Kinetic Modeling of Texture and Color Changes During Thermal Treatment of Chicken Breast Meat

Heat treatment is commonly applied as a primary method for ensuring the microbial safety of poultry meat and to enhance its palatability. Although texture and color of cooked chicken breast meat are important quality parameters for the consumers that need to be controlled during thermal processing, studies assessing the temperature-time-dependent quality changes during thermal treatment are lacking. This work aims to investigate the texture and color changes of chicken breast meat during thermal processing and to develop kinetic models that describe these changes. We studied the storage modulus changes of chicken breast meat as a function of temperature. The storage modulus increases from 55 °C until leveling off in an equilibrium value above 80 °C, which was attributed to microstructure changes and described with a sigmoidal function. The changes in the texture (TPA) and color (CIE L*a*b*) of chicken breast meat were measured as a function of temperature and time. The texture and color parameters show a rise with heating time until reaching an equilibrium value, while the rate of change increased with temperature. Kinetic models that take the non-zero equilibrium into account were developed to describe the color (lightness) and texture (hardness, gumminess, and chewiness) changes with heating time and temperature. The kinetic models provide a deeper insight into the mechanisms of texture and color changes during thermal treatment. They can be used to predict the texture and color development of chicken breast meat during thermal processing and, thus, help to optimize the process.
Effect of ohmic heating parameters on inactivation of enzymes and quality of not-from-concentrate mango juice

Background and Objective: Ohmic heating (OH) is one of the electrothermal technologies that have recently been used for food processing to inactivate microorganisms and enzymes. In present study, effect of OH parameters (voltage gradient and temperature) on inactivation of polyphenoloxidase (PPO) and pectinmethylesterase (PME) of not-from-concentrate (NFC) mango juice was investigated. Multiple response surface methodology (RSM) was used to optimize the OH parameters, where the effect of voltage gradient and temperature on PPO and PME in the NFC mango juice was evaluated. After optimization, the NFC mango juice was produced with optimized OH conditions. Methodology: The PPO and PME activity, total phenolic, total carotenoids, ascorbic acid, cloud value, color as well as physical properties were determined and compared with mango juice reported by conventional heating (CH). Results: The PPO activity was completely inactivated for mango juice produced by OH (at 40 V cm⁻¹, 80°C and holding time for 60 sec) and CH (at 90°C holding time for 60 sec), while the inhibition of PME activity were 96 and 90%, respectively. The reduction in the ascorbic acid for OH (11.3%) was significantly lower than for CH (20%) treated samples. The total phenolic content was increased by 8 and 5% for the OH and CH treated samples, respectively. The reduction in total carotenoids level was significantly lower in the OH (10.9%) than in the CH (19.4%) treated sample. Conclusion: Overall, OH is a potential mild thermal treatment in the production of mango juice with improved functional properties instead of conventional methods.
Modelling the transport phenomena and texture changes of chicken breast meat during the roasting in a convective oven

A numerical 3D model of coupled transport phenomena and texture changes during the roasting of chicken breast meat in a convection oven was developed. The model is based on heat and mass transfer coupled with the kinetics of temperature induced texture changes of chicken breast meat. The partial differential equations of heat and mass transfer as well as the ordinary differential equations that describe the kinetics of the texture changes were solved using COMSOL Multiphysics® 5.2a. The predicted temperature, moisture and texture (hardness, chewiness and gumminess) profiles were validated using experimentally values. The developed model enables the prediction of the texture development inside the chicken meat as function of the process parameters. The model predictions and measured values show the clear effect of changing process settings on the texture profiles during the roasting process. Overall, the developed model provides deep insights into the local and spatial texture changes of chicken breast meat during the roasting process that cannot be gained by experimentation alone.

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Contributors: Rabeler, F., Feyissa, A. H.
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Scopus rating (2017): CiteScore 3.54 SJR 1.279 SNIP 1.671
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Scopus rating (2016): CiteScore 3.71 SJR 1.476 SNIP 1.837
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BFI (2015): BFI-level 1
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BFI (2014): BFI-level 1
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BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.1 SJR 1.348 SNIP 1.891
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.84 SJR 1.36 SNIP 1.978
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Web of Science (2009): Indexed yes
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Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.099 SNIP 1.552
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.802 SNIP 1.425
Scopus rating (2004): SJR 0.875 SNIP 1.452
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.877 SNIP 1.613
Scopus rating (2002): SJR 1.191 SNIP 1.48
Scopus rating (2001): SJR 0.92 SNIP 1.232
Optimization of ohmic heating parameters for polyphenoloxidase inactivation in not-from-concentrate elstar apple juice using RSM

