Preventing the waste of animal source foods by predicting the kinetics of oxidation reactions

Jason Sicard, Alain Kondjoyan

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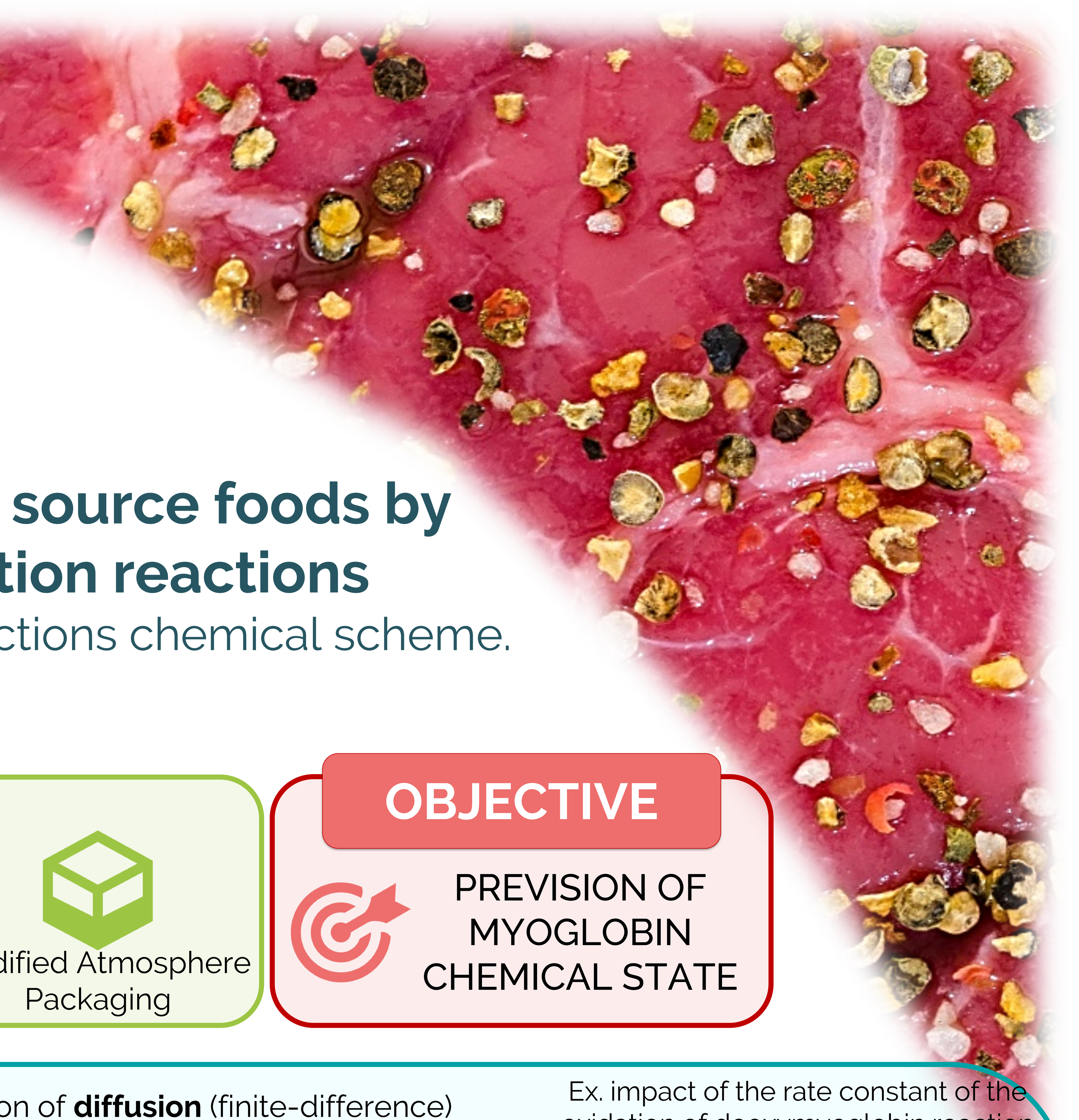

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Reaction-diffusion modelling of a 44-reactions chemical scheme.

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BACKGROUND

Carbon footprint of meat

Consumers reject brown-colour meat

Met- Deoxy- Oxy-
Myoglobin influences colour

Modified Atmosphere Packaging

OBJECTIVE

PREVISION OF MYOGLOBIN CHEMICAL STATE

MATERIAL AND METHOD

3 groups of reactions

O_2
- ❖Myoglobin oxidation reactions
- ❖mitochondrial respiration
- ❖production of hydrogen peroxide by glycolysis

Fe
- ❖Fenton reactions (non-heme iron)

Ao
- ❖Water-soluble antioxidants reactions

resolution of **diffusion** (finite-difference) and **reactions** (ordinary differential equations)

$$\frac{d[C_i]}{dt} = \sum_{j=1}^{N} a_{ij}k_j \left(\prod_{i\in[1,M],a_{ij}<0} [C_i]^{-a_{ij}} \right)$$

