



**HAL**  
open science

## Evaluation of O<sub>2</sub> transfer in the food/packaging system for a better shelf life evaluation of modified atmosphere food packaging.

Estelle Chaix, Valérie Guillard

### ► To cite this version:

Estelle Chaix, Valérie Guillard. Evaluation of O<sub>2</sub> transfer in the food/packaging system for a better shelf life evaluation of modified atmosphere food packaging.. 2012 EFFoST Annual Meeting - A Lunch Box for Tomorrow: An interactive combination of integrated analysis and specialized knowledge of food, Nov 2012, Montpellier, France. pp.2. hal-01601670

**HAL Id: hal-01601670**

**<https://hal.science/hal-01601670v1>**

Submitted on 6 Jun 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/282664387>

# Evaluation of O<sub>2</sub> transfer in the food/packaging system for a better shelf life evaluation of modified atmosphere food...

Conference Paper · November 2012

CITATIONS

0

READS

17

2 authors:



**Estelle Chaix**

French National Institute for Agricultural Res...

17 PUBLICATIONS 54 CITATIONS

SEE PROFILE



**Valérie Guillard**

Université de Montpellier

109 PUBLICATIONS 1,278 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



EcoBioCap [View project](#)



Information Extraction for Adabidopsis Thaliana [View project](#)



# Evaluation of O<sub>2</sub> transfer in the food/packaging system for a better shelf life evaluation of modified atmosphere food packaging



Estelle CHAIX, Nathalie GONTARD, Valérie GUILLARD

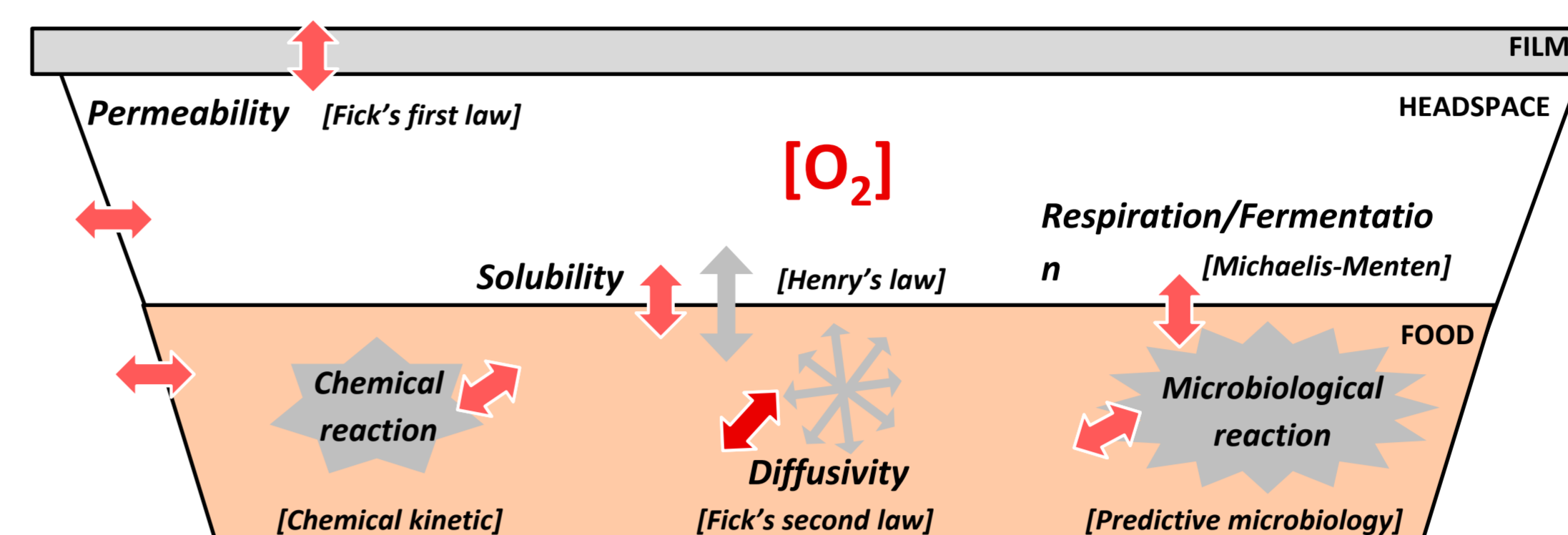
Contact : [estelle.chaix@univ-montp2.fr](mailto:estelle.chaix@univ-montp2.fr) ; [nathalie.gontard@univ-montp2.fr](mailto:nathalie.gontard@univ-montp2.fr) ; [guillard@univ-montp2.fr](mailto:guillard@univ-montp2.fr)