In this study, optimization of ohmic heating (OH) process parameters (temperature and voltage gradient) to inactivate polyphenoloxidase (PPO) of not-from-concentrate (NFC) apple juice was conducted. Response surface methodology was used for optimization of OH parameters, where the voltage gradient and temperature on the PPO activity in the NFC apple juice was evaluated. Then the optimized condition was used to produce the NFC apple juice and the quality parameters were evaluated and compared to NFC apple juice prepared by conventional heating (CH). The studied parameters were: PPO activity, total phenolic, total carotenoids, ascorbic acid, cloud value, color as well as physical properties (i.e., TSS, acidity, electric conductivity and viscosity). The reduction of PPO activities was 97 and 91% for OH (at 40 V/cm and 80 °C) and CH (at 90 °C and 60 s), respectively. The reduction of the ascorbic acid was 66.8% for OH significantly lower than the 80% for CH treated samples. The total extracted phenolic content was increased by 5.4 and 2.5% with OH and CH treatments, respectively. The decrease in the concentration of total carotenoids for OH (13.17%) was significantly lower than for CH (34.23%). The color values (L*, a*, b* and ΔE) were only significantly increased in the OH treatment. OH is a potential mild thermal treatment in the production of apple juice with improved functional properties instead of conventional methods.

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Organisations: National Food Institute, Research group for Analytical Food Chemistry, Research group for Food Production Engineering, Cairo University
Contributors: Abedelmaksoud, T., Mohsen, S. M., Duedahl-Olesen, L., Elnikeety, M. M., Feyissa, A. H.
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Web of Science (2016): Impact factor 1.262
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.08 SJR 0.483 SNIP 0.903
Web of Science (2015): Impact factor 1.241
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BFI (2014): BFI-level 1
Fysiske principper bag kunsten at lave god mad i stor skala

General information
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Contributors: Adler-Nissen, J., Feyissa, A. H.
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An investigation on the application of ohmic heating of cold water shrimp and brine mixtures

Cooking is an important unit-operation in the production of cooked and peeled shrimps. The present study explores the feasibility of using ohmic heating for cooking of shrimps. The focus is on investigating the effects of different process parameters on heating time and quality of ohmic cooked shrimps (Pandalus Borelias). The shrimps were heated to a core temperature of 72 °C in a brine solution using a small batch ohmic heater. Three experiments were performed: 1) a comparative analyses of the temperature development between different sizes of shrimps and thickness (head and tail region of the shrimp) over varying salt concentrations (10 kg m⁻³ to 20 kg m⁻³) and electric field strengths (1150 V m⁻¹ to 1725 V m⁻¹) with the heating time as the response; 2) a 2 level factorial experiment for screening the impact of processing conditions using electric field strengths of 1250 V m⁻¹ and 1580 V m⁻¹ and salt concentrations of 13.75 kg m⁻³ and 25.75 kg m⁻³ and 3) evaluating the effect of pretreatment (maturation) of the shrimps before ohmic processing. The maturation experiment was performed with the following maturation pre-treatments: normal tap water, a 21.25 kg m⁻³ brine solution and without maturation. The measured responses for experiments 2 and 3 were: the heating time until the set temperature of the shrimps was reached, weight loss, press juice and texture profile. It was possible to fit main effects model relating process settings and the heating time, weight loss and press juice measurements. Furthermore, the results showed that over the tested process workspace no significant changes were seen in the texture measurements of the shrimps and that the shrimp achieved a comparable quality compared to the conventional heating processes reported in the literature. The findings show a promising utilization of ohmic heating as a unit operation for the shrimp.

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Contributors: Pedersen, S. J., Feyissa, A. H., Brøkner Kavli, S. T., Frosch, S.
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Web of Science (2016): Impact factor 3.099
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.58 SJR 1.475 SNIP 1.858
Web of Science (2015): Impact factor 3.199
The design of domestic cooking stoves is usually optimized by performing time-consuming cooking experiments, often using frying of pancakes as a standard. Simulation of cooking processes may reduce the number of experiments used in the development of the cooking stoves, saving time and resources. In this work we propose a model of contact frying of pancakes in domestic cookers, particularly in induction hobs and radiant cookers, in which the heating of the cooking vessels can be non-uniform. This non-uniformity is unavoidable in practice, but it can be reduced by optimizing the design of the cooker. The proposed model combines heat and mass transfer phenomena, and also includes the correlation between the browning development and the temperature distribution, the local water content and the cooking time. The model has been also validated through experiments using a commercial induction hob and a radiation stove. With this model the color of the cooked pancakes can be predicted, taking into account also uneven heating, and through
simulations the design of the cooker can be improved.

