Modeling Water Immersion Thawing of Raw Tuna Fishes

S. Curet[1], O. Rouaud[1], J.M. Bonny[2], L. Mazuel[2]
1. ONIRIS, CNRS, GEPEA, UMR 6144, site de la Géraudière, Nantes, F-44322, France
2. IVIA – IMoST UMR1240 INSERM/UCA, 58 rue Montalembert, Clermont-ferrand, F-63000, France

COMSOL CONFERENCE 2018 LAUSANNE

INTRODUCTION:

In the canning industry dedicated to fish processing, thawing of large tuna pieces with air or water immersion are common unit operations. In this work, COMSOL Multiphysics® is used to model these thawing processes for raw tuna fishes with different sizes. The objective is to predict accurately the thawing time in order to optimize the fluid and energy consumption of the process.

COMPUTATIONAL METHODS:

For modelling purpose, MRI scanning techniques (GE MR750) from axial plan is used to reconstruct the real geometry of a 1.5m length tuna (figure 1).

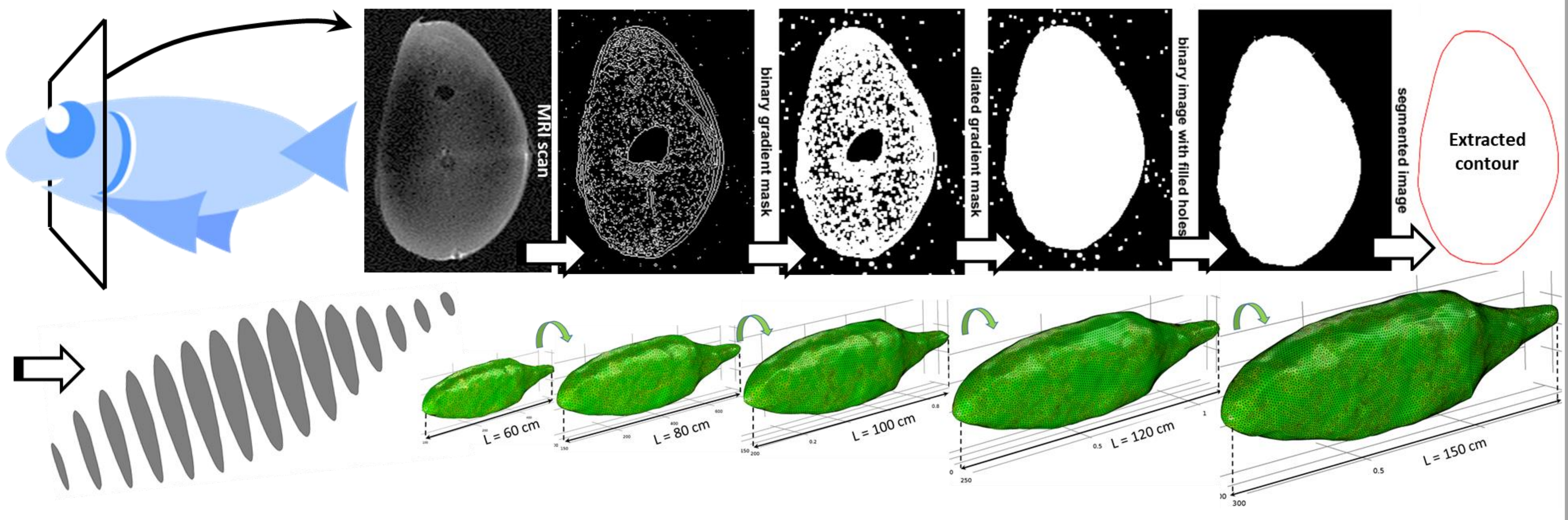


Figure 1. 3D reconstruction of the real fish geometry

The geometry was then imported into COMSOL Multiphysics® as a STereoLithography file.

The general governing equation for the thawing process is the transient heat equation involving phase change (apparent specific heat approach):

$$\rho(T)Cp_{app}(T)\ \frac{\partial T}{\partial t} = \nabla.(\lambda(T)\nabla T)$$

Convective flux is considered at the external surface of the fish surrounded by a medium at temperature T_{ext} (air or water) :

$$-\vec{n}(-\lambda\nabla T) = -h(T - T_{ext})$$

The entire product is assumed to have a uniform initial temperature T_0 = -25 °C.