UMR IATE , CC 023, Université Montpellier 2, Place Eugène Bataillon, Montpellier, France

## Context

Modified atmosphere packaging (MAP) relies on **modification of the atmosphere** inside the package in order to **extend food shelf life** by reducing physico-chemical (namely oxidation), microbial and physiological (for respiring foods) degradation rate while limiting the use of preservatives.

MAP **simulating tool** based on the use of mass transfer models concomitantly with predictive microbiology would be the **most appropriate method** to allow a correct design and sizing of modified atmosphere packaging systems. One of the **main bottlenecks** in the evaluation and study of impact of O<sub>2</sub> transfer on microorganism growth is the **quantification of dissolved oxygen in the solid food**.



Headspace gas concentration change during storage due to permeation through the packaging, **gas sorption and diffusion** into food, and **gas consumption** due to chemical and enzymatic reactions and microbial activity. (Fig 1.)

Fig 1. Schematic diagram for oxygen mass transfer and reactions in MAP

Oxygen transfer in food is characterised by a thermodynamic parameter, **solubility**, and a kinetic parameter, **diffusivity**. No data on oxygen diffusivity in non-respiring solid food matrix exists in the scientific literature. The proposed method permits to acquire the value of **oxygen diffusivity in solid matrices**.

## Materials and Methods

### Experimental set-up for monitoring oxygen transfer

- Establish a concentration gradient between the atmosphere and the product (Oxygen adsorption kinetics) (Fig2.)
- Have an appropriate method for monitoring the oxygen transfer (Fig 3.)
- Mathematical modelling and identification of the diffusivity (Fig 4.)

