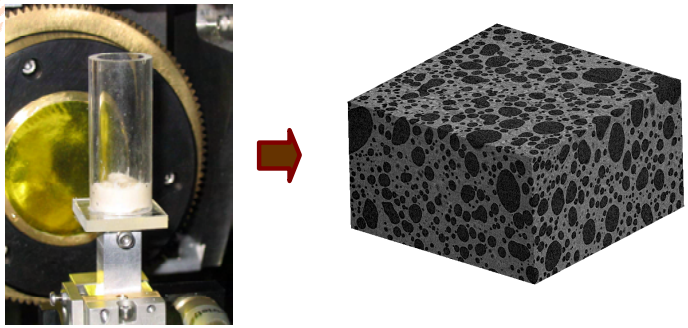

Bread crumb : a bubble story investigated by X-ray tomography

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Food

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Bread crumb : a bubble story investigated by X-ray tomography

A better knowledge of the phenomena governing the **development and setting of crumb structure** in viscous medium requires an accurate mapping of the **cellular structure set up**.

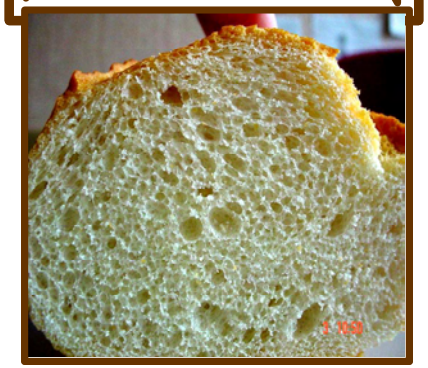
X-ray tomography is a fast, 3D, non invasive technique which appears to be well suited to overcome difficulties encountered with more classical imaging techniques.

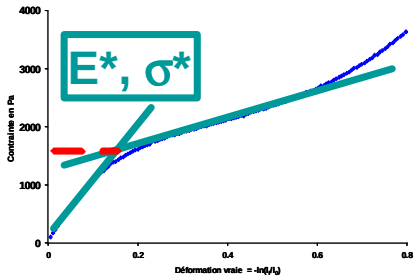
Wheat flour dough, which expands by a volumic factor of 3 during proofing and 1.3 during baking offers a good opportunity for such a study.