Thermophysical properties of raw tuna (loin) were determined as a function of temperature.

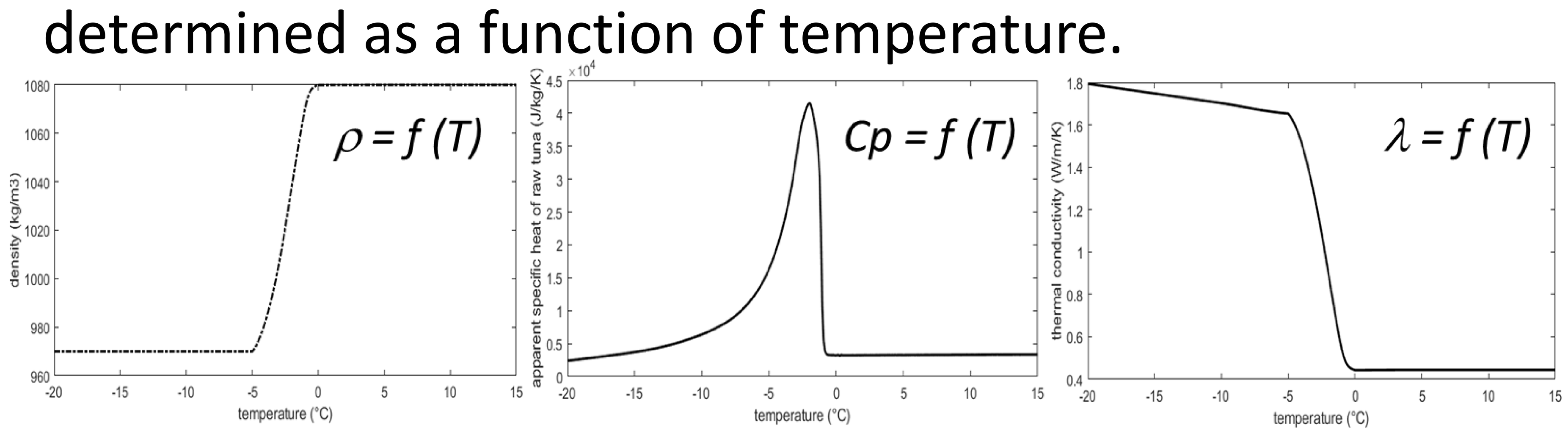


Figure 2. Thermophysical properties of raw tuna fish (loin muscle) as a function of temperature from -20 °C to +15 °C

RESULTS: For each different sized-fish, temperatures were tracked at three locations within the product : T_1 close to the tail, T_2 at the core, T_3 close to the head (figure 3 & 4).