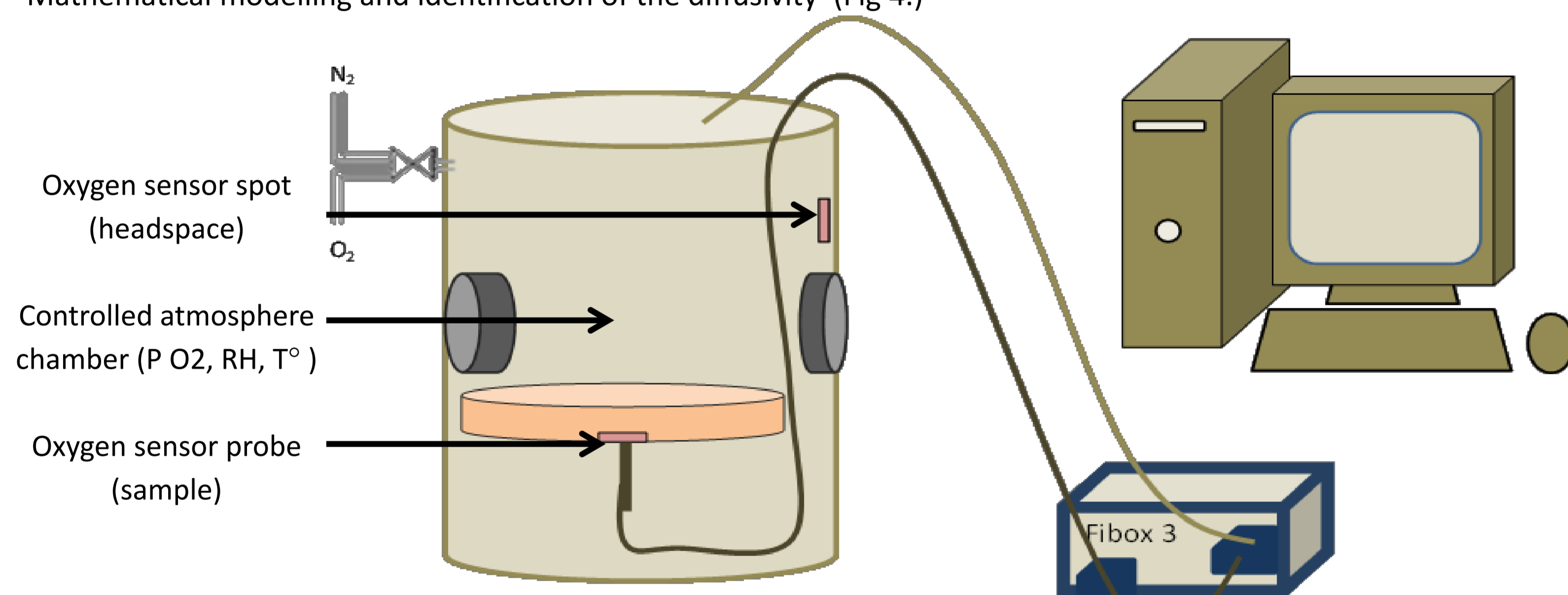


Fig 2. Experimental set up to measure the oxygen diffusivity in solid sample

### Non-invasive and non-destructive optical oxygen sensor:

A **non-invasive and non-destructive** method was used to measure the **oxygen partial pressure** inside a transparent container by monitoring the fluorescence without consumption of oxygen (PSt6 & Fibox 3Presens, Neuburg, Germany).

