Predicting carotenoid concentrations in growing and ripening tomato fruits under varied irrigation and light conditions

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17th ISHS Symposium on Processing Tomato

Predicting carotenoid concentrations in growing and ripening tomato fruits under varied irrigation and light conditions

Results from coupled confocal microscopy and image analysis

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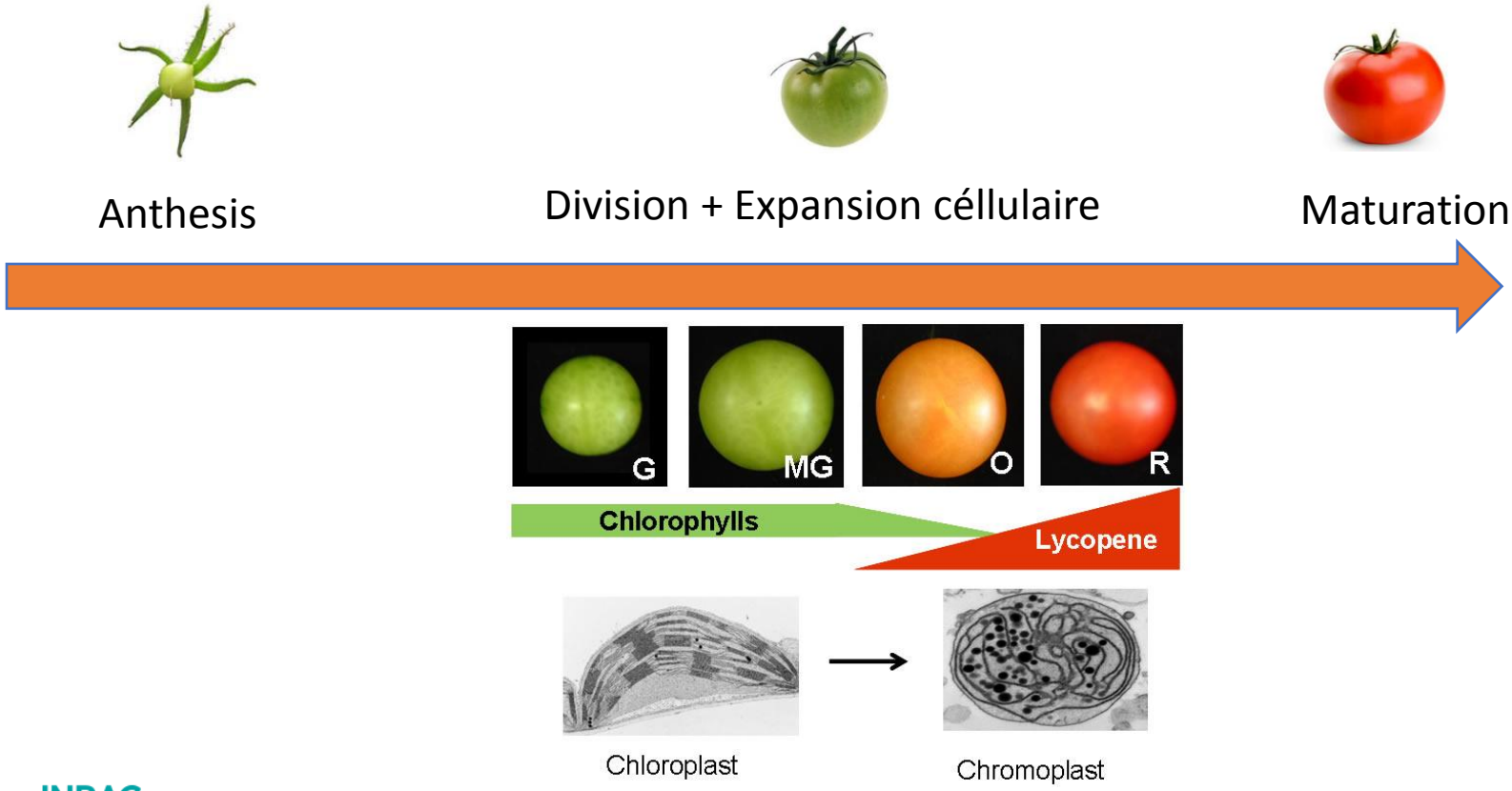
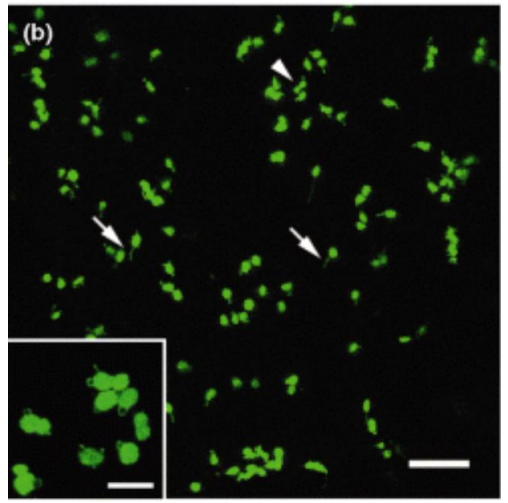
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE