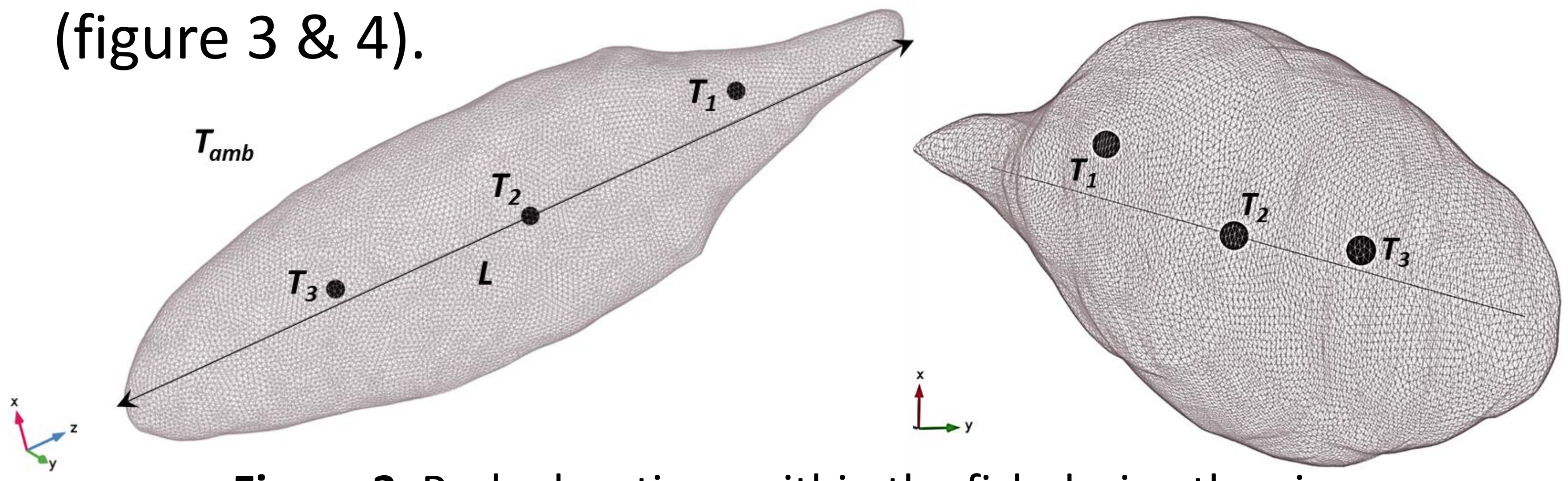


Figure 3. Probe locations within the fish during thawing

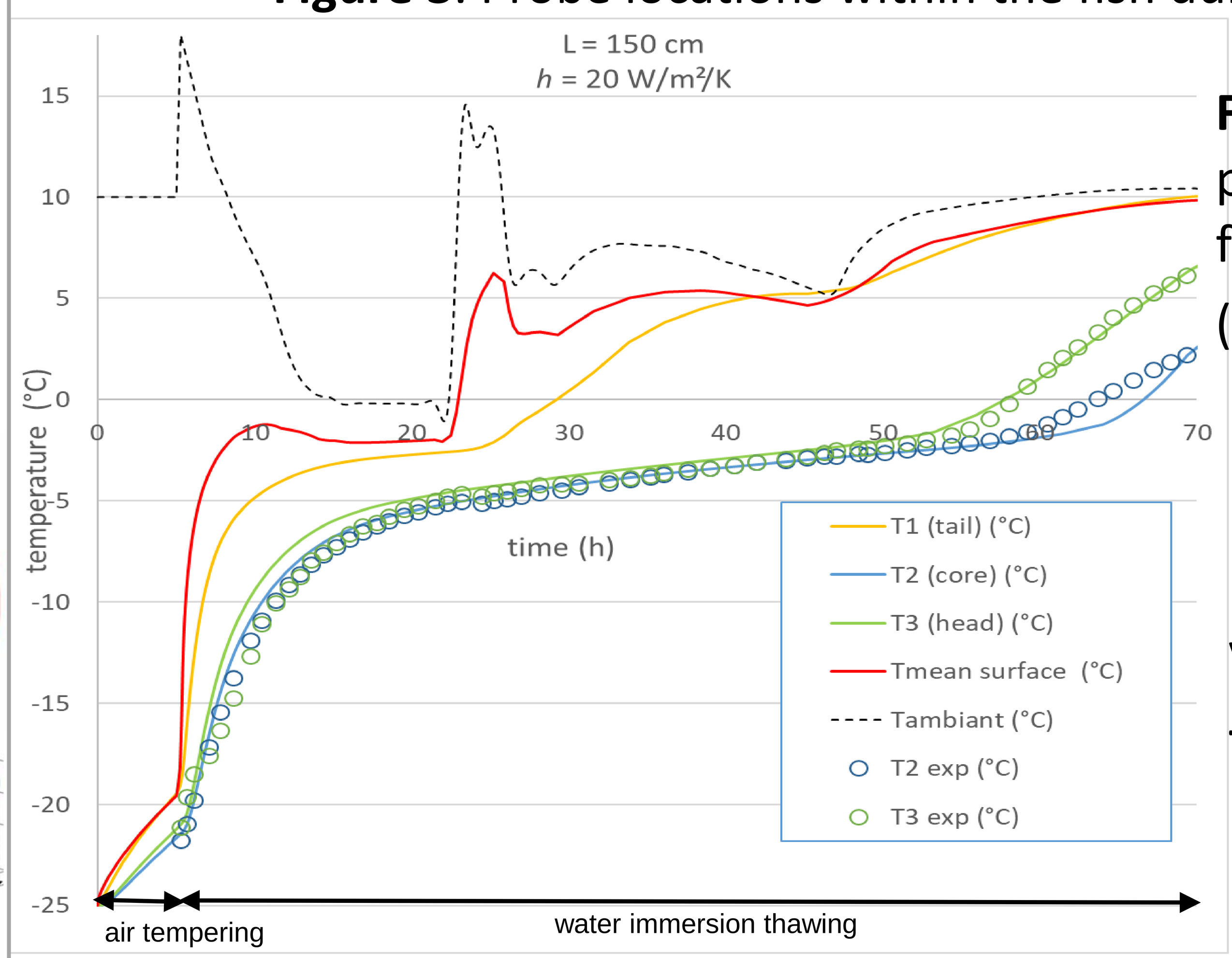


Figure 4. Temperature profiles during thawing for 1.5m length tuna (h_{water} = 20 W.m^{-2}.K^{-1})