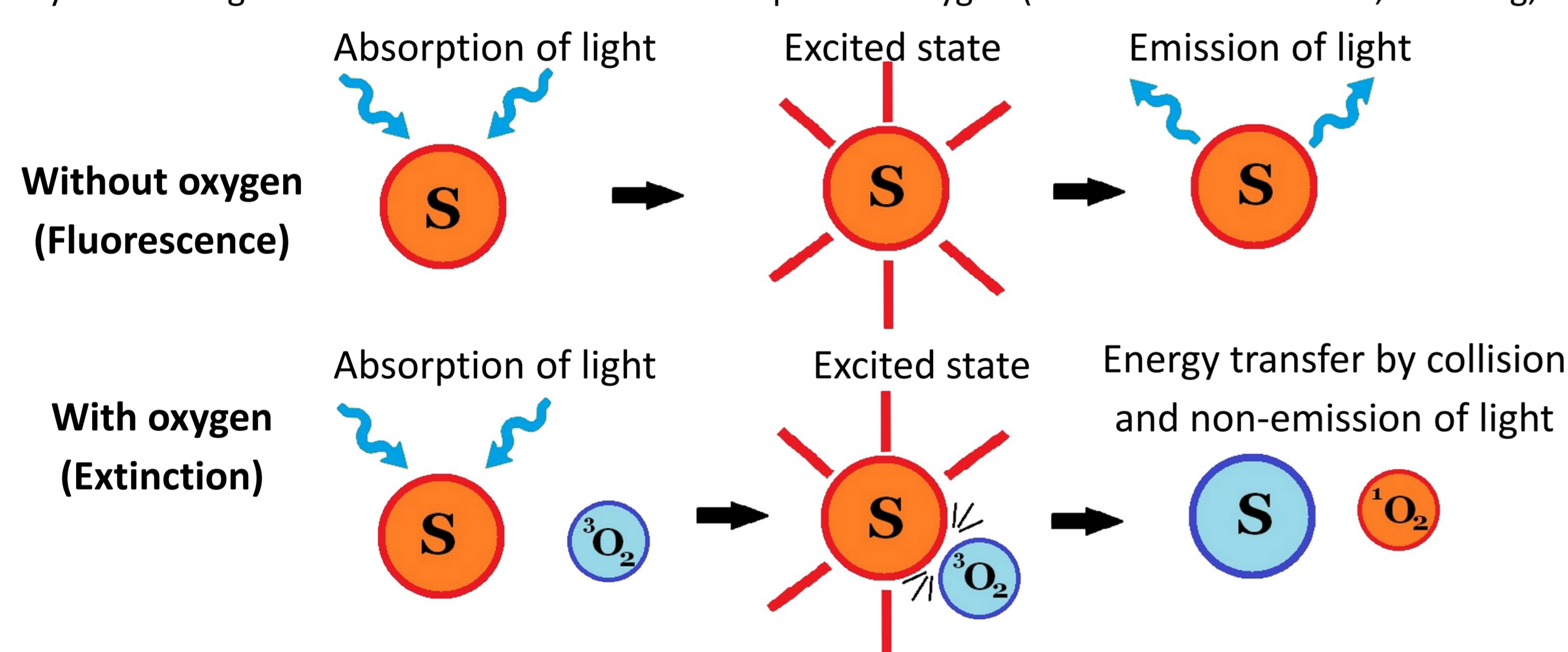


Fig 3. Principle of measurement of the oxygen partial pressure by extinction of luminescence

Our reference to validate the methodology is the invasive method syringe with luminescence quenching <sup>(1)</sup> (Fig 3.). Both the method (syringe and spot (Fig 2.)) have used in this work.

