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Exploration of seaweed and wheat grain by magnetic resonance imaging: Preliminary results

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MRI @ BIBS Facility

Bioresources: **I**maging, **B**iochemistry & **S**tructure Facility

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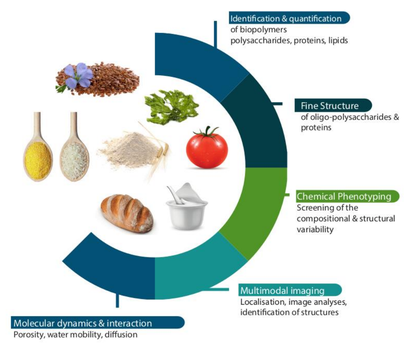
- characterization of plants, organs, and biopolymers to plant derived bioresources
- at a scale ranging from molecule to object by physical and chemical methods
- 4 analytical labs: mass spectrometry, microscopy, nuclear magnetic resonance and chemical phenotyping
- 1 bioinformatics lab
  - ➢ open to local, national and international collaborations: 221, the last 5 years
  - ➢ open to academic and private projects



Examples of projects involving µMRI to investigate non-destructively seaweed and wheat grain structures:

- **PEPR B-BEST FillingGaps** (ANR-23-PEBB-0006, 2023-2027): Multi-scale approaches, for representative biomass species (maize, seaweed, wood), in order to establish relationships between scales with a view to highlighting markers of biomass properties and reactivity. www.linkedin.com/in/projet-fillinggaps-pepr-b-best-60ba4b30a
- **FSOV Climaboul**: Adaptation of wheat to climate change and its impact on baking quality (2024-2028).

Equipment

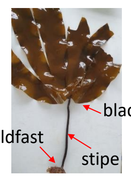
400 MHz WB
AVANCE NEO
ParaVision 360 v3.5

multi-echo MRI microscopy
Resonators: 20 and 30 mm

- ➢ to non-destructively explore plants
- ➢ to carry out *in situ* studies of water distribution and mobility in plants at tissue level[1] and in plant-derived bioresources[2]

Morphology and Water dynamics in seaweed blade and stipe by MRI

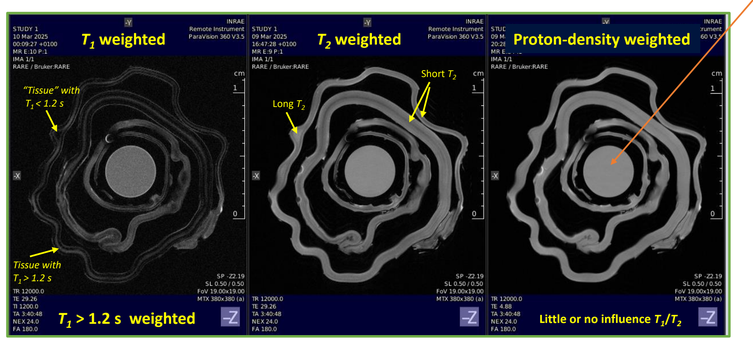
Seaweed: a source of polysaccharides in food, cosmetics, pharmaceuticals, bio-based chemicals and bioplastics industries



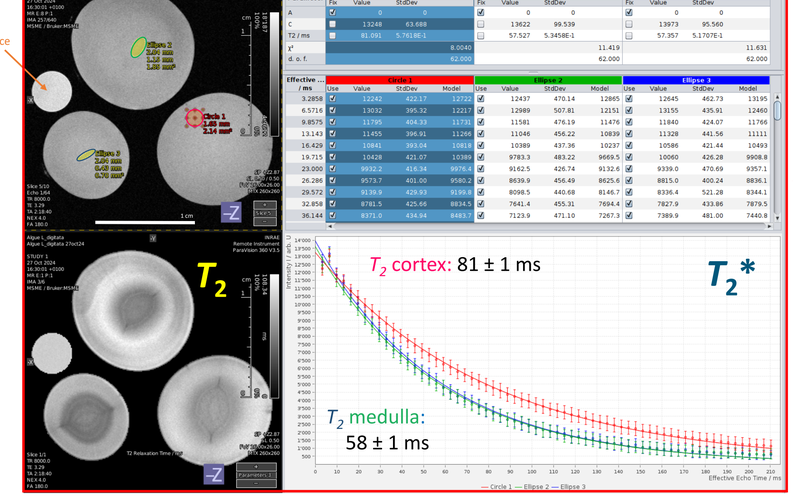
Laminaria digitata

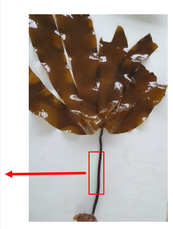
Saccharina latissima

Blade of *S. latissima* harvested in March 2025



Slice: 0.5 mm
Experiment time: 3h40
Voxel: 50 µm X 50 µm X 500 µm





Stipe of *L. digitata* harvested Oct. 2024

Slice: 0.5 mm
Experiment time: 2h19
Voxel: 100 µm X 100 µm X 500 µm

➢ **Identification of different tissue structures in the blade and stipe of algae**

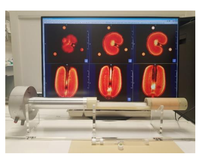
Morphology and Water dynamics in wheat grain by MRI

Wheat: one of three most important food crops in the world
Need to develop wheat varieties more tolerant to climate change stresses, while maintaining their ability to be processed into stable quality bread products

Comparison of wheat grains from plants submitted to heat stress (23/29°C night/day) or not (15/21°C), grown under controlled conditions in growth chambers.