➔Model validation during thawing for a 1.5m length tuna

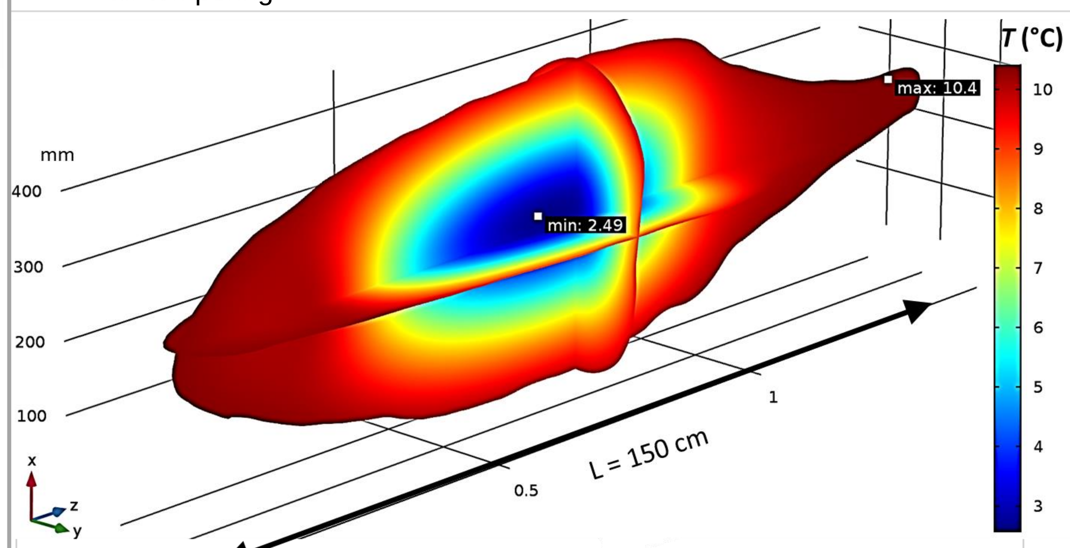
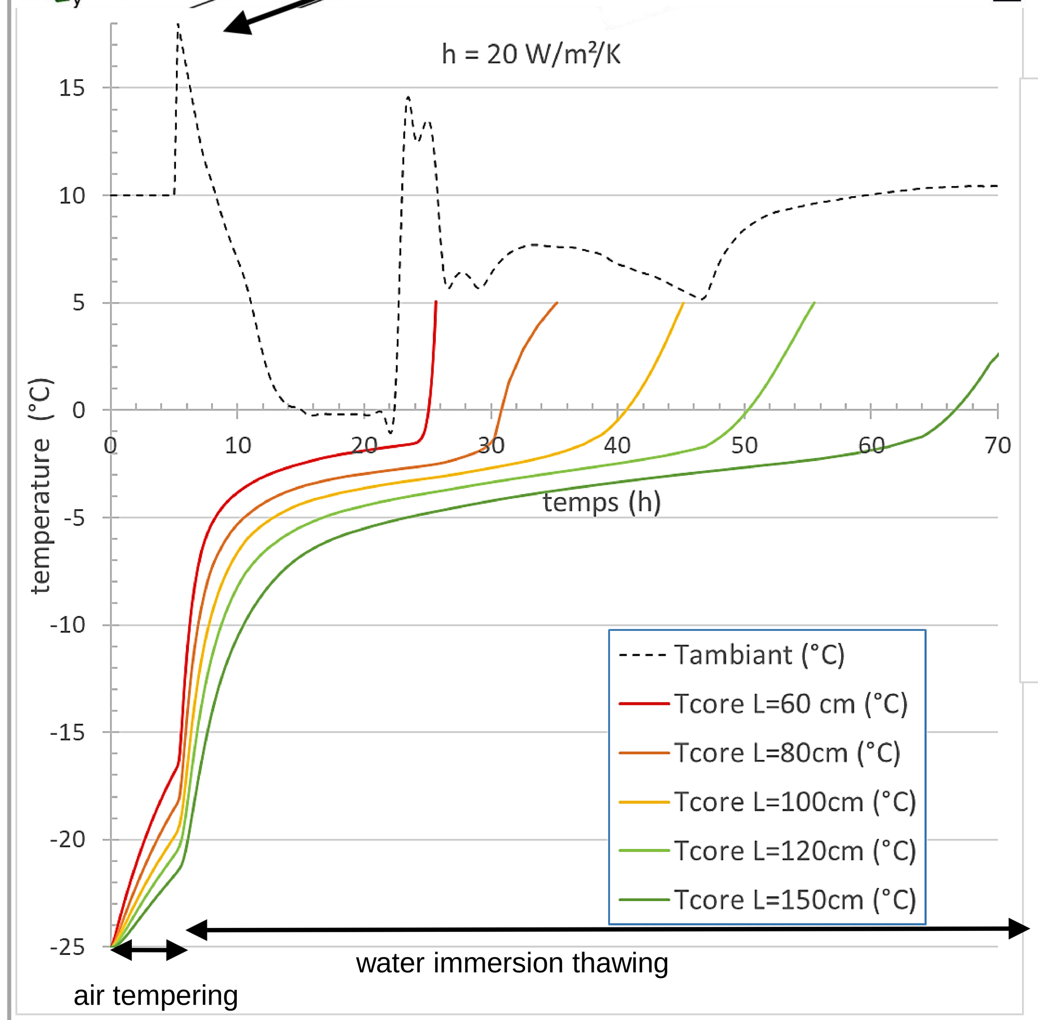
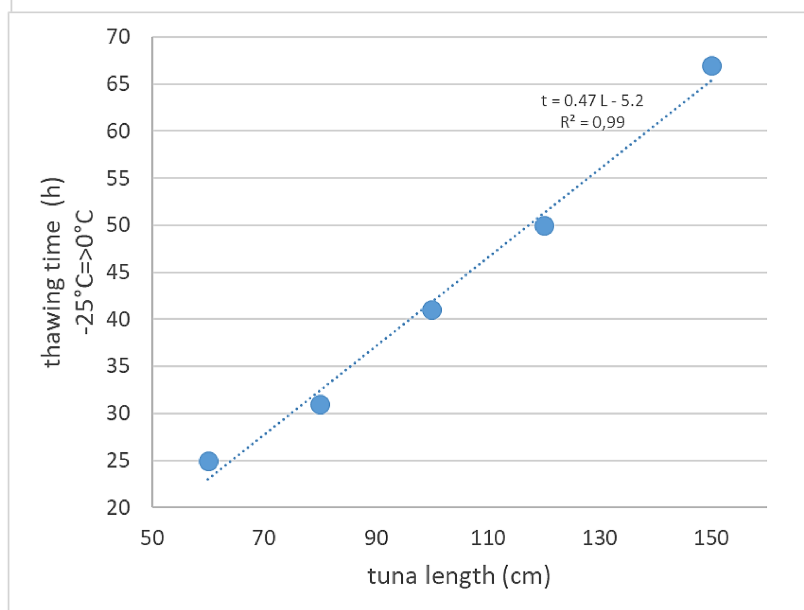


Figure 5. Temperature mapping at the end of thawing (t =70h) for 1.5m length tuna

➔$\Delta T_{min\text{-}max}$ = 8°C





➔Linear increase of thawing time as a function of fish length

Figure 6. Temperature profiles and thawing time as a function of fish length

CONCLUSIONS:

- Good prediction of inner temperatures of the fish during the process (tempering + thawing)
- Extrapolation of results for different sized-products
- Future directions of the work will include the influence of the external temperature evolution on the thawing time prediction.