### Mathematical model

**Fick's second law** is used to model the oxygen transfer and express the variation of the concentration with space (x) and time (t). The system of equations given in Fig 4 is numerically solved and programmed on MATLAB<sup>®</sup> software. Then the **diffusivity (D)** is identified by minimizing the sum of squared error between experimental and predict data.

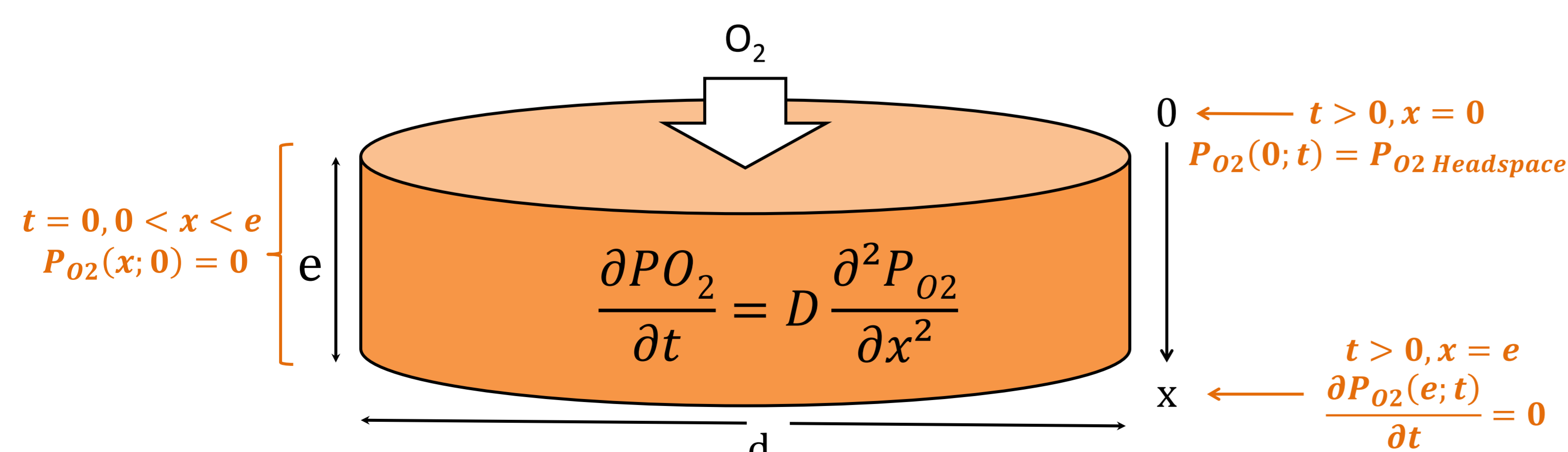


Fig 4. Thin slab type system for the analysis of gas transport in food matrix

## Results

### Validation of method :

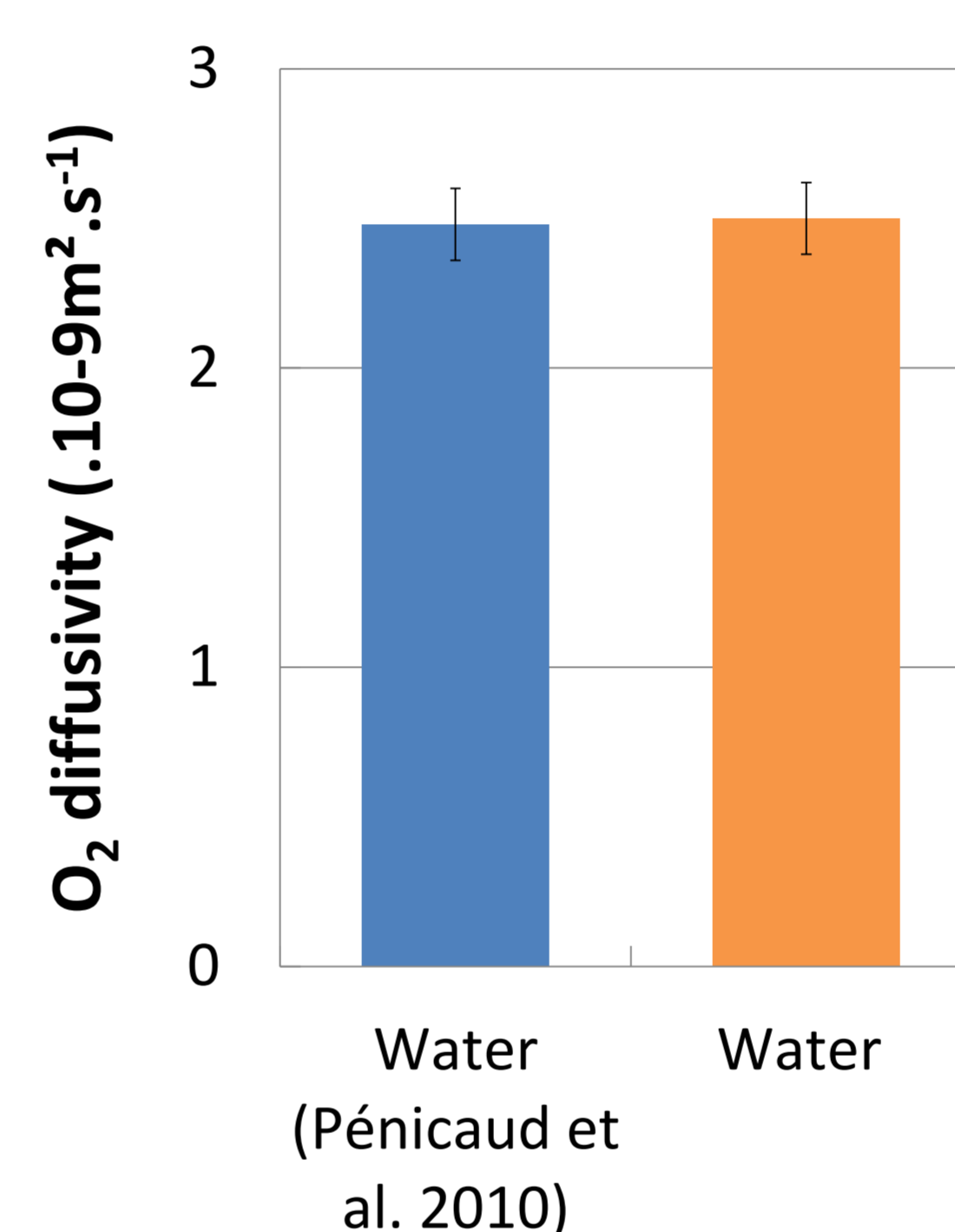


Fig 5. Oxygen diffusivity in water in the literature versus experimental (20°C)

