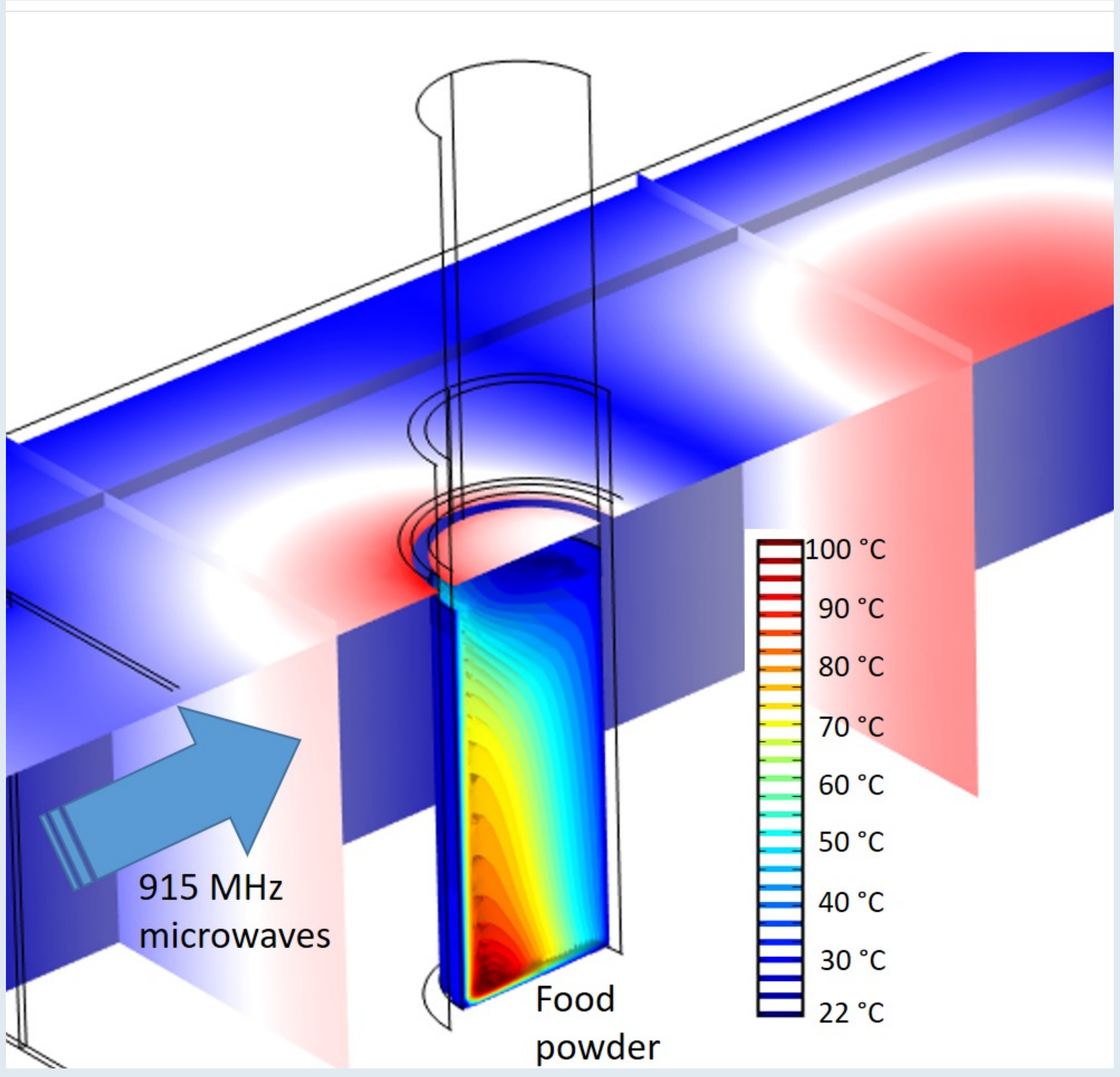

Influence of Dielectric Constant on Low-Moisture Food Pasteurization in a 915MHz Single Mode Microwave Cavity

Microwave heating of dry products is a complex task due to their low dielectric properties. Simulation highlights the problems inherent in these processes.

Olivier Rouaud[a], Ana-Caroline C. Frabetti[b], Tristan Garnault[b], Hugo Curto[b], Alexandre Thillier[b], Lionel Boillereaux[a], Sebastien Curet[a]

[a] Oniris, Nantes Université, CNRS, GEPEA, Nantes, France.
[b] SAIREM, Lyon, France.

