NTNU
100 skapende år

EIT-project -Group FUTHARK

Åsmund Ervik, Paul Vo, Knut Halvor Skrede, Joakim Johnsen and Turid S. Solberg

Introduction

Numerical simulations and experiments with bacon preparation in a microwave oven were performed. The numerical simulations were performed using the Crank-Nicolson numerical scheme on various heat equations for the different media in bacon. The experiments were performed with regular and with thick bacon in an ordinary household microwave oven, for single slices, and preparation times in the range 30-70 seconds. The results of the experiments are in good agreement both with expected behaviour and with the results of the numerical work.

Result

In this project we discretized the heat equation using Crank-Nicholson. We thus obtain the implicit method for the heat equation

$$u_m^{n+1} - \mu k(\frac{1}{h^2}\delta_x^2 u_m^{n+1} - \frac{1}{f^2}\delta_y^2 u_m^{n+1} - \frac{1}{g^2}\delta_z^2 u_m^{n+1}) = u_m^n + \mu k(\frac{1}{h^2}\delta_x^2 u_m^n + \frac{1}{f^2}\delta_y^2 u_m^n + \frac{1}{g^2}\delta_z^2 u_m^n)$$

with truncation error of order

$$\frac{\tau_m^n}{k} = \mathcal{O}(k^2 + h^2 + g^2 + f^2)$$

The truncation error $\frac{\tau_m^n}{k} \Rightarrow 0$ as $h, f, g, k \Rightarrow 0$, and the Crank-Nicolson method is consistent for the heat equation. By performing a von Neumann analysis of the numerical scheme, one can show that the method are unconditional stable, thus the scheme converges.

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea $c = \lambda f$ commodo consequat:

$$\sin^2\theta_{hkl} = (\frac{\lambda^2}{4a^2})(h^2 + k^2 + l^2)$$

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

$$\sin^2\theta_{i+1} - \sin^2\theta_i = (\frac{\lambda^2}{4a^2})\Delta n$$

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Conclusion

The performed numerical simulations and experiments with bacon preparation in a microwave oven gave satisfactory results so far as they were implemented. The numerical simulations of the heat equations gave reasonable results in agreement with experiments. An implementation of the transport equation would have been more satisfactory, and is suggested as a possibility for future work in this direction. As microwave preparation of bacon is shown elsewhere to be the healthiest option, expanding on the work here with more simulations and experiments, and introducing a more complicated model of bacon fat at high temperatures, one should be able to attain a complete understanding of the preparation process and thus produce guidelines for the optimal preparation of bacon.

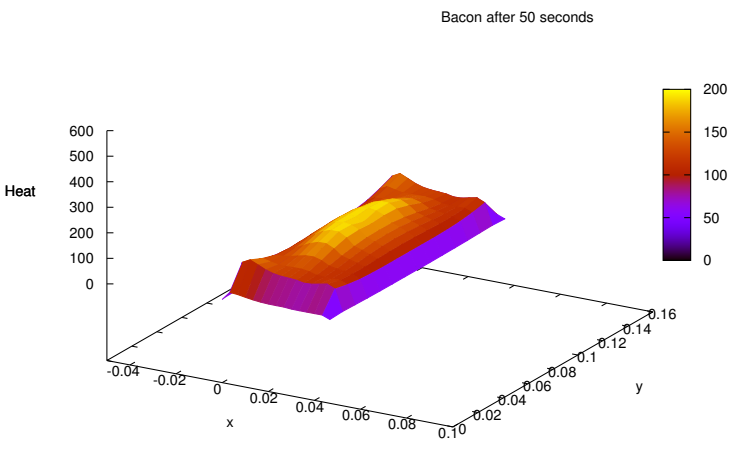

Figure: A slice of bacon after fifty seconds in a microwave oven