### Activation energy of O<sub>2</sub> diffusivity in model matrix : Miglyol 812

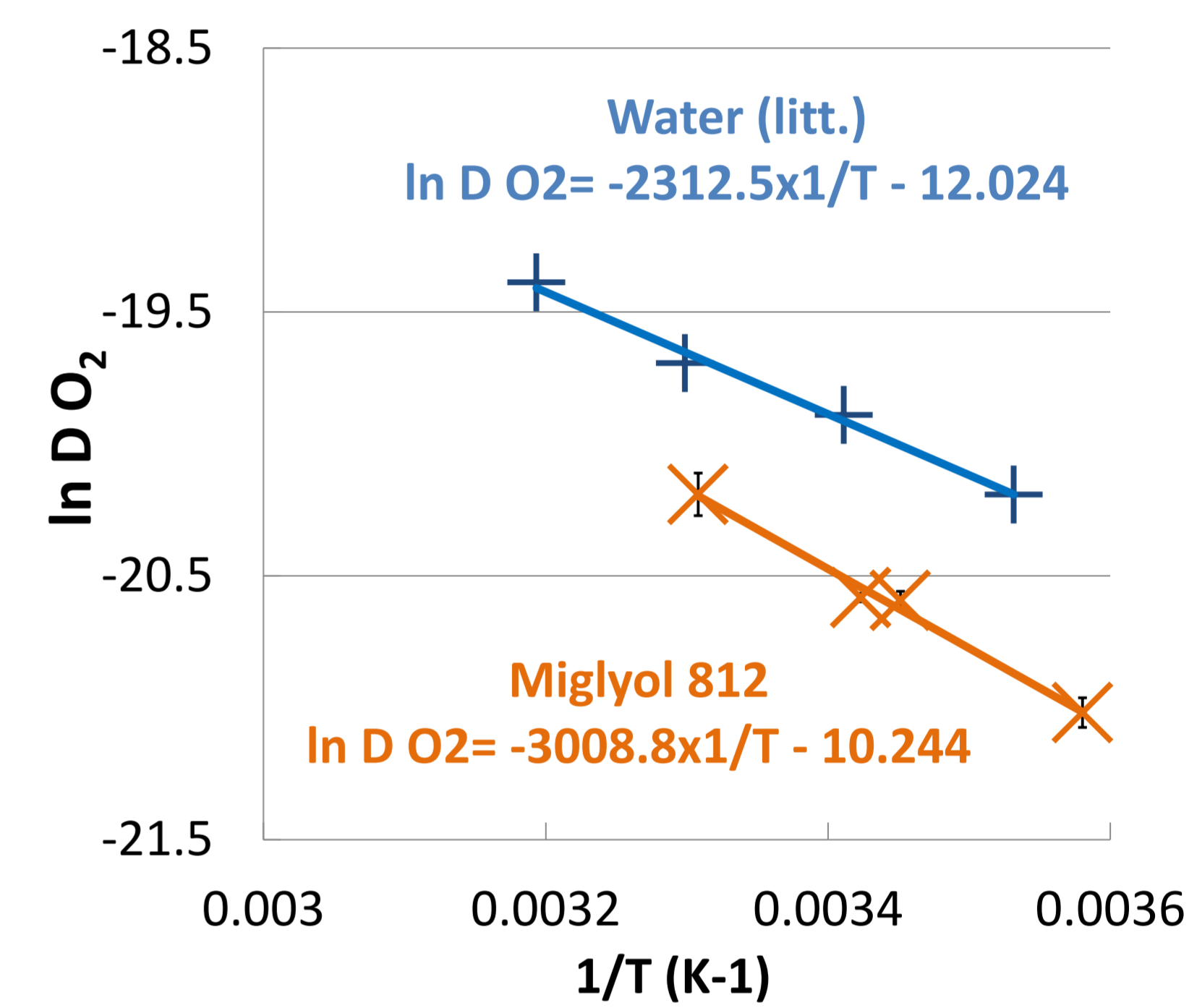


Fig 6. Arrhenius plot showing the temperature dependence on oxygen diffusivity in Miglyol 812 between 6°C and 29°C

