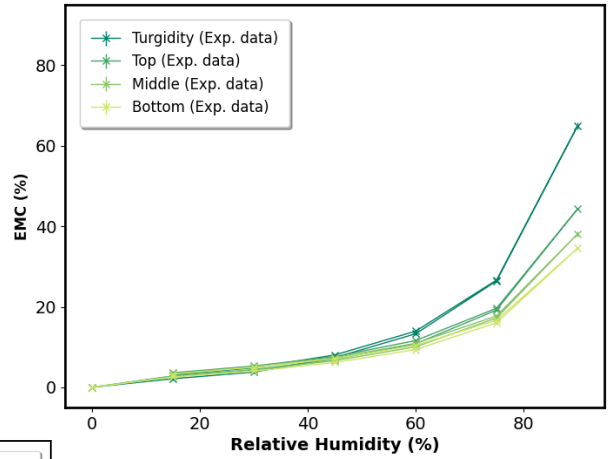
C and K: constants related to the sorption characteristics,

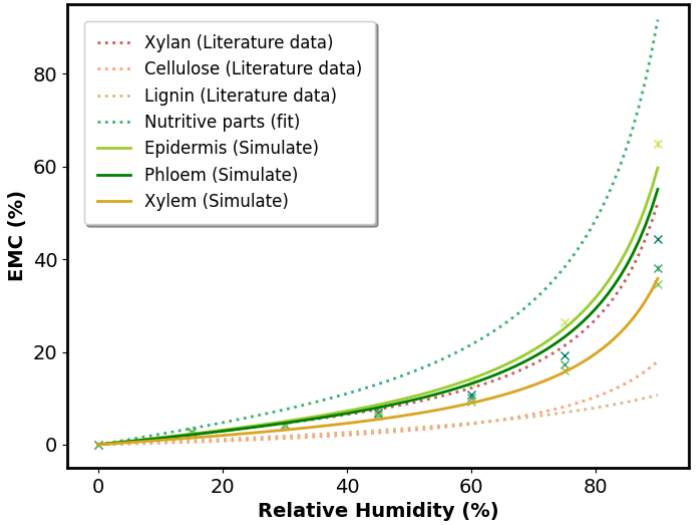
a_w: the water activity, $a_w = RH/100$.



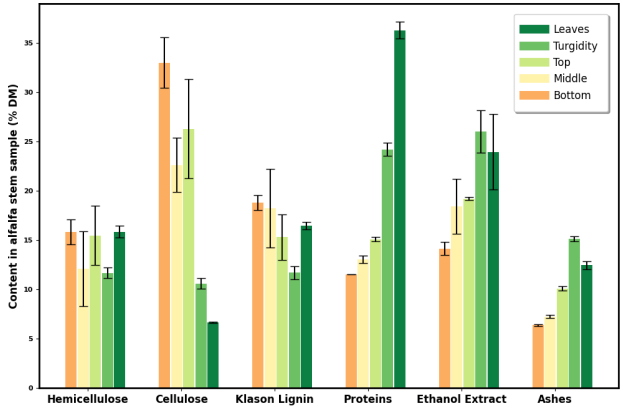
$Model_{GAB} = \alpha * Model_1(M_{n1}, C_1, K_1) + \beta * Model_2(M_{n2}, C_2, K_2)$