Abstract

The contamination of food products with low water contents is a safety issue that cannot be disregarded due to potential contamination by micro-organisms that are heat-resistant. In some cases, conventional pasteurization techniques (steam or hot air) may prove ineffective (due to low thermal conductivity of food). As an alternative, 915 MHz microwaves can be used as an efficient heating method. In this study, numerical simulations using COMSOL Multiphysics® were carried out. Radiofrequency and Heat Transfer modules were used to model the electric field distribution and local temperatures within 80 g of paprika powder filled in a quartz tube. Simulations were carried out with several pairs of dielectric properties values (constant ε′ and linear relationships ε′′=*f*(T) for powder). Results show that uncertainties on the dielectric constant give rise to greater temperature differences than those in the loss factor. This numerical study highlights the importance in measuring accurately the dielectric properties of low moisture foods for accurate temperature predictions.

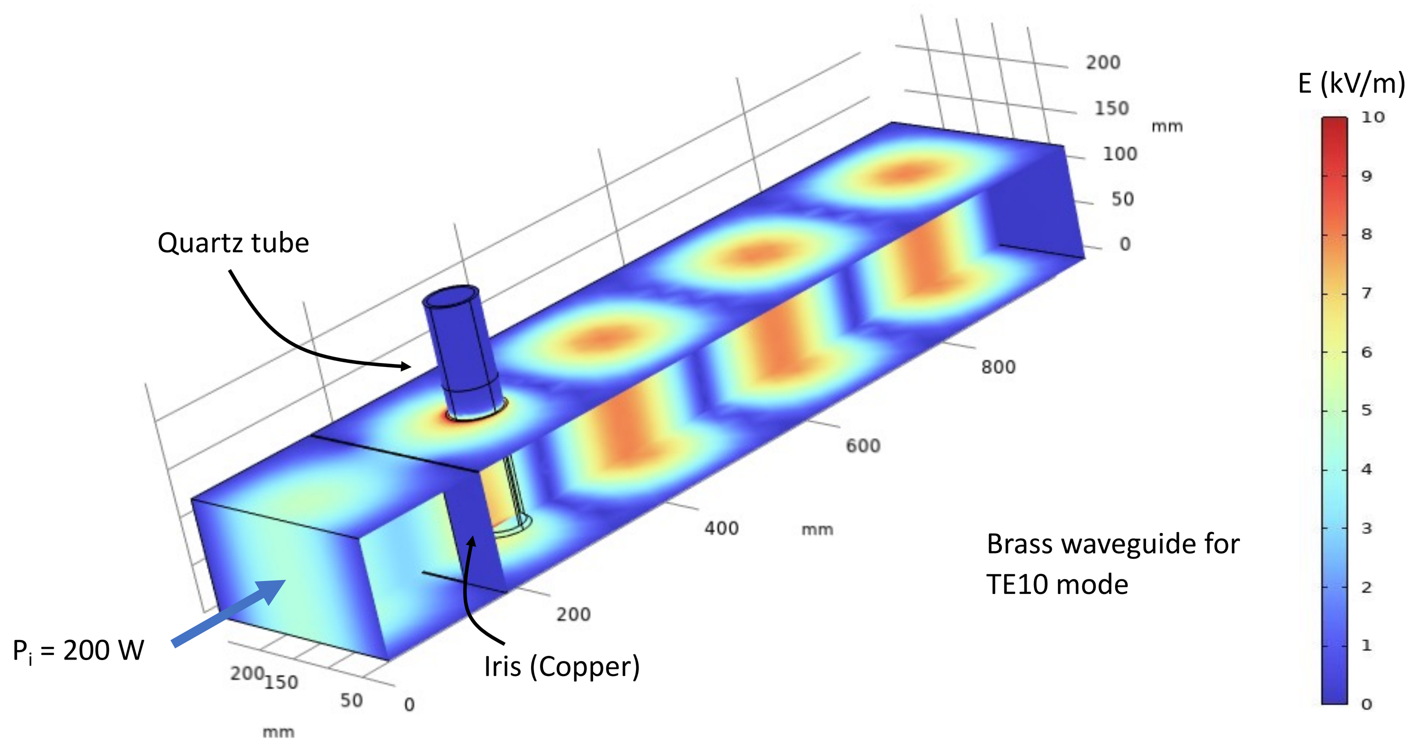

FIGURE 1. Geometry and EM Field for the microwave applicator operating at 915 MHz.

Methodology

- The COMSOL® Multiphysics numerical model includes the modelling of a 915 MHz single-mode microwave applicator with both iris and sliding short circuit for impedance matching.
- 80 g of paprika powder is heated in a quartz tube (46 mm inner diameter, 4 mm thickness and 240 mm height).
- The thermophysical physical properties of paprika were measured experimentally (density, specific heat and thermal conductivity)
- Dielectric properties of paprika powder: $\begin{cases} \varepsilon_r' \in [1.53 - 1.96] & (1) \\ \varepsilon_r'' = a\,T + b & (2) \end{cases}$

with a = 0.01275 K^{-1} and b = -3.538 or -3.498 for 293 K < T < 393 K.