Investigating the link between physical properties and mouthfeel

Processing ↔ **Structure** ↔ **Mechanical properties** ↔ **Sensory properties**





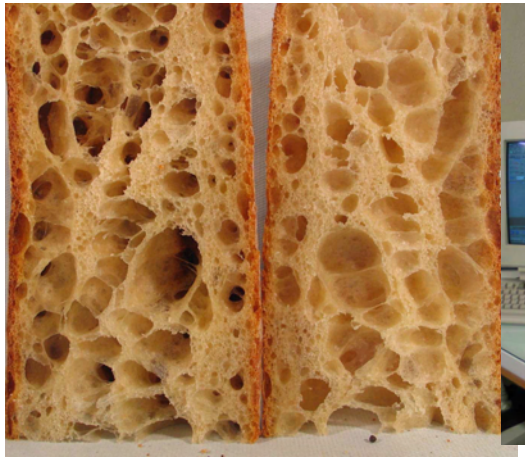
☹ ☺

Soft

Crispy

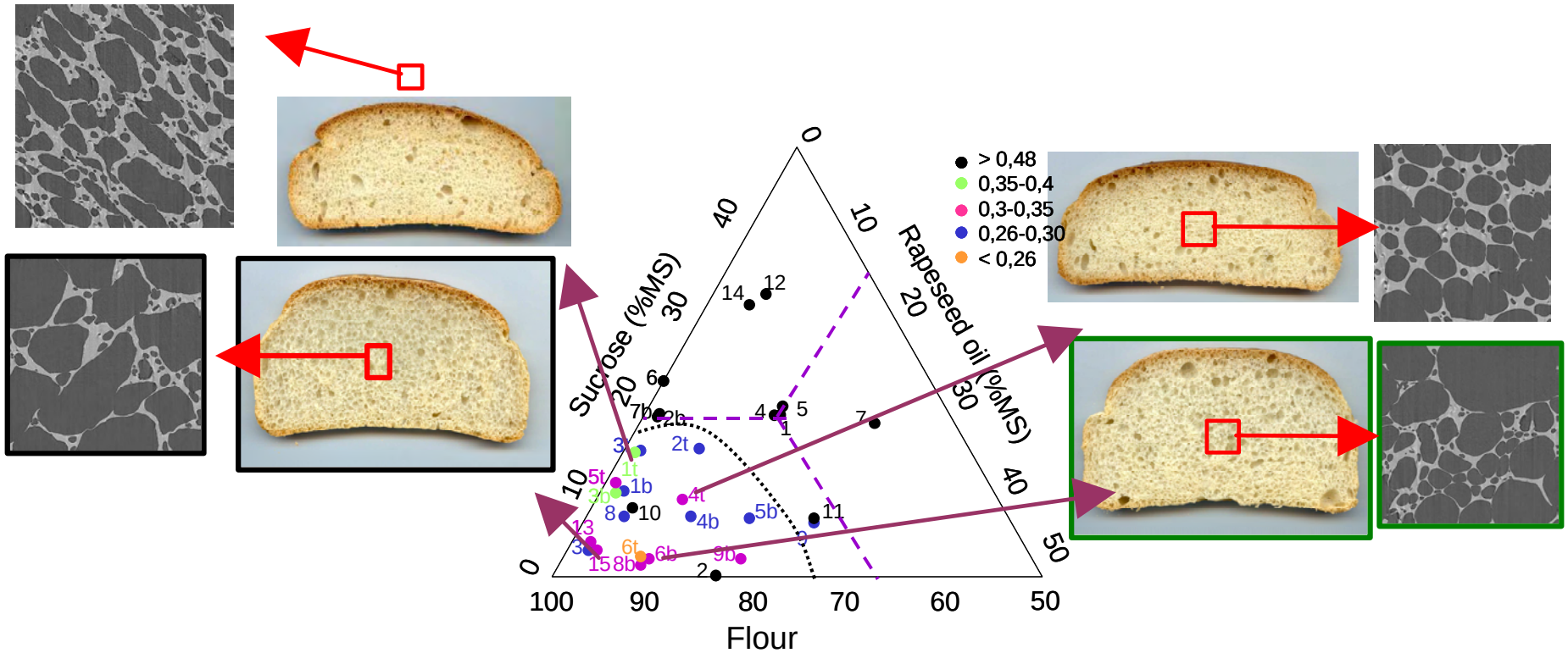
Airy

…



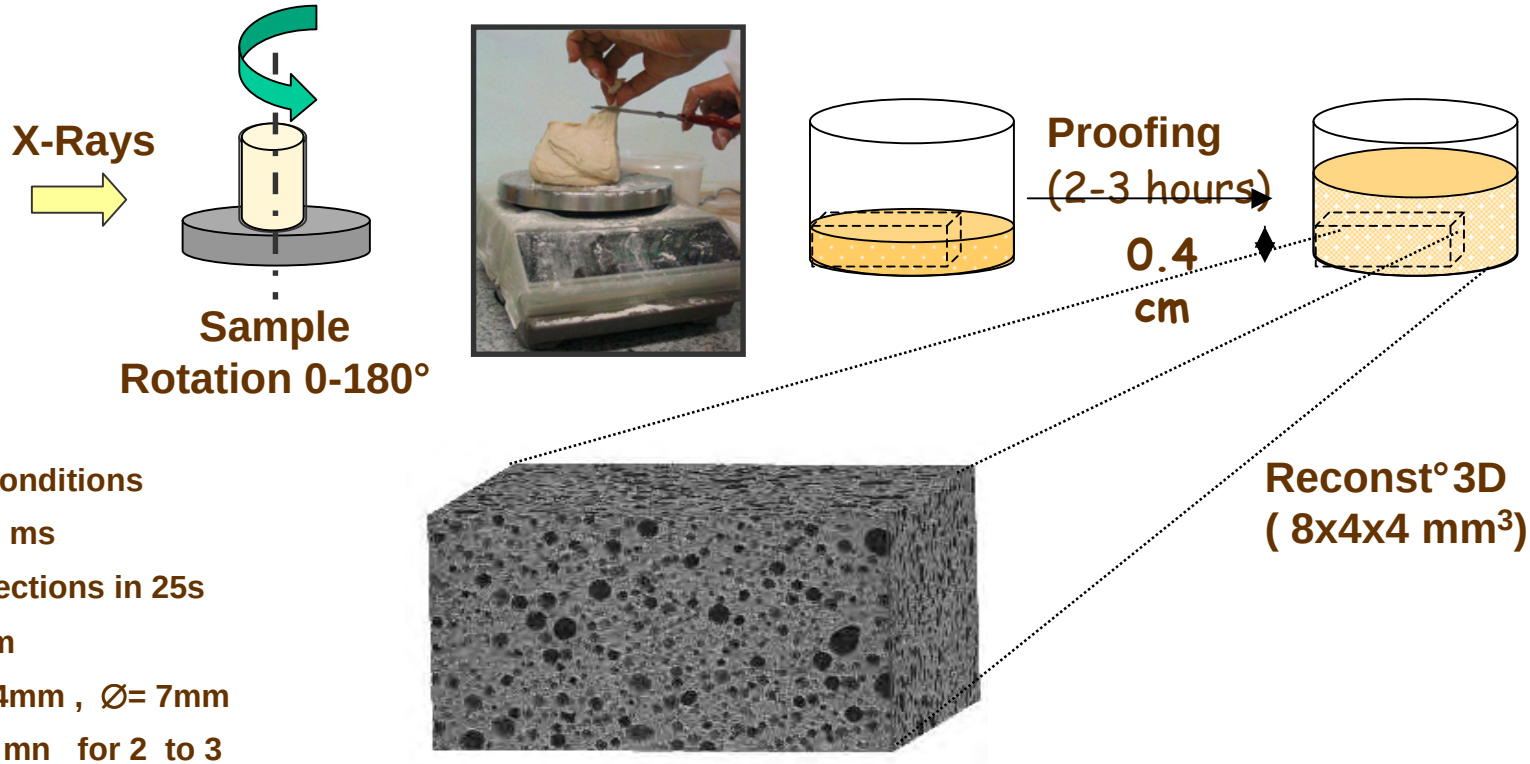
Materials

Different doughs (food foams) of selected compositions (flour, water, yeast, sugar, oil) have been baked for close density values.