➢ **µMRI to investigate**

- **wheat grain structures**
- **water distribution and mobility in different grain tissues**
- **at different development stages**
- **the impact of heat.**

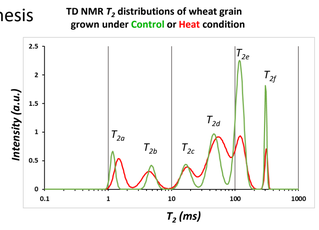


Resonator: 20 mm
Homemade object holder

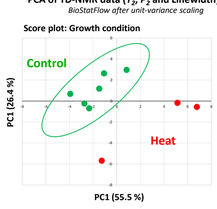
Wheat variety: Extase
Day of harvest: 247 degree day post anthesis
Stage: early grain-filling period
2 plants per condition Control or Heat
2 spikelets selected per plant
1 grain per spikelet

TD-NMR: 20 MHz (0.47 T) Bruker CPMG acquisition
T_2 modelling: groups of water environments in the sample

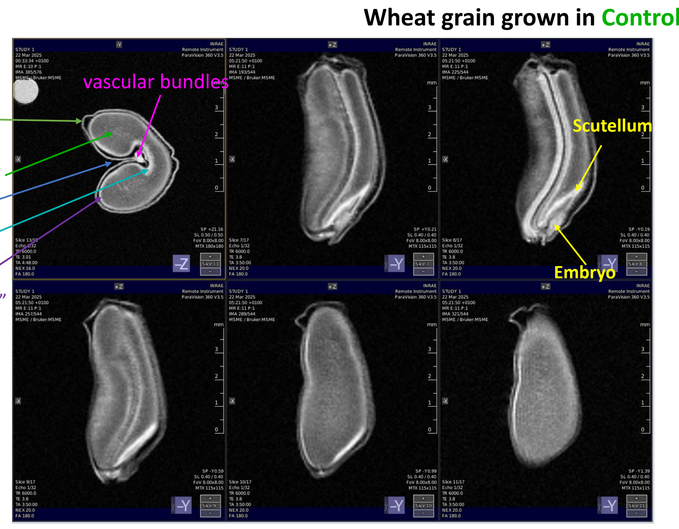
TD NMR T_2 distributions of wheat grain grown under Control or Heat condition



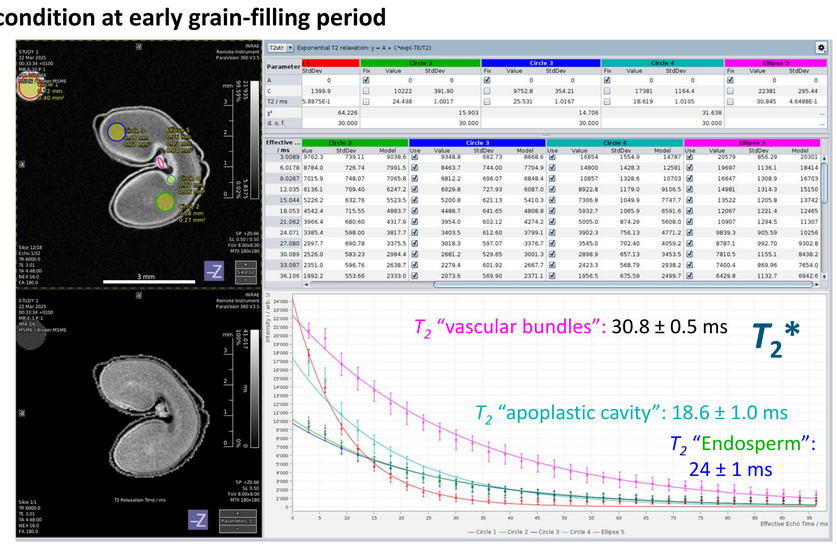
PCA of TD-NMR data (T_2, P_2 and Linewidth)
BioStatFlow after unit-variance scaling



Wheat grain grown in Control condition at early grain-filling period



Slices:	Axial 0.5 mm	Transversal 0.4 mm
Experiment times:	Axial 4h48	Transversal 3h50
Voxel:	Axial 44 µm X 44 µm X 500 µm	Transversal 70 µm X 70 µm X 400 µm



➢ **Identification of different tissue structures in the wheat grain**
➢ **Embryo, vascular bundles and "intermediate layers": high MR signal due to the presence of "free" water likely associated with biological activities[3]**
➢ **Six water environments were identified by TD-NMR, enabling sample discrimination according to culture conditions**

Conclusions & Perspectives

- MRI is a non-destructive and quantitative technique to explore morphology, to measure water content, distribution and mobility in plant organ and/or tissue.
- Production of the first morphological and water mobility images of seaweed stipe and blade.
- Very promising preliminary results: differences in structure and water mobility between tissues are observed.
- Follow the water dynamics in wheat grain at two other stages of grain development under heat stress vs control: *on-going*
- Development of MRI parametric image treatment software: *on-going*
- Producing morphological and water mobility image of seaweed to be combined with MALDI mass spectrometry image, (to add chemical/metabolite information) such as in wheat[4]: *planned*

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