Carotenoids accumulation

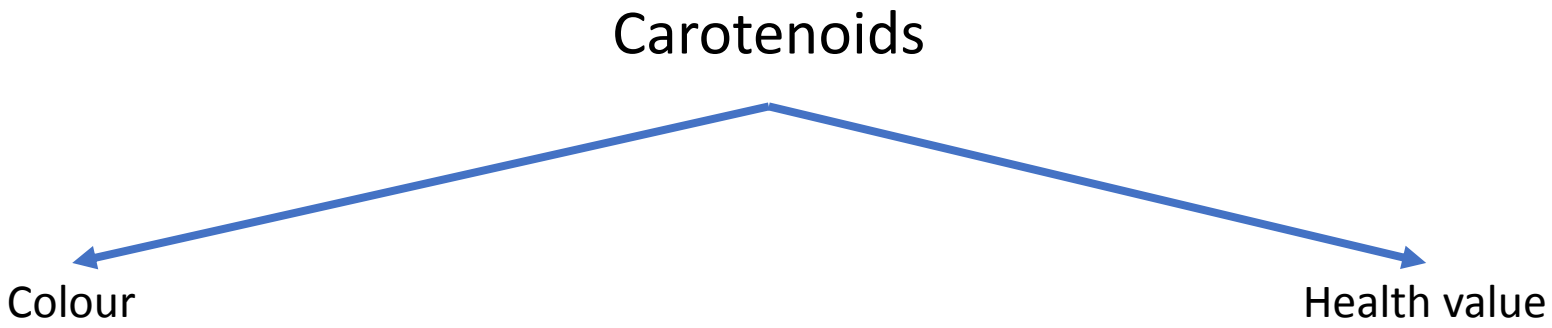
- Carotenoids formation:
  - Carotenoids are stored in chromoplasts during ripening
  - Chromoplasts derive from chloroplasts