ESRF : European Synchrotron Radiation Facility Grenoble, X Ray Tomography 3D

1) Proofing

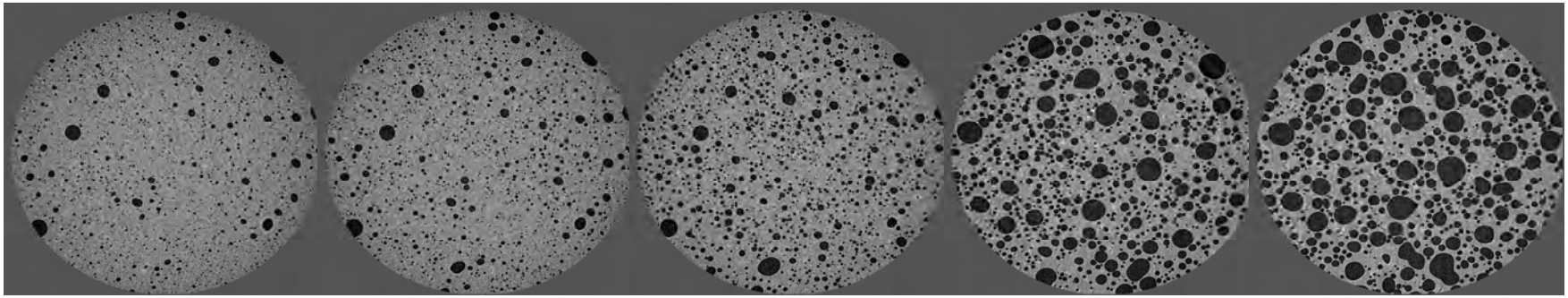


Operating Conditions

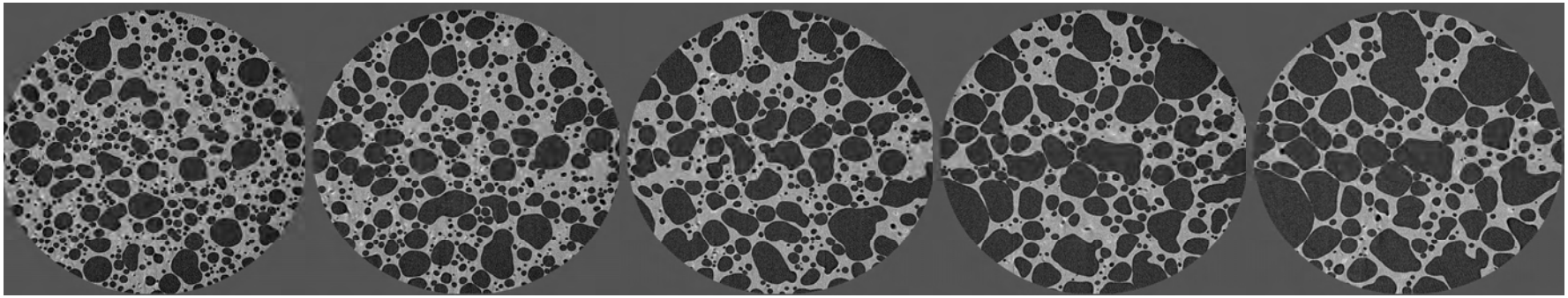
- 1 projection for 30 ms
- 1 scan of 400 projections in 25s
- Resolution = 15 µm
- Sample size : h= 4mm , ∅= 7mm
- 1 scan every 5/10 mn for 2 to 3 hours

