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IMAGING AND ANALYSIS OF AN APPLE PEST BEHAVIOUR: MRI AND X-RAY MICROTOMOGRAPHY COMPARISON

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Purposis:

As part of the research work dealing with the potential effect of pest behaviors on apple, MRI and X-ray imaging were compared in their ability to extract 3D tunnel made by the codling moth, *Cydia pomonella* (L) (Lepidoptera: Tortricidae), especially when they are exposed to the biological insecticide: the codling moth granulovirus CpGV. The target stage is the first caterpillar stadium when the *C. pomonella* caterpillar feeds on apple by making a mine that characterizes the codling moth's behavior.

Material et methods :

MRI

MRI follow up (3 weeks and twice a week) was conducted on a Bruker Biospec 47/40 spectrometer with BGA 26 gradients unit and 20 cm-diameter Birdcage RF coil

Imaging protocol : RARE T1 pulse sequence (TR/TE = 1200/12 ms), 4 segments; Up to 96 1-mm thick slice images (to cover the whole apple in the axial, sagittal and coronal planes) were acquired for each session with a FOV of 9.6 cm and 256x256 matrix size

Image processing: A home-made image processing software (PiafBto3D*) was used to reconstruct 3D volume from the set of 2D images and to extract tunnels.

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X-Ray microtomography

Equipment: Phoenix X-ray Nanotom© microtomograph*

Imaging: 1620 frames (angle step = 0.22°). Voltage= 60 kV,

Intensity = 400 mA, no X-ray filter

Acquisition time: 750ms / frame

Reconstructed volume: 1100x1170x1100 voxels

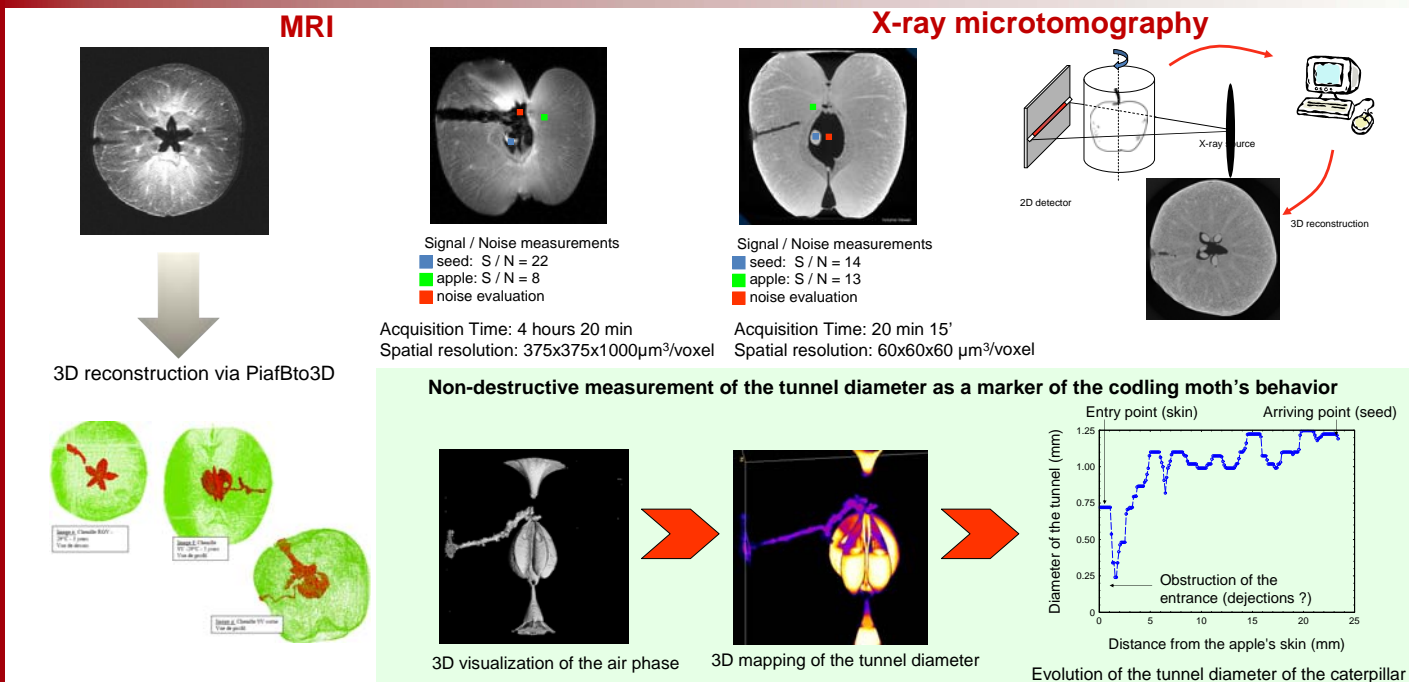
Format: 16 bits dynamic

Image processing : ImageJ was used to extract the tunnel according to the x-ray absorption contrast and to visualize the air phase.

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Results:



Conclusions and prospect: MRI is very efficient for high water content products. Microtomography is very efficient for biphasic materials if densities are quite different (e. g., solid-air porous media). MRI is the preferred tool for quantifying the amount of water and its state in the sample while the CT is used to differentiate solid phases. X-ray technologies provide better spatial resolution than MRI. Thus, MRI and X-ray microtomographic technologies are complementary tools. Nevertheless, in case of the study of the 3D tunnel made by the codling moth in the apple, both tools give relevant results because:

- high spatial resolution was not required
- the main issue was to separate the solid phase (apple= porous solid media filled with water) from the air phase (tunnel).

Few points of major difference:

- X-ray microtomography can provide very high spatial resolution (up to 1 μm) and does not require more time for isotropic volume. The complete isotropic volumes make easier 3D distance measurements for morphology characterizations.
- Time: for the same spatial resolution and same Signal / Noise ratio, the acquisition time would be around 1 to 2 min with X-ray microtomography.
- Safety point: X-ray microtomography generates ionization (safety issue for living beings: the caterpillar died few days after X-ray experiments)
- X-ray microtomography is not efficient to separate water from other components if they show similar densities
- X-ray microtomography is very efficient for multiphase materials with contrasted absorption properties since differences in magnetic susceptibilities at the air-parenchyma interface damage the signal and lead to the overestimation of tunnel size. Specific sequences could be developed for such application.

Both tools provide a good description of the caterpillar tunnel. Thus they can be used to characterize the evolution of the tunnel diameter and to observe the behavior of the mining pest. Nevertheless, MRI is safe for the caterpillar since X-ray microtomography could be much faster for dynamic observations.