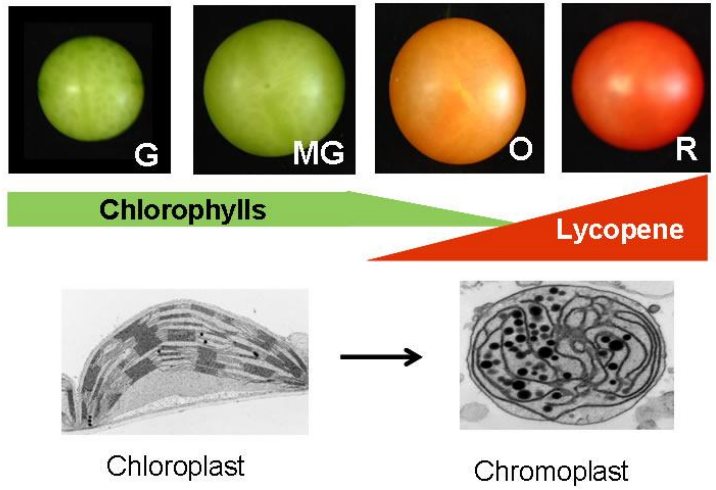


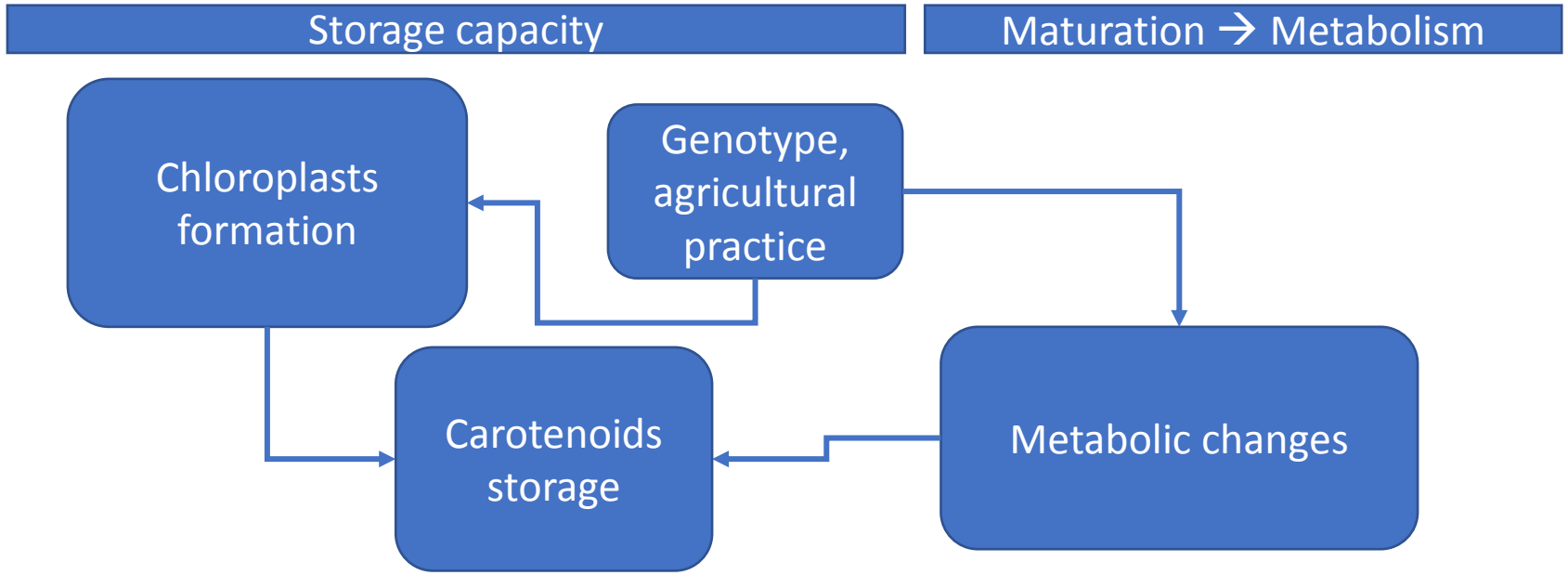
Waters et al. 2004

Carotenoids and quality of tomato fruit

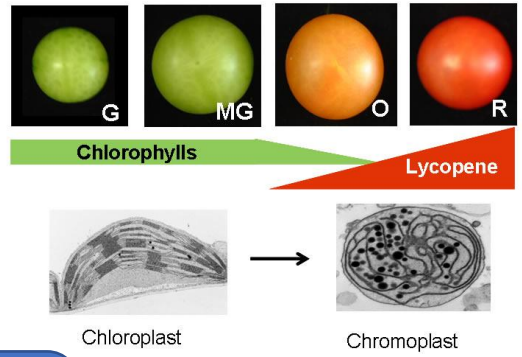


Link with practices





Link with practices and post processing



Water scarcity

Different development of cells