Sorption data

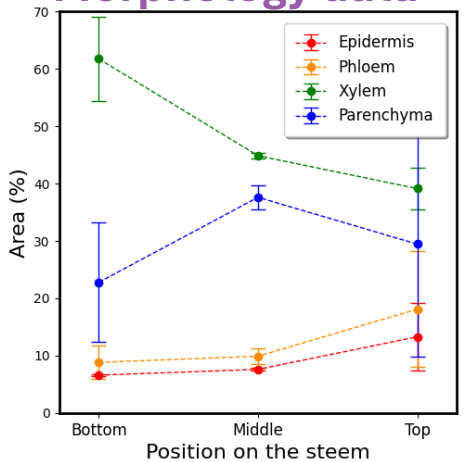




Chemical composition



Morphology data

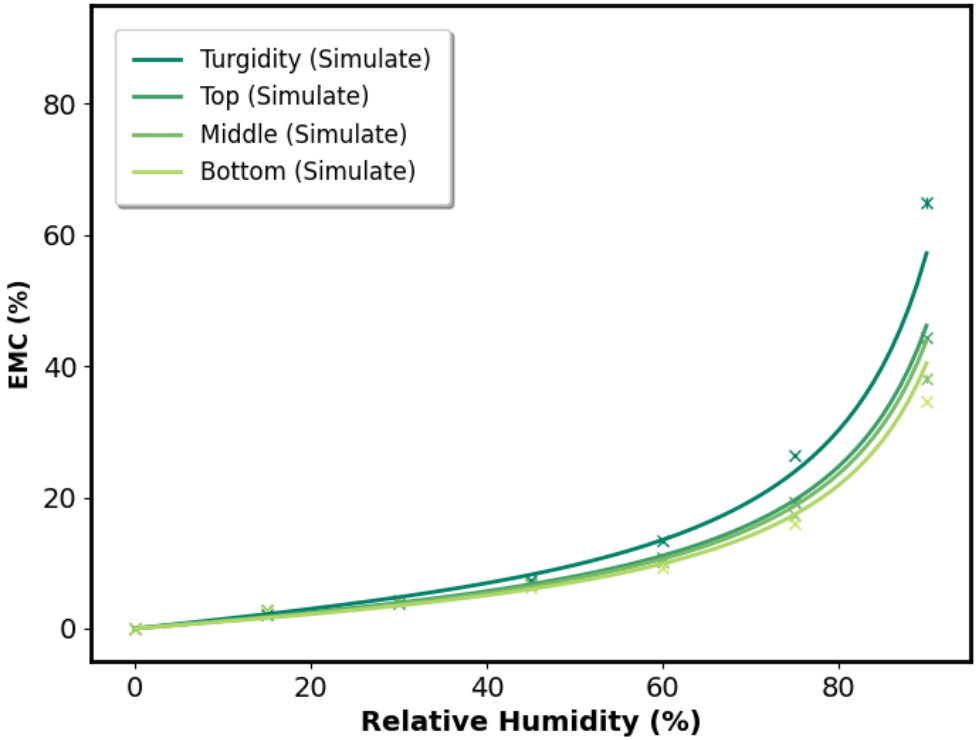


Fit GAB model

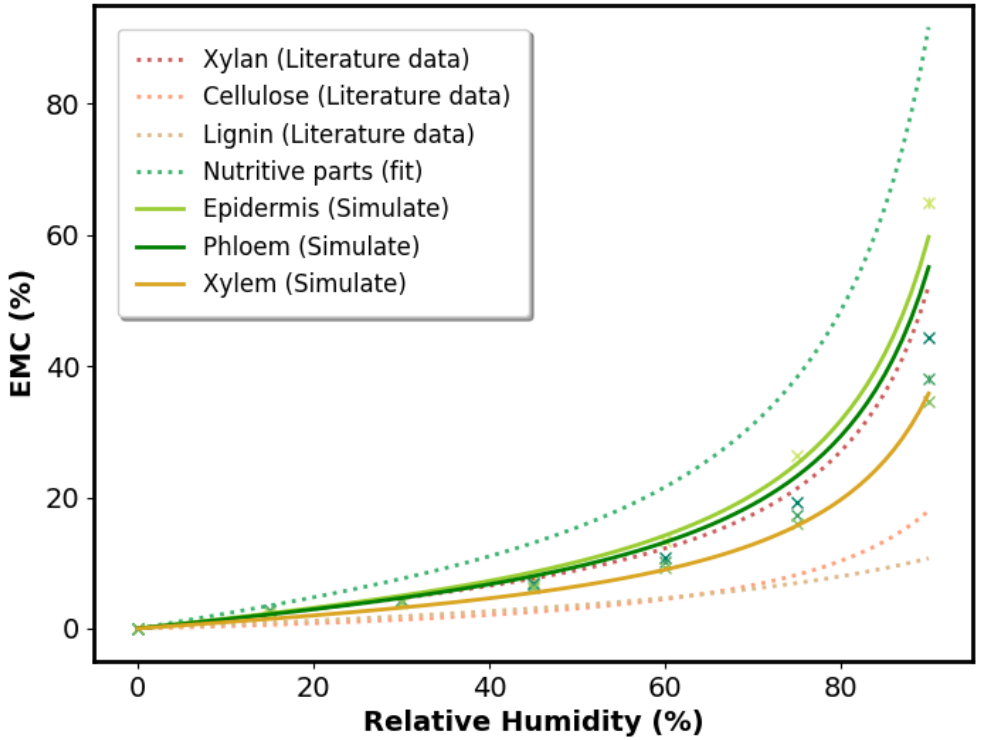
$$EMC = \frac{M_m C K a_w}{(1 - K a_w)(1 - K a_m + C K a_w)}$$

M_m: monolayer moisture content,
C and K: constants related to the sorption characteristics,
a_w: the water activity,
$a_w = RH/100$.

Final results



Sorption curve prediction of each sample given the three others as training dataset



Alfalfa tissues sorption curves modeling

Literature data: Muraille et al. 2015

Thank you for your attention.

Rich protein parts valorization.

Rich lignocellulosic parts valorization

- PhD student:
  - **Sarah Orbach**
- Supervisors:
  - **Dr. Brahim Mazian**
  - **Pr. Pedro Augusto**
  - **Pr. Patrick Perré**

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