3D Image analysis (granulometry & labelisation)

Gradual development of crumb porosity during proofing



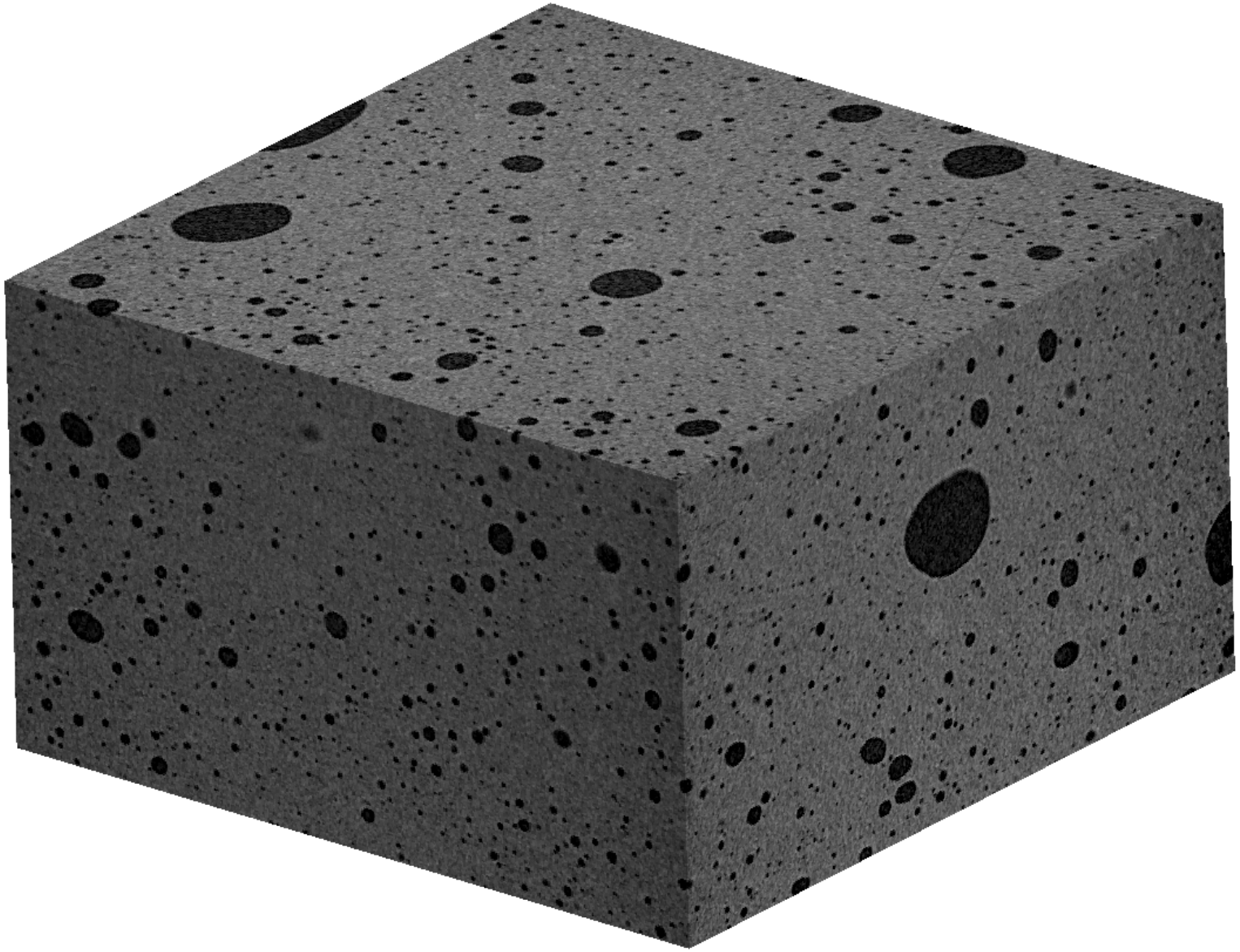
T 0 | + 20mn | + 40mn | + 60mn | + 80mn