Sinkora et al., 2023

Purée texture

Purée quality

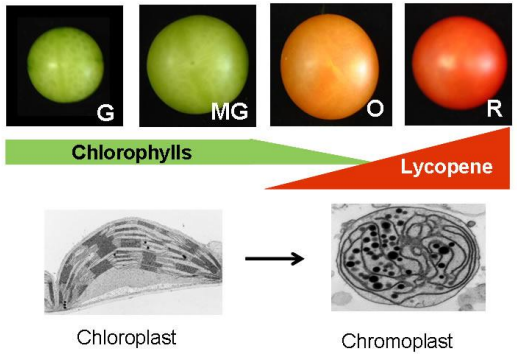
Chloroplasts formation

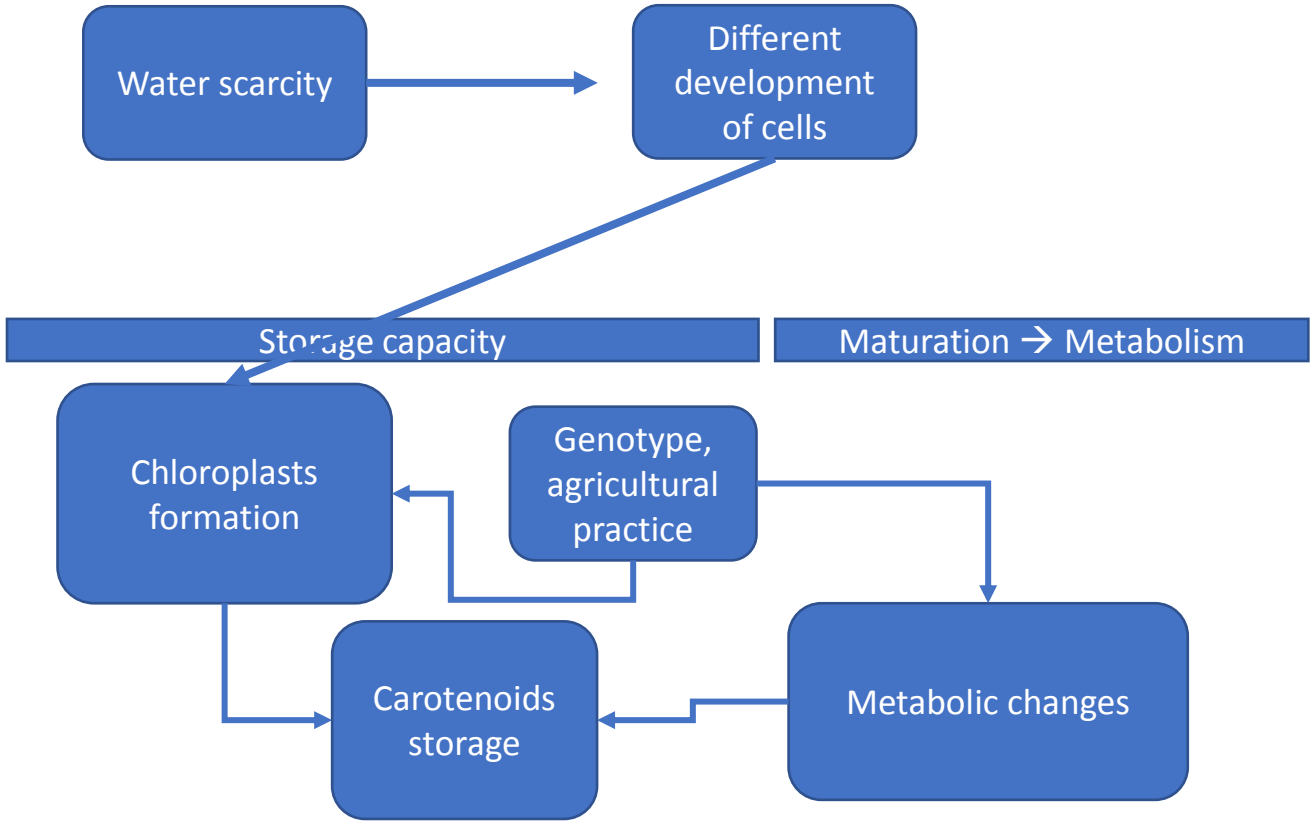
Genotype, agricultural practice

Carotenoids storage

Metabolic changes

A pathway to model carotenoids formation

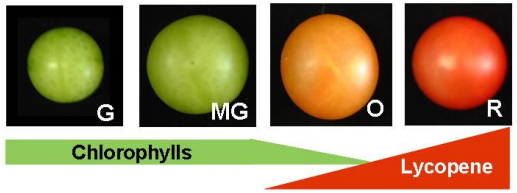