Results

Experimental uncertainties on the relative dielectric constant of paprika powder are used as input for the numerical modelling (*dielectric properties were measured from open-ended coaxial probe and resonant cavity techniques*[1]).

Relative dielectric loss factor cannot be considered as constant following temperature evolution (Fig2a).

➔ Uncertainties for ε_r' measurements give rise to greater temperature differences than those by considering dielectric loss factor variations (Fig 2b).

➔ Accurate estimation of dielectric properties could be carried out by inverse method (work in progress)

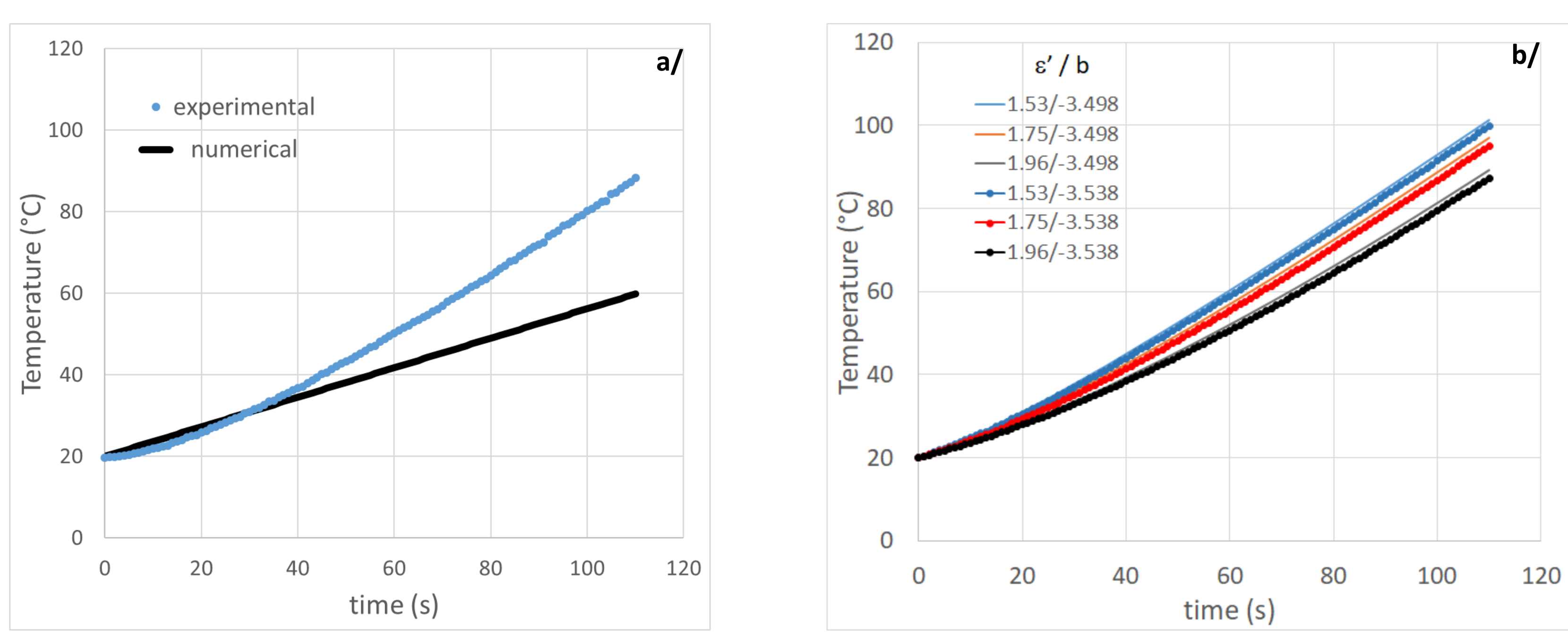

FIGURE 2. Temperature rise at the centre of the paprika powder as a function of several dielectric properties: a/ constant value of ε_r'' and b/ according to equations *(1)* and *(2).*

REFERENCES

[1] Frabetti, A.C.C., Garnault, T., Curto, H., Thillier A., Boillereaux, L., Rouaud O., Curet, S. Dielectric properties of low moisture foods measured by open-ended coaxial probe and cavity perturbation technique. Eur Food Res Technol 249, 2861–2873 (2023). https://doi.org/10.1007/s00217-023-04333-7

Oniris VetAgroBio Nantes ÉCOLE NATIONALE
GEPEA UMR CNRS 6144
sairem microwave & radio frequency