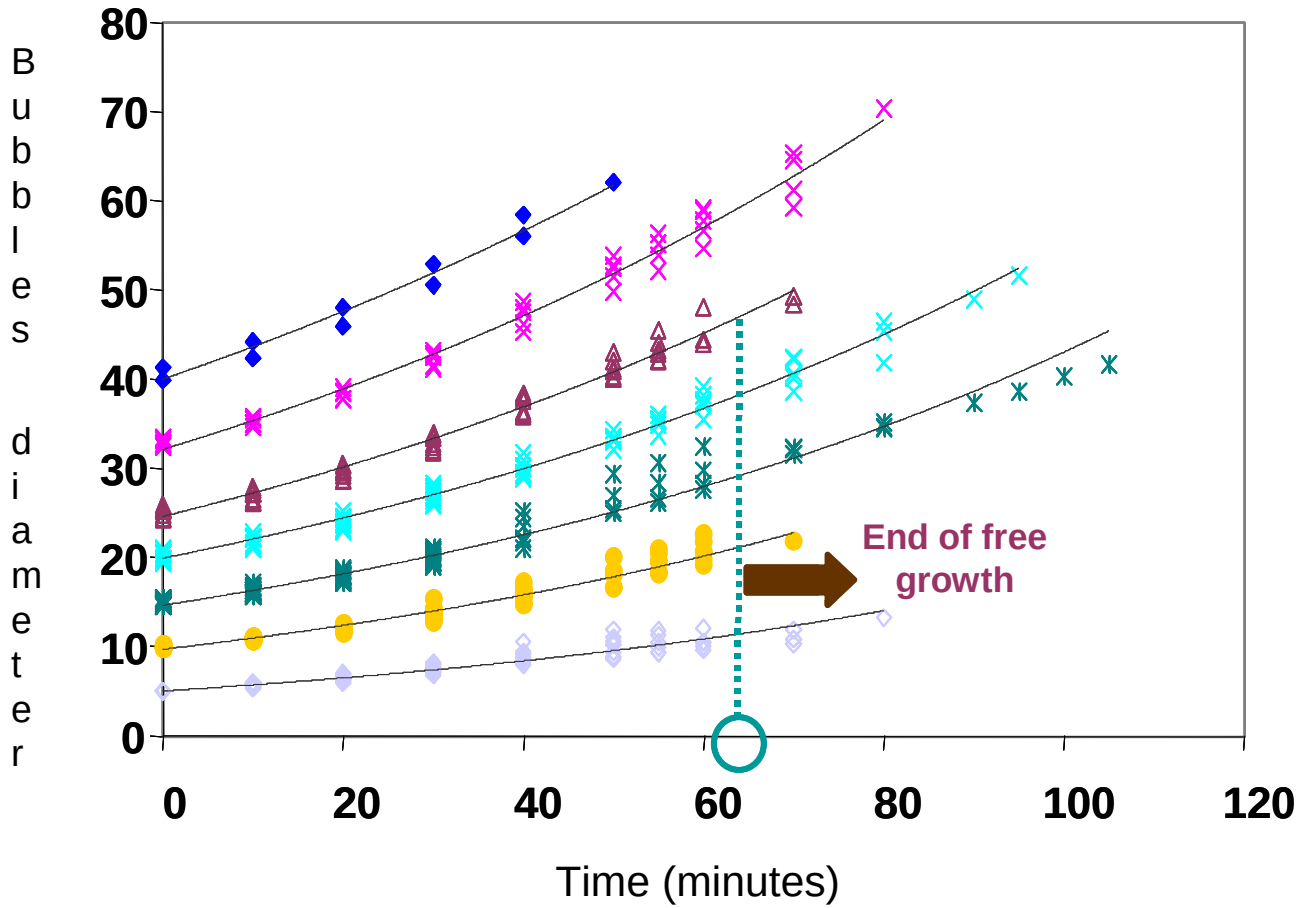
+ 90mn | + 110mn | + 130mn | + 150mn | + 170mn

Final crumb texture is highly dependant on yeast concentration, proofing conditions and heating set up.