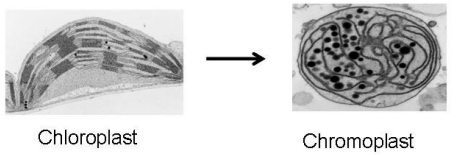


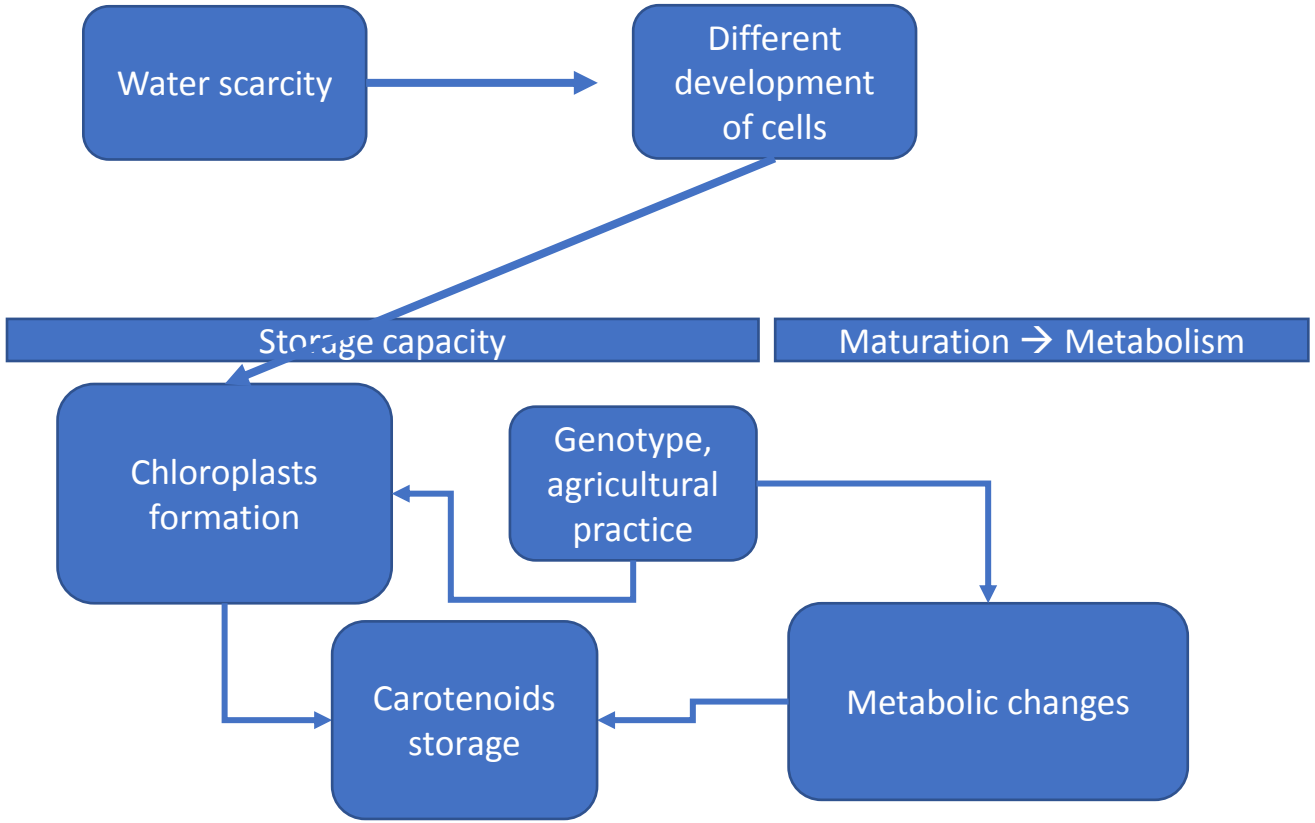
- What kind of relationship between chloroplast presence and chlorophyll?
- Can we predict carotenoids based on this relationship?

Develop a process-based model to link chlorophyll accumulation and carotenoids metabolism

