Introduction: Hydration is the key unit operation in the industrial thermal process of dates. This study focuses on modelling and simulation of this operation. The work is divided into two parts:

- An experimental investigation in which dry Tunisian Deglet Nour dates were hydrated by saturated air at laboratory scale.
- A numerical modelling with COMSOL Multiphysics release 5.1 in which both moisture diffusivity and convective mass transfer coefficient were estimated. The simulations based on estimated coefficients can be used to predict and optimize the hydration of dates.

Computational Methods:

- **Geometry**
  - A 2D axisymmetric domain

- **Equations**
  - Moisture diffusion in date flesh: Fick’s Law: \( \frac{\partial C}{\partial t} = \nabla \cdot (D \nabla C) \)
  
  - Uniform initial concentration of moisture in date flesh: \( C_0 = \frac{X_p \rho_s}{M_w} \)
  
  - Null flux at the interior surface in contact with the date pit
  
  - Natural convection at the outer surface in contact with saturated air: \( N = k_c (C_0 - C) \) with \( C_s = \frac{P_{vs}}{RT} aw \)

- By neglecting hysteresis phenomenon, \( aw \) is defined using the GAB model proposed by Kechaou and Mâalej [1].

- **Modelling approach**
  Using the “Transport of diluted species” physic and “optimization module”, the modelling procedure is as follows:
  - Computation of moisture distribution in date flesh
  - Calculation of average moisture concentration with the average coupling operator
  - Estimation of moisture diffusivity and convective coefficient using Levenberg-Marquardt optimization solver by minimizing the least-square objective function calculated from experimental and numerical mean moisture contents.

Results: Only results for two dates of one type of Deglet Nour dates which are slightly harder and drier than labeled Extra category dates are presented.

<table>
<thead>
<tr>
<th>Date Number</th>
<th>( D \text{(m}^2\text{/s)} )</th>
<th>( k_c \text{(m/s)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date1</td>
<td>5.54E-11</td>
<td>0.00123</td>
</tr>
<tr>
<td>Date2</td>
<td>5.54E-11</td>
<td>0.00126</td>
</tr>
</tbody>
</table>

- The root mean square difference (RMS) values are shown in the following table:

\[
\text{RMS} = \left( \frac{C_{av} - C_{av}^{exp}}{C_{av}^{exp}} \right)^2 \times 100 [1]
\]

<table>
<thead>
<tr>
<th>Date Number</th>
<th>\text{RMS} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date1</td>
<td>1.39</td>
</tr>
<tr>
<td>Date2</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Conclusions:

- There is a good agreement between experimental and computed data
- Estimated coefficients vary little with initial concentration
- Moisture diffusion mainly occurs near the outer surface for the considered range of hydration times
- The proposed modelling approach can be employed to simulate hydration of dates in order to improve the quality of final product and reducing processing time.

Reference: