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

Contact

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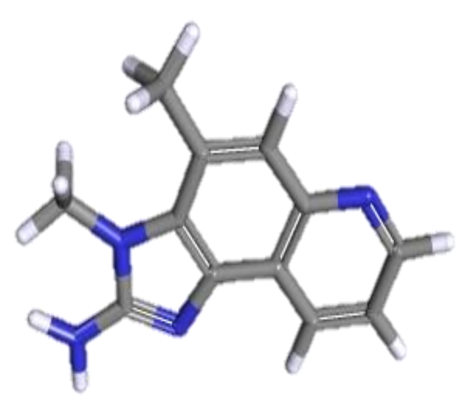
Background

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.

Raw meat surface can be contaminated ex: Escherichia coli

HCAs
ex : MeIQ



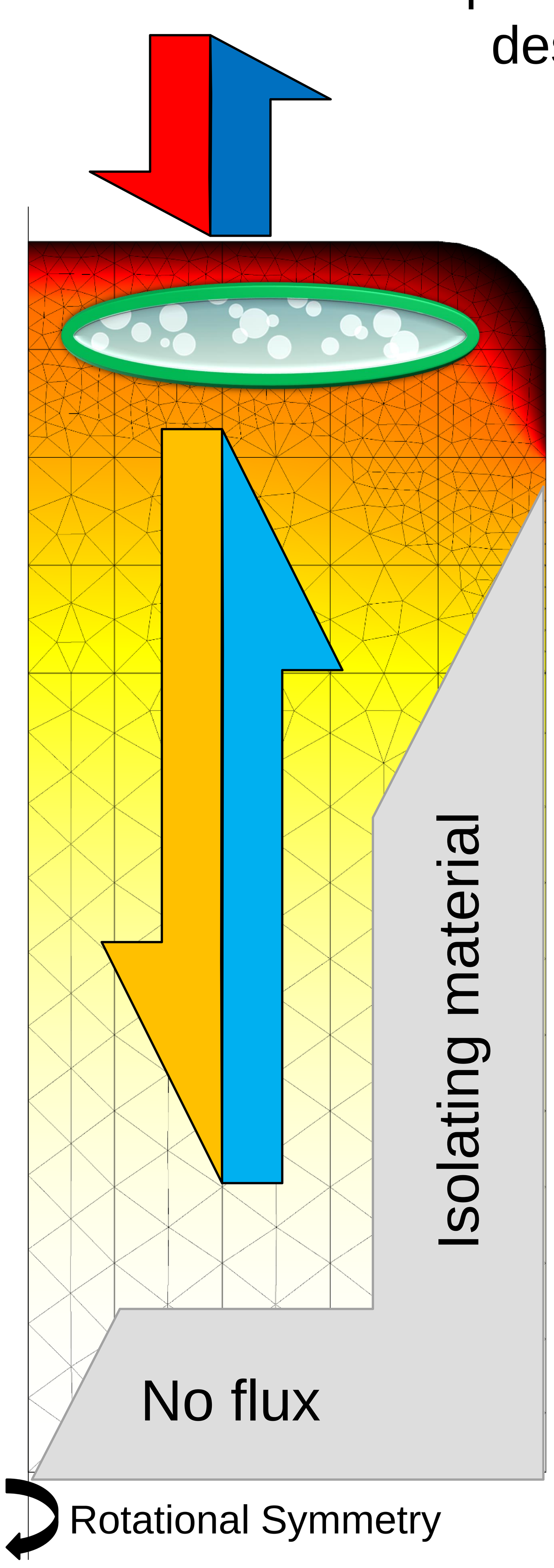
Some cooking methods induce the formation of a **crust** – a surface layer of hard dry meat.

High-temperature cooking (particularly charring) of meat forms carcinogenic compounds like some heterocyclic amines.

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

$$\lambda_{eff} \nabla T = h\left(T_{jet} - T_{surf}\right)$$

Water concentration

$$X_{w,surf} = X_{eq}(T)$$

Domain Physics

Conduction

$$\rho_{eff} Cp_{eff} \frac{\partial T}{\partial t} = \nabla \cdot \left(\lambda_{eff} \nabla T\right)$$

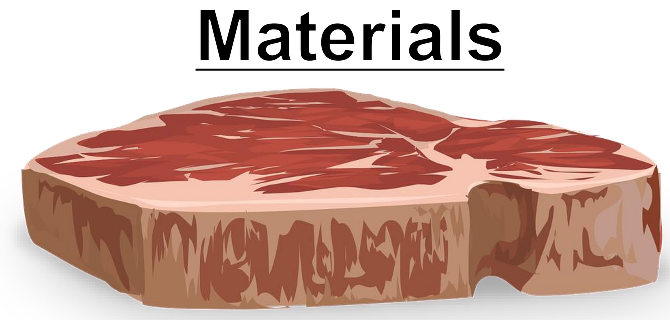
Diffusion of water/vapour

$$\frac{\partial (X_v + X_w)}{\partial t} = \nabla \cdot \left(D_{eff} \nabla (X_v + X_w)\right)$$