A pathway to predict carotenoids formation





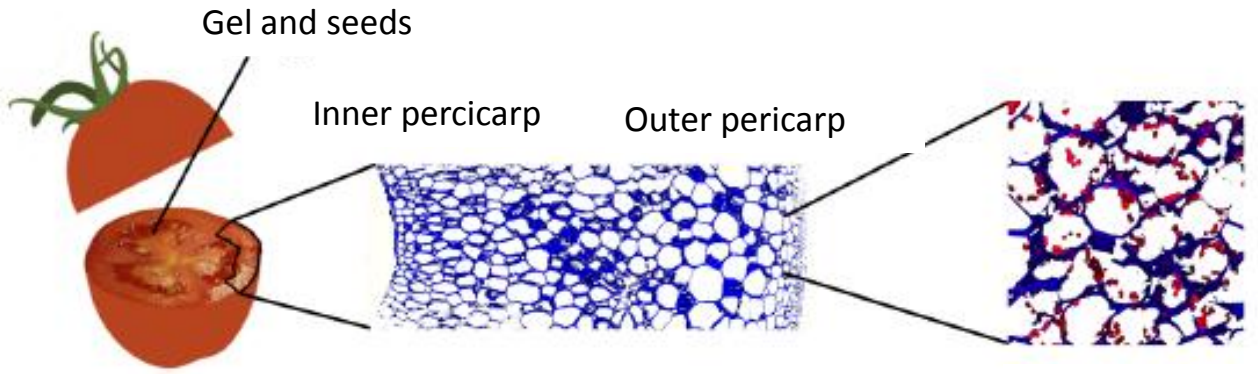


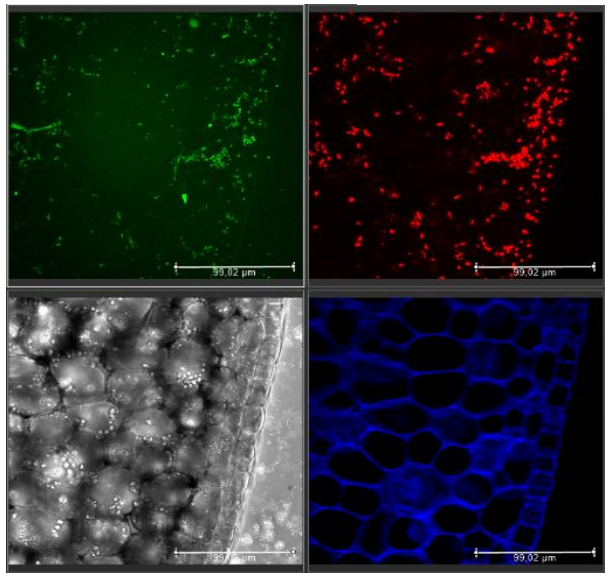
Is chlorophyll concentration a good proxy of chloroplasts presence?

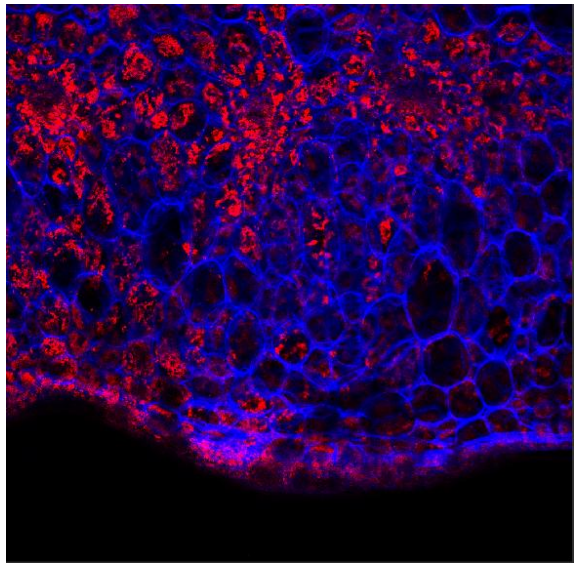
- **What kind of relationship between chloroplast presence and chlorophyll?**
- Can we predict carotenoids based on this relationship?

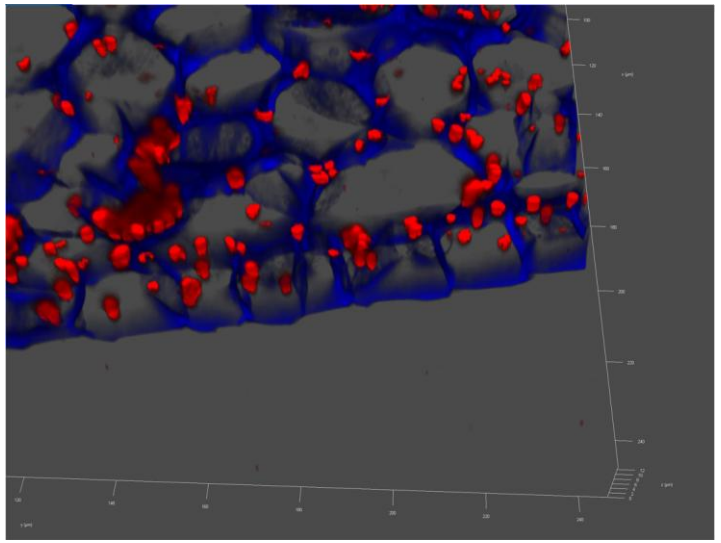
Develop a process-based model to link chlorophyll accumulation and carotenoids metabolism

