Numerical design and use of a portable probe for the identification of mechanical and mass transport properties within fermenting food matrices: application to semi-hard cheese

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The monitoring of semi-hard cheese ripening is empirically based on manual inspection of the cheese blocks. Cheese manufacturers are demanding for new technologies to be used in ripening cellar and making it possible to follow the evolution of physico-chemical parameters for better following the ripening process. This study presents the multiphysic computer assisted design and experimental validation of a portable probe able to measure locally, at its tip: the dynamic viscosity, Henry's constant, the CO2 concentration, the CO2 diffusivity and production rate within a couple of hours with the use of only one probe.
The probe consists of a pressure sensor within a sealed cylinder that is plunged in a few millimeters of the food matrix. The cylinder is then swept using either CO2 or N2 and one or two impulses of pressure are generated. The pressure then decreases as a function of the ability of the matrix to absorb/transport the gas in a dissolved form and its ability to deform. Miscellaneous shapes of the tip of the probe were numerically investigated and optimized using a model previously validated (Laridon, et al., 2020).
The probe was experimentally validated on distilled water and a reference tar for the viscosity.
CO2 Henry's constant was identified using two pressure impulses. The measure gave a value of 3.5×10-4 mol.m-3.Pa-1 for a value of 3.8×10-4 mol.m-3.Pa-1 for pure water (Sanders, 2015). The diffusivity of CO2 was then measured at 1.5×10-9 m2.s-1 compared to a mean value of 1.8×10-9 m2.s-1 (Chaix, E, 2014). The viscosity of a reference tar was identified with 8% uncertainty at 20°C.
On semi-hard cheese, once Henry's constant was identified at 5×10-4 mol.m-3.Pa-1 the concentration of the CO2 solubilized in the core of a semi-hard cheese was measured at 25-26 mol.m-3. The diffusivity of CO2 was measured at 3.8×10-10 m2.s-1 for the semi-hard cheese under study.
Acceptable agreements were found between the measurements of the CO2 transport properties in both water and cheese as well as for the measurement of viscosities. Three improved prototypes are now tested in industrial conditions.