**General information**

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**BFI (2015):** BFI-level 1  
Scopus rating (2015): CiteScore 3.58 SJR 1.475 SNIP 1.858  
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Web of Science (2015): Indexed yes  
**BFI (2014):** BFI-level 1  
Scopus rating (2014): CiteScore 3.44 SJR 1.496 SNIP 1.96  
Web of Science (2014): Impact factor 2.771  
**BFI (2013):** BFI-level 1  
Scopus rating (2013): CiteScore 3.1 SJR 1.348 SNIP 1.891  
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ISI indexed (2012): ISI indexed yes  
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**BFI (2010):** BFI-level 1  
Scopus rating (2010): SJR 1.447 SNIP 1.795  
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**BFI (2009):** BFI-level 1  
Scopus rating (2009): SJR 1.423 SNIP 1.614  
Web of Science (2009): Indexed yes
Modelling of coupled heat and electric field distribution during ohmic heating of solid foods with varying sizes

Heat treatment is an important process in the manufacturing of a wide range of solid foods. When food products of different sizes (e.g. cooking of shrimps) are processed with the conventional thermal processes, the products are heated unevenly where the small bodies are overcooked and the large bodies are undercooked. Ohmic heating (OH) is one of the novel technologies potentially solving this problem. However, the ability to predict and optimize the resulting temperature profile in solid foods processed by OH rests on a better understanding of the fundamental aspects of OH and of the physical factors leading to variations and uncertainties in prediction of the right process parameters. The current work is focused on modelling of OH of solid food pieces of varying sizes cooked in one batch. A 3D mathematical model of coupled heat transfer and electric field during OH of shrimps has been developed. The mathematical model has been formulated from mechanistic understanding of the process. The resulting coupled model equations were solved using the Finite Element Method (COMSOL Multiphysics® version 4.3b). Experiments were carried out using a newly developed laboratory-scale ohmic heater where the product (shrimps of different sizes) was immersed in the water with (1-2% salt solution). Temperature profiles and current were measured during the experiment and the model has been validated using the experimental data. Good agreement has been achieved between model predictions and the experimental values. The temperature distributions including the cold and hot spots have been predicted inside unpeeled shrimp (that consist of head, meat and other parts). Furthermore the effect of the voltage and salt concentration on the temperature distribution were also investigated. Through the development of this model a better understanding of OH has been obtained. The model can be used for the optimization, upscaling and design of OH of shrimps.

Investigation of ohmic heating for seafood processing

General information
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Organisations: National Food Institute, Research group for Food Production Engineering, Royal Greenland A/S
Contributors: Feyissa, A. H., Beknæs, N., Nielsen, P., Frosch, S.
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This paper presents and demonstrates a novel idea of using spherical potatoes as a dispensable, cheap device for determining the fluid-to-particle heat transfer coefficient, $h_{fp}$ in vessel cooking processes. The transmission of heat through the potato can be traced by measuring the distance from the surface to the gelatinization front, which is easy to identify visually. Knowing this distance, the gelatinization temperature, the period of immersion, and the average radius of the potato, the heat transfer coefficient can be calculated. Either a numerical model based on the Finite Element Method (FEM) or an analytical solution of the Fourier equation can be applied for the calculation. The gelatinization temperature of the potatoes used was determined to be 67°C by a direct temperature measurement and by visual inspection of the progression of the gelatinization front. A sensitivity analysis demonstrates that the method is rather precise at relevant values of $h_{fp}$ in vessel cooking ($100$–$300 \text{ [W/m²K]}$), allowing a prediction of the centre temperature within ±0.6°C.
Developing and modelling of ohmic heating for solid food products

Heating of solid foods using the conventional technologies is time-consuming due to the fact that heat transfer is limited by internal conduction within the product. This is a big challenge to food manufacturers who wish to heat the product faster to the desired core temperature and to ensure more uniform quality across the product. Ohmic heating is one of the novel technologies potentially solving this problem by allowing volumetric heating of the product and thereby reducing or eliminating temperature gradients within the product. However, the application of ohmic heating for solid food products such as meat and seafood is not industrially utilized yet. Therefore, the aim of the current work is to model and develop the ohmic heating technology for heating of solid meat and seafood.

A 3D mathematical model of coupled heat transfer and electric field during ohmic heating of meat products has been developed. The resulting coupled model equations were solved using the Finite Element Method (COMSOL Multiphysics® version 4.2). The experiments were carried out using a newly developed laboratory-scale ohmic heater with different setups e.g., different applied voltages. The temperature profiles and current were continuously measured inside the product. The model has been validated using the experimental data. Good agreement was achieved between model predictions and the experimental values. The model has been utilized to predict the temperature distribution and to control the process by tracking the cold spot and hot spot within meat products during the ohmic heating process. The conclusion is that Ohmic heating is a promising technology for heating of solid meat and seafood, and the developed model can be used in the design and optimization of the ohmic heating processes for the meat and seafood products.
3D modelling of coupled mass and heat transfer of a convection-oven roasting process