Evaporation as a Heat Sink

$$Q = \dot{m}_w L v_w$$

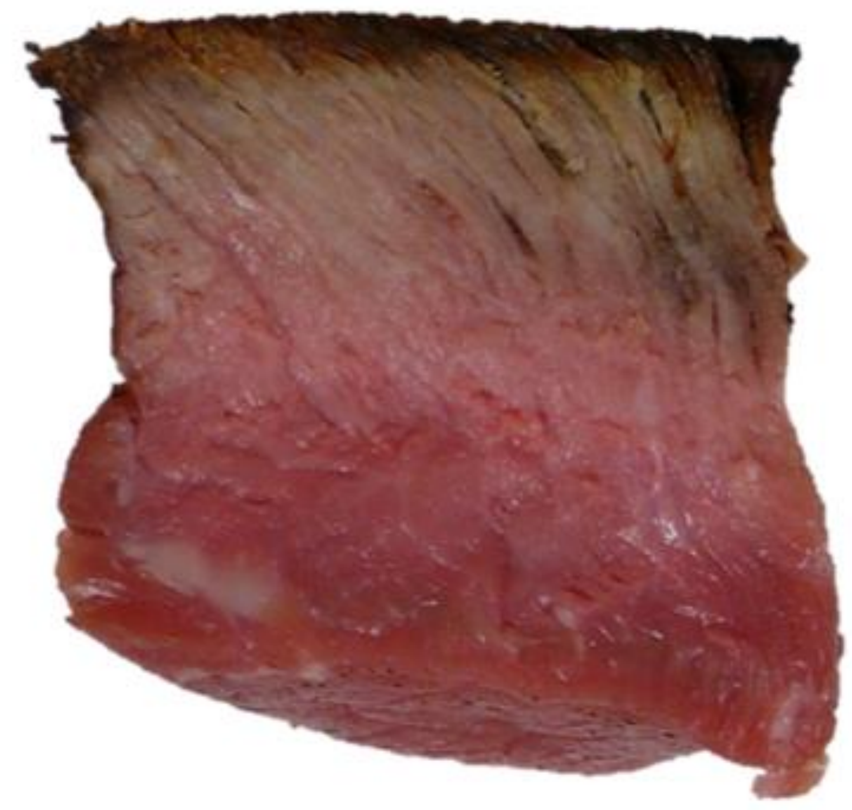
Materials

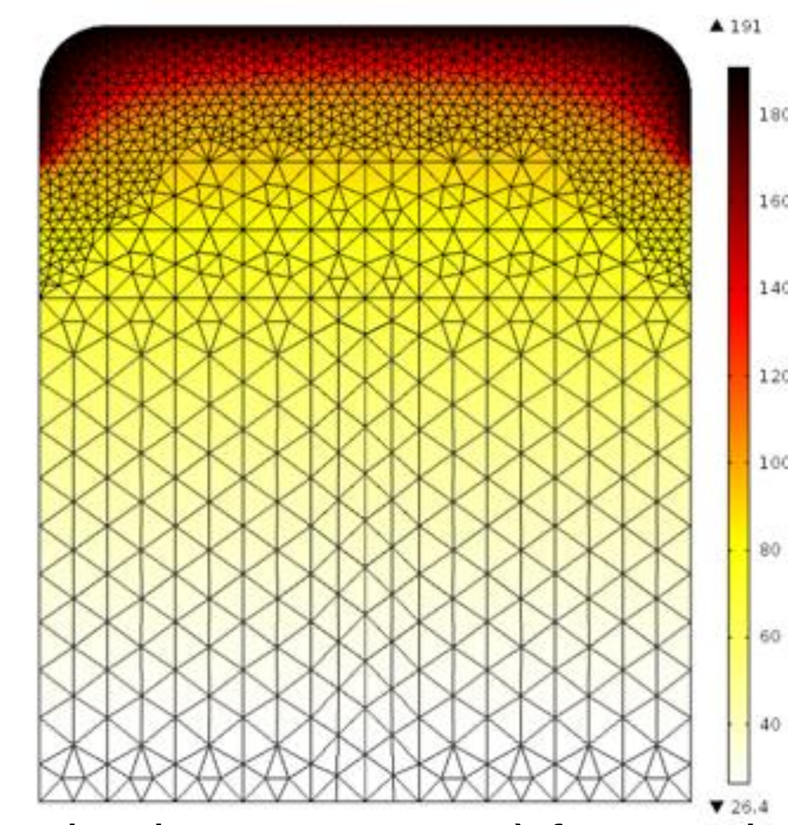


Single Material with parametric properties which depend on local water/vapour amount

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)

	Experimental Method	Simulation Performance
Surface temperature	Thermography	
In-Crust temperature	Thermocouples	
First-7mm water profiles	Magnetic resonance	

within experimental incertitude

In order to increase predictive performance in depth an important limitation must be lifted : lack of deformation.
Hence tests have been performed to take it into account using the Deformed Geometry (dg) Physics, however instability ensued.

Equivalent material behaviour validated on *Longissimus thoracis* muscles. Preliminary data indicates negligible muscle-type-based variability.

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

1. A. Kondjoyan et al., Modelling the formation of heterocyclic amines in slices of longissimus thoracis and semimembranosus beef muscles subjected to jets of hot air, Food Chemistry, 123(3), 659-668 (2010)
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)

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