Crumb motion picture

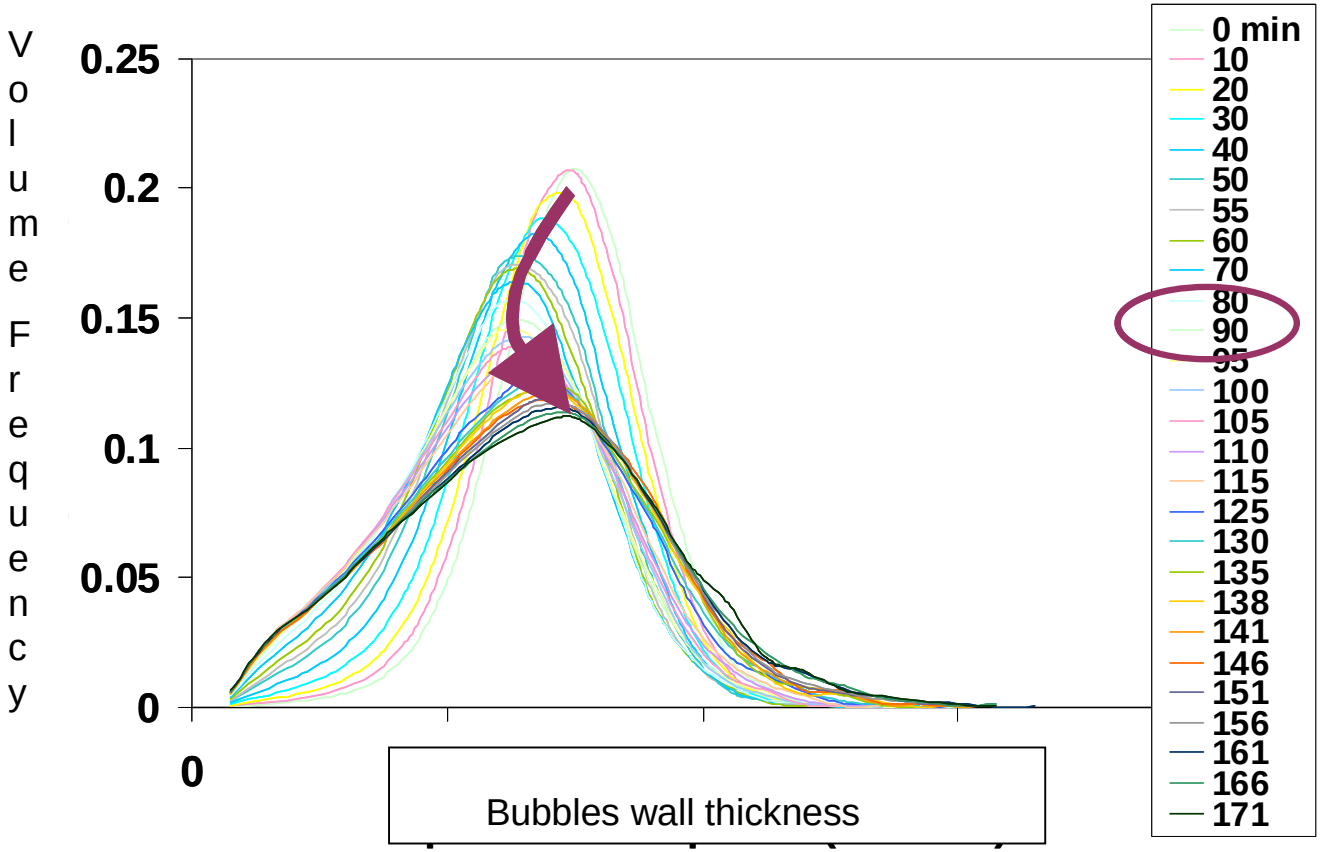


$t < t_1$ free bubble growth: measuring diameter



Constant strain rate

Evolution of wall thickness distribution

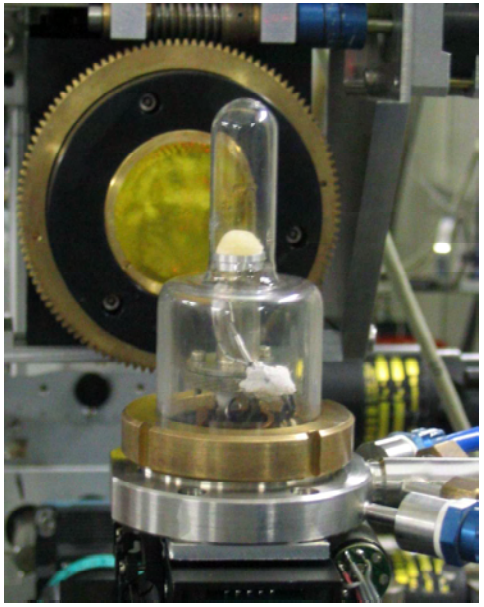


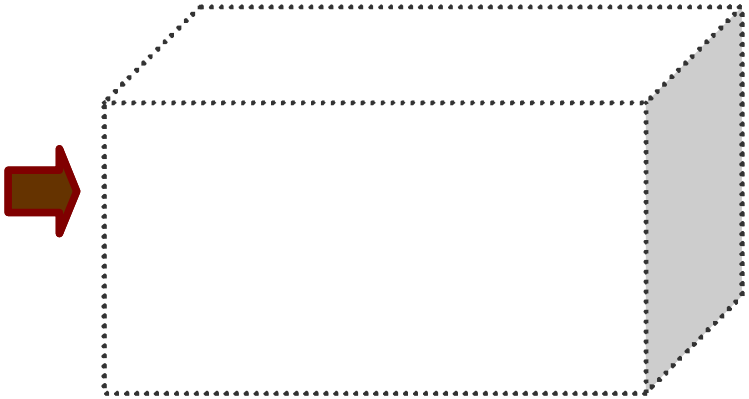
Wall thickness evolutions and connectivity determine a 2nd critical time t_2 of cell structure coarsening, by coalescence.

$t < t_1$	**free growth**
$t_1 < t < t_2$	**bubbles interactions**
$t > t_2$	**coalescence prevails**

X Ray Tomography 3D (ESRF, BM05)

