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Modelling the colour changes of chicken breast meat during convective roasting

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The color of cooked chicken meat is the first quality parameter evaluated by the consumer even before the actual consumption. The aim of this study was to combine the mechanistic model of heat and mass transfer with kinetic models to predict the color development (CIELAB lightness parameter, $L^*$) of chicken breast meat during convective roasting. This will further our understanding of the cooking process and improve predictions and control of the product quality.

Model of heat and mass transfer
Heat transfer:

$$\frac{d\rho cm}{dt} = \mathcal{V}(k_{cm} FT) - \rho_0 \mathcal{V} c_{pw} U_w FT$$

Mass transfer:

$$\frac{dC}{dt} = \mathcal{V} \left( -D \frac{C}{C_m} + C \frac{U_w}{U_m} \right)$$

Modelling the browning process
The browning of the surface is mainly a result of Maillard reactions. It was modelled with a first order reaction and the reaction rate constant described as function of temperature and water activity:

$$\frac{dL^*_b}{dt} = -k_b(T, \omega_w) L^*_b$$

$$k_b = p_0 + \frac{p_1}{\omega_w(t)} \exp \left( \frac{p_2 + p_3}{T(t)} \right)$$

By combining the kinetic model with the model of heat and mass transfer, the color development inside the chicken meat was predicted, as shown in Fig. 2.

Modelling the whitening process
Chicken breast meat becomes white during heating mainly due to heme-protein denaturation. The temperature dependent development was modeled with a modified reaction rate law and the Arrhenius equation:

$$\frac{dL^*_w}{dt} = k_w(T) (L^*_w - L^*_w^*)^n$$

$$k_w = k_0 \exp \left( -\frac{E_w}{RT} \right)$$

Conclusion
A combined modelling approach was used to simulate the color changes of chicken breast meat during roasting.

- The developed model is able to predict the color change inside and at the surface during roasting for different process temperatures.
- The developed model can be used to control and optimize the roasting process to ensure the safety and quality of the product for the consumer.