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Crust development at the surface of whole beef meat subjected to hot air jet

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Background
Meat is most often cooked to develop and improve flavor and to make it safer – kill any harmful bacteria which may have contaminated the product.

HCAs
ex: MeIQ

Raw meat surface can be contaminated ex: Escherichia coli

Some cooking methods induce the formation of a crust – a surface layer of hard dry meat.

This crust impacts product savor and flavor but may contain dangerous compounds formed due to heat. [1]

Computational Methods
This model reproduces an experimental device described in [2].

Heated Boundary conditions
Convective Flux
\( \lambda_{eff} \nabla T = h(T_{jet} - T_{surf}) \)

Water concentration
\( X_{w,surf} = X_{eq}(T) \)

Domain Physics
Conduction
\( \rho_{eff} C_{p,eff} \frac{\partial T}{\partial t} = \nabla \cdot \left( \lambda_{eff} \nabla T \right) \)

Diffusion of water/vapour
\( \frac{\partial (X_{w} + X_{v})}{\partial t} = \nabla \cdot \left( D_{eff} \nabla (X_{w} + X_{v}) \right) \)

Evaporation as a Heat Sink
\( Q = m_{w} L v_{w} \)

Materials
Single Material with parametric properties which depend on local water/vapour amount

Results
Due to evaporation and parametric material properties, this model is solved Fully Coupled.

Beef meat cooked at 192 degC (impacting jet temperature) for 60 min. experimental picture and simulated temperature (degC)


Conclusion and Outlook
This model correctly predicts temperature and water concentration profiles in the crust. This allows for prediction of Water Activity, which governs food microbial safety during storage and shelf life.

Furthermore, kinetics for carcinogenic or aroma compounds shall be added in the post-processing.

References
2. S. Portanguen et al., Mechanisms of Crust Development at the Surface of Beef Meat Subjected to Hot Air: An Experimental Study, Food and Bioprocess Technology, 7(11), 3308-3318 (2014)