### Oxygen diffusivity in viscous and solid food matrices:

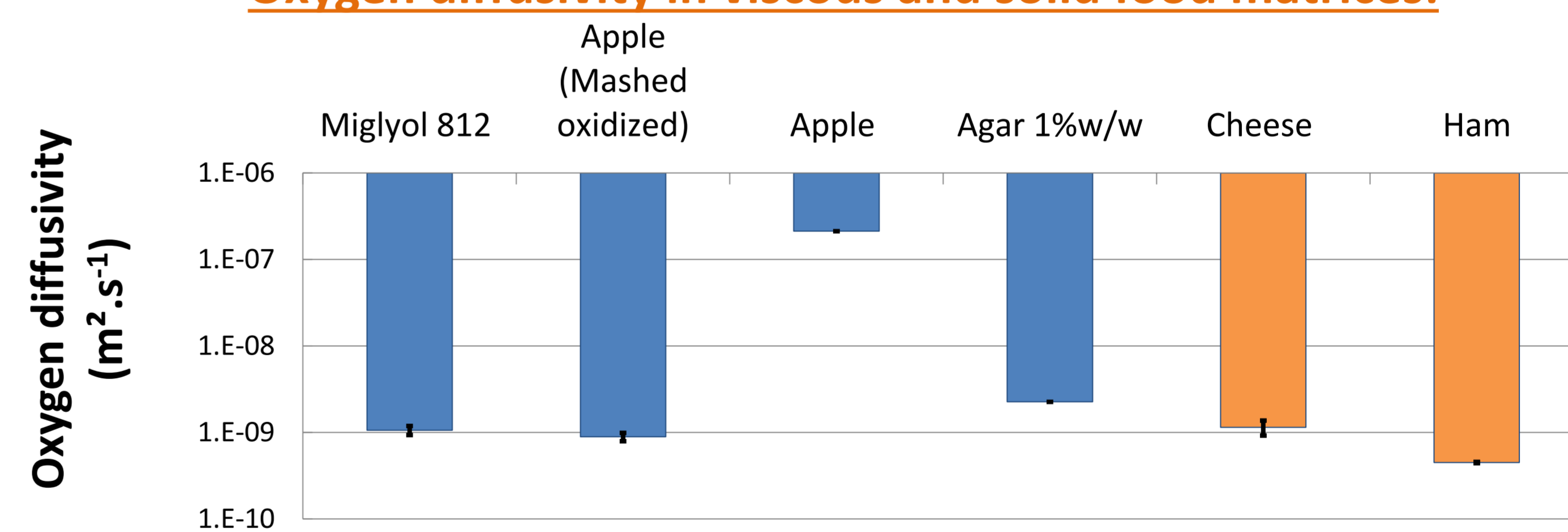


Fig 7. Data diffusivity of oxygen in the literature versus experimental (20°C)

## Discussion

- The values obtained for water are **in agreement** with those found in the literature, and that **permits a validation of our method** (Fig 5.)
- The oxygen diffusion was found to be **strongly dependent on temperature**: oxygen diffusivity increase with temperature, in **accordance with the Arrhenius equation**. The activation energies of oxygen diffusivity is **25 kJ.mol<sup>-1</sup> in miglyol 812**, from 6 to 29°C, and we estimated at **19.2 kJ.mol<sup>-1</sup> the activation energy of oxygen diffusivity in water**, from literature value, from 10 to 40°C <sup>(2)</sup>.
- Oxygen diffusivity data in food matrix in the literature are **widely dispersed**, especially for fruit (e.g. D<sub>O2</sub> in apple are between 2.12x10<sup>-7</sup> m<sup>2</sup>.s<sup>-1</sup> <sup>(3)</sup> to 9.9x10<sup>-10</sup> m<sup>2</sup>.s<sup>-1</sup> <sup>(4)</sup>). For inert materials, the values of oxygen diffusivity are between 1.57x10<sup>-10</sup> m<sup>2</sup>.s<sup>-1</sup> (agar) <sup>(4)</sup> to 2.6x10<sup>-9</sup> m<sup>2</sup>.s<sup>-1</sup> (water) <sup>(1)</sup>. **Our values of oxygen diffusivity for cheese matrix and ham are in accordance with the data available in the literature** (Fig 7.)

This work presents a **non-invasive and non-destructive methodology**, to measure oxygen sorption kinetic in solid food. The use of luminescence sensor allows the implementation of a simple experiment set-up. A strong dependence between Temperature and Oxygen Diffusion was found. The first results in solid food matrices are in accordance with literature data.

This work is done in the project MAP'Opt (2011-2015), funded by the French National Research Agency, whose full name is "Equilibrium gas composition in modified atmosphere packaging and food quality".

(1) Pénicaud et al., 2010 « Oxygen transfer in foods using oxygen luminescence sensors: influence of oxygen partial pressure and food nature and composition » *Food Chemistry*, 123 (4), pp 1275-1281. (2) Wise, D. L. & Houghton, G. (1966). The diffusion coefficients of ten slightly soluble gases in water at 10-60 C. *Chem Eng Sci* 21, 999-1010. (3) Rajapakse et al., 1989 « Oxygen diffusion in apple fruit flesh » *Proc Fifth Int Controlled Atmosphere Research Conf*, Wenatchee, WA, (1), pp 13-21. (4) Miller et al., 2003 « Novel apparatus to measure oxygen diffusion in gel-type foods. » *Food Australia*, 55(9), pp 432-435.