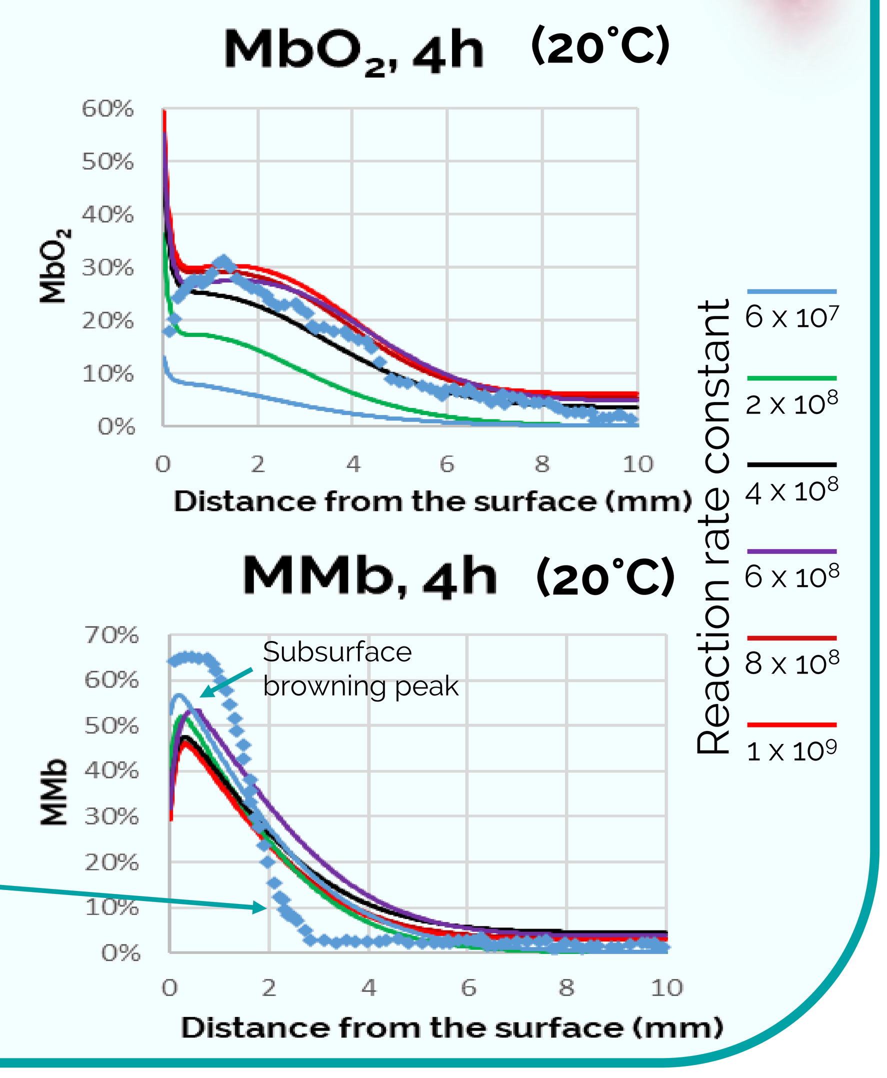
Rate constants literature

Sensitivity analysis (homogeneous O_2) → Diffusion of O_2 → Optimization

- Simplified reaction scheme
- Reaction-diffusion model
- Consolidated rate-constant values

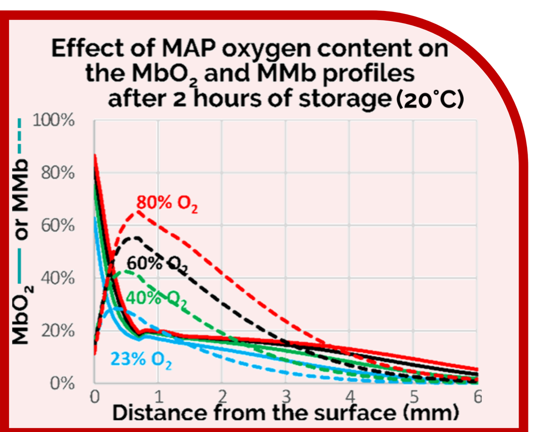
Validation with experimental in-depth myoglobin profiles on longissimus lumborum muscle

Ex. impact of the rate constant of the oxidation of deoxymyoglobin reaction $MbFe^{2+} + O_2 \rightarrow MbFe^{2+}O_2$



RESULTS

- ❖ Water-soluble antioxidants offset the effect of Fenton chemistry on the shape of MbO_2 and MMb profiles.
- ❖ MAP extends the shelf-life of meat by increasing both CO_2 and O_2 to preserve the bright red colour. However, high oxygen also increases both the intensity and width of subsurface browning, eventually leading to a bright red surface covering a thick brown meat.



22 reactions optimized* scheme

*to provide the same results as the complete scheme for the targeted compounds (myoglobin states, oxygen and hydrogen peroxide)

DISCUSSION

- ❖ This model allows for the identification of conditions leading to colour instability or other phenomena sometimes observed in practice when using MAP.
- ❖ The influence of a change in environmental conditions on microorganisms and microorganisms' influence on colour and safety also need to be considered.
- ❖ Supplemental comparison data is needed to evaluate the activation energy of reactions. (see 2nd ref.)
- ❖ Multi-compartments modelling would be required to go further, notably to account for marbling fat particles and the reactions that take place in them.
- ❖ This methodological approach successfully represented a complex scheme of reactions involved in the variation of surface quality of a solid food and is **applicable to other foods!**

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References:

Kondjoyan, A.; Sicard, J.; Badaroux, M.; Gatellier, P. Kinetics Analysis of the Reactions Responsible for Myoglobin Chemical State in Meat Using an Advanced Reaction–Diffusion Model. *Meat Science* **2022**, *191*, 108866, doi:10.1016/j.meatsci.2022.108866.

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