Confocal microscopy





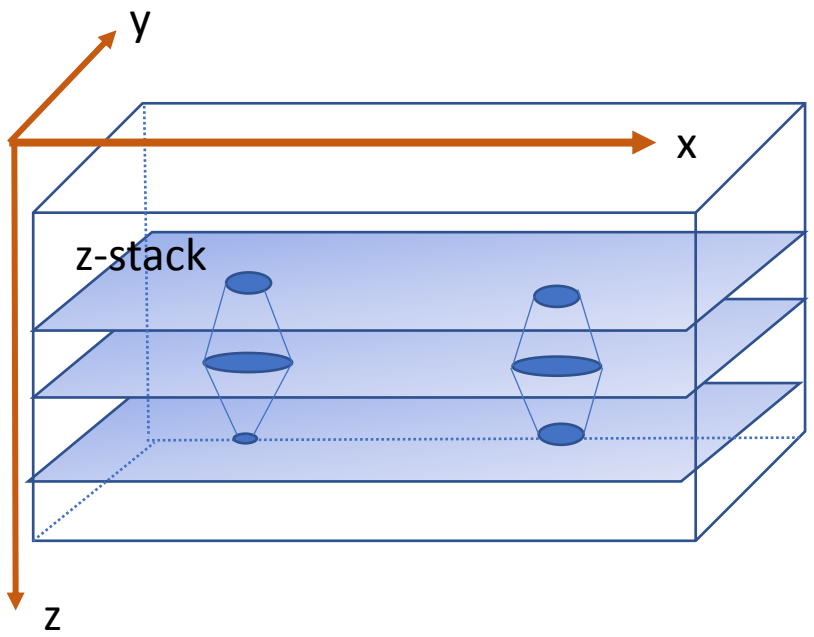


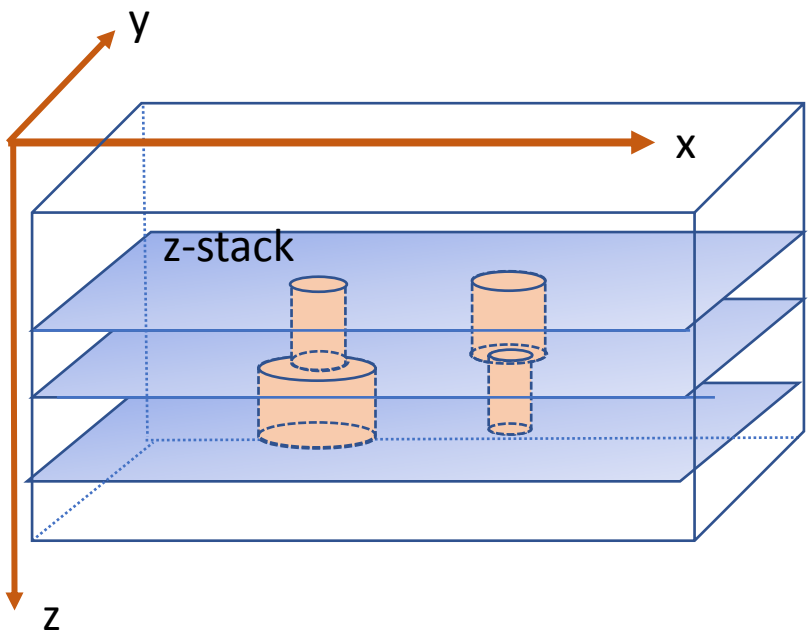


Images from INRAe confocal microscope LASx software

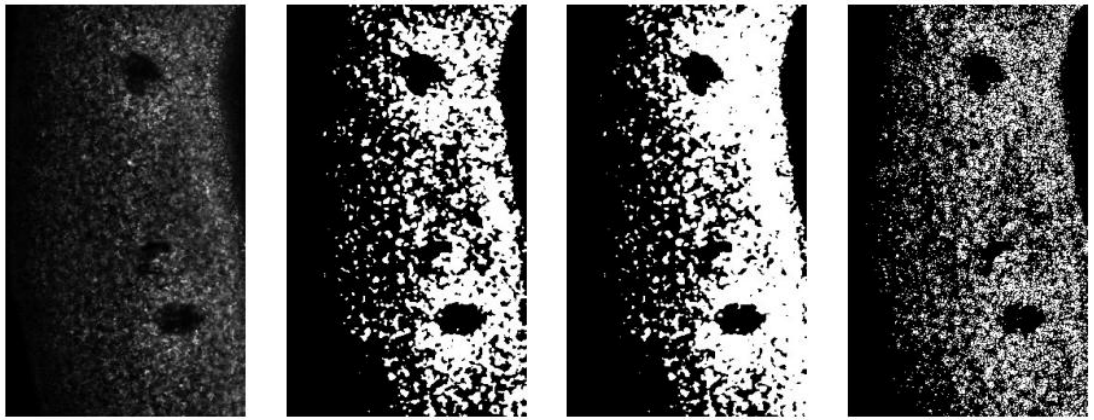
Computing the volume ratio

Volume Chloroplasts in sample : Volume of sample =
= Volume of Chloroplasts : Volume of the fruit