2) Baking

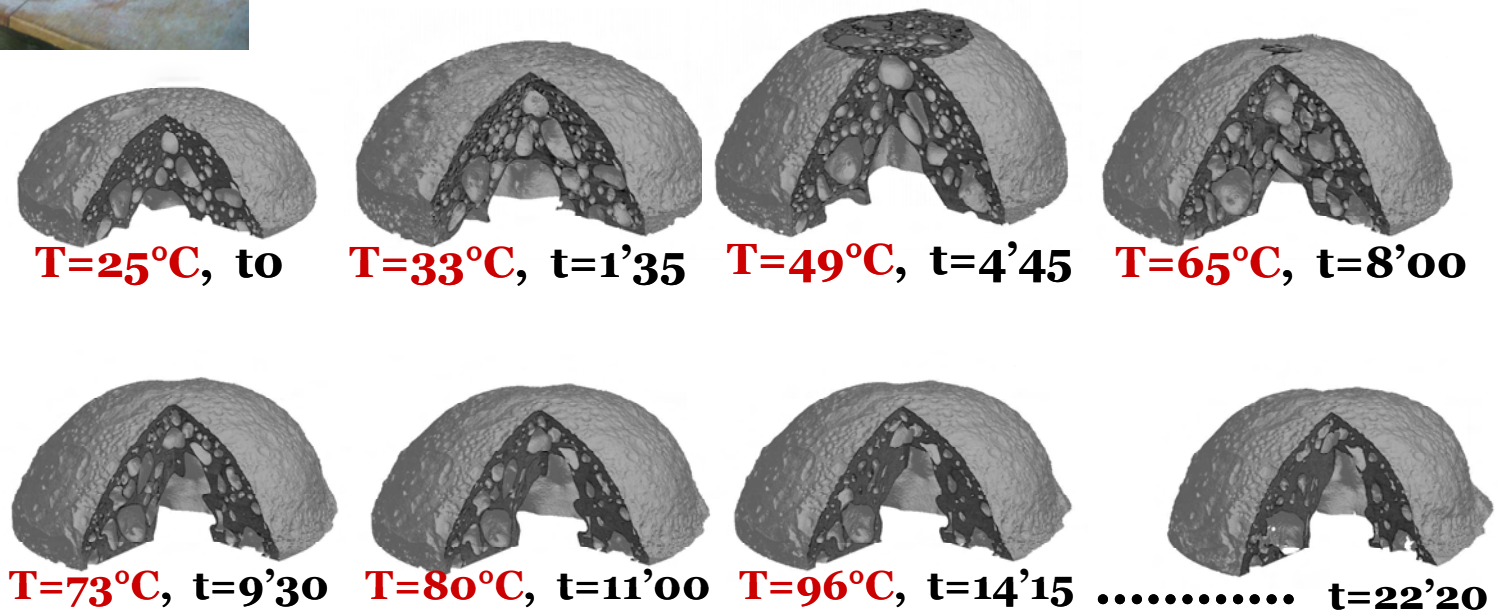




Operating Conditions

- **1 scan every 3 minutes - Baking: heating at 5℃/ mn**

Further results on baking

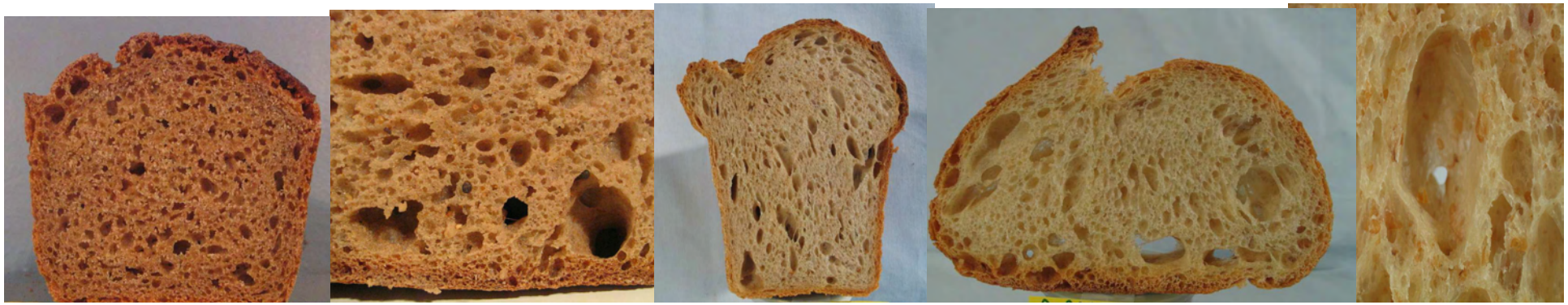


Maximum expansion is reached ≈ 50℃ and setting occurs ≈ 75℃, in agreement with main biopolymer state changes (dough to crumb transition).

With these conditions, during baking, cellular structure undergoes little changes at millimetric scale.

Conclusions

- X-ray tomography coupled with 3D image analysis provide quantitative information, by determining critical times for bubble growth and coalescence.