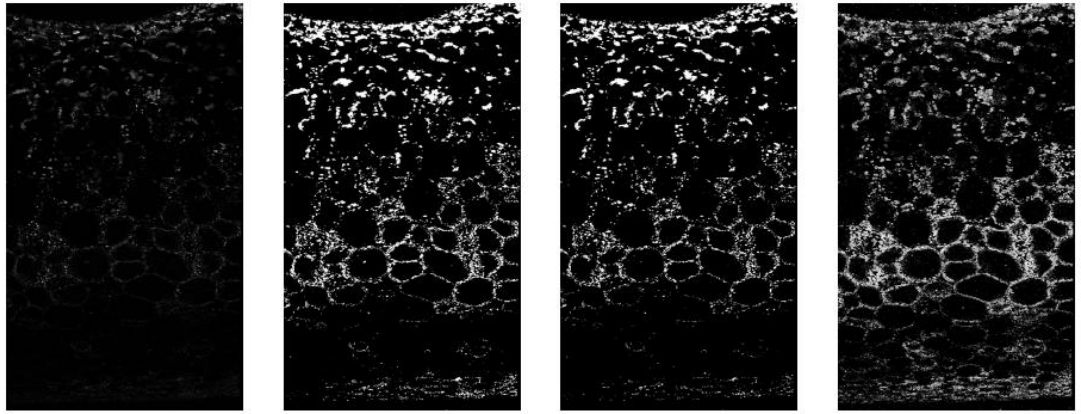

y
x
z-stack
z

Computing the volume ratio



(a) Image originale (b) Méthode 1 (c) Méthode 2 (d) Méthode 3

FIGURE 10 – Exemple de Segmentation par les trois méthodes : Stade 5 DPA



(a) Image originale (b) Méthode 1 (c) Méthode 2 (d) Méthode 3

FIGURE 12 – Exemple de Segmentation par les trois méthodes : Stade 37 DPA

Methods

1 2 3

Gaussian filter

1 3

Adaptive equalizer of histogram (CLAHE) for improving contrast

2

Gamma adjustment for improving contrast

3

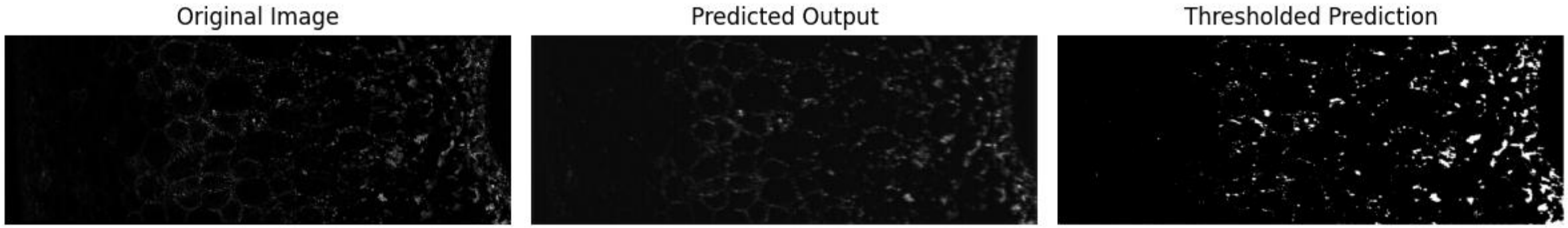
Laplacian filter to highlight contours

1 2 3

Otsu segmentation

Computing the volume ratio

U-Net algorithm → convolutional neural network



- The algorithm was trained by the best images obtained with the 3 methods
- The algorithm distinguishes chloroplasts to other fluorescent points
- We can estimate the volume

- Disadvantage: we do not have a certain “true” image to use to train the algorithm

Breniere PhD. 2024

Confronting the volume to the biochemical measurements

Breniere PhD. 2024