- New insights on the role of surface active components in texture of baked products can be suggested.
- Breadmaking is an amazing way to create such different crumb structures.



Perspectives :

Numerical computation of E* (FEM-3D)

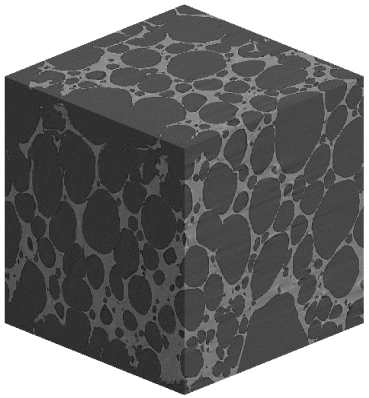
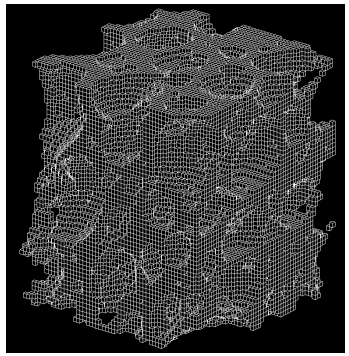
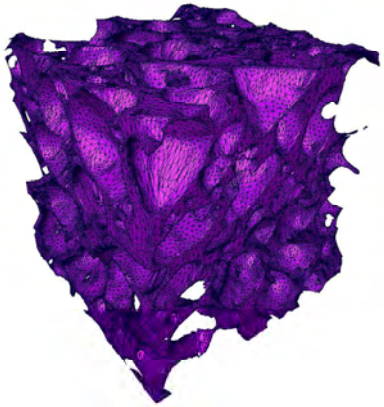


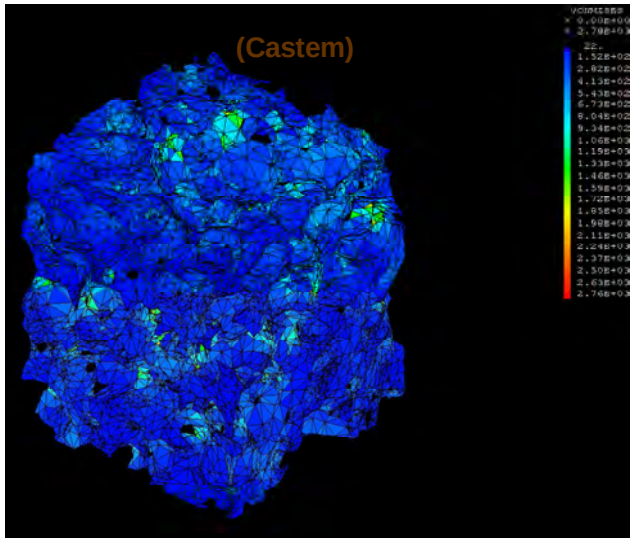
Image 3D



Meshing



compression test simulation



3D- images can be used for validation of **numerical models** of foaming and mechanical properties towards the aided **design of cellular structures**.

Thank you for your attention

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