A 3D mathematical model of coupled heat and mass transfer describing oven roasting of meat has been developed from first principles. The proposed mechanism for the mass transfer of water is modified and based on a critical literature review of the effect of heat on meat. The model equations are based on a conservation of mass and energy, coupled through Darcy's equations of porous media - the water flow is mainly pressure-driven. The developed model together with theoretical and experimental assessments were used to explain the heat and water transport and the effect of the change in microstructure (permeability, water binding capacity and elastic modulus) that occur during the meat roasting process. The developed coupled partial differential equations were solved by using COMSOL Multiphysics®3.5 and state variables are predicted as functions of both position and time. The proposed mechanism was partially validated by experiments in a convection oven where temperatures were measured online. © 2012 Elsevier Ltd.
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Scopus rating (2013): CiteScore 2.9 SJR 1.512 SNIP 1.83
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): CiteScore 2.84 SJR 1.617 SNIP 1.881
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ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.75 SJR 1.769 SNIP 1.788
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ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.567 SNIP 1.619
Web of Science (2010): Impact factor 2.619
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.367 SNIP 1.504
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
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Web of Science (2008): Indexed yes
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Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.15 SNIP 1.62
Scopus rating (2005): SJR 0.847 SNIP 1.526
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.099 SNIP 1.681
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.778 SNIP 1.54
Web of Science (2003): Indexed yes
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Investigating fluid to food particle heat transfer in a laboratory scale half-vessel through video-recording and modeling

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Contributors: Feyissa, A. H., Christensen, M. G., Pedersen, S. J., Hickman, M., Risum, J., Adler-Nissen, J.
Number of pages: 1
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Uncertainty and sensitivity analysis: Mathematical model of coupled heat and mass transfer for a contact baking process

Similar to other processes, the modelling of heat and mass transfer during food processing involves uncertainty in the values of input parameters (heat and mass transfer coefficients, evaporation rate parameters, thermo-physical properties, initial and boundary conditions) which leads to uncertainty in the model predictions. The aim of the current paper is to address this uncertainty challenge in the modelling of food production processes using a combination of uncertainty and sensitivity analysis, where the uncertainty analysis and global sensitivity analysis were applied to a heat and mass transfer model of a contact baking process. The Monte Carlo procedure was applied for propagating uncertainty in the input parameters to uncertainty in the model predictions. Monte Carlo simulations and the least squares method were used in the sensitivity analysis: for each model output, a linear regression model was constructed and the standardized regression coefficients (SRCs) and R² were computed. The effect of input parameters on model predictions was calculated, and the relative impact of the parameters on each of the outputs was ranked. Results of the uncertainty and sensitivity analysis can be used to prioritize future experimental efforts, as discussed for the contact baking process.
Computer aided simulation for developing a simple model to predict cooling of packaged foods

A new equation to predict equilibrium temperatures for cooling operations of packaged foods has been deducted from the traditional 1st order solution to Fourier’s heat transfer equations. The equation is analytical in form and only requires measurable parameters, in form of area vs. volume ratio (A/V), thermo-physical properties calculated from the recipe, and the heat transfer coefficients measured in the equipment. The equation is based on an overall Biot number. The simple deducted model was tested and validated with experimental and simulated setups. Simulations have been performed using COMSOL Multiphysics, commercially available software, to test the new equation. Additionally, an experiment with all boundary conditions known, and the three dimensional coordinates of the position of six thermocouples were conducted. The COMSOL simulation showed very good conformity with experimental results matching all individual thermocouples. Simulations are used as a validation tool for cooling predictions. This was done by comparing the simulated equilibrium temperature with the calculated using the new equation. The simulations are able to evaluate cooling situations in the industry where experiments are too laborious or impossible to conduct. The deducted equation was tested for irregular geometries, unequal heat transfer and headspace restrictions. The new equation predicted equilibrium temperature curves of the simulated cooling with a low error (1.5°C for Fourier numbers below 0.3) and good precision at the target temperature (error below 0.5°C for Fourier numbers above 0.3).

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Organisations: National Food Institute, Division of Industrial Food Research, Research group for Food Production Engineering
Contributors: Christensen, M. G., Feyissa, A. H., Adler-Nissen, J.
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Modelling of coupled heat and mass transfer during a contact baking process

A mathematical model of coupled heat and mass transfer of a contact baking process is developed. In the current model formulation, a local evaporation of water is described with a reaction–diffusion approach, where a simultaneous diffusion and evaporation of water takes place. The resulting coupled model equations (unsteady state heat transfer, liquid water and water vapour) were solved using the Finite Element Method (COMSOL Multi-physics® version 3.5). During the baking process, local temperatures and overall moisture loss were measured continuously. The model – predicting temperature, liquid water content in the product and water in the vapour phase – was calibrated and partially validated using data obtained during baking of a representative food model (a pancake batter) under controlled conditions on a specially designed experimental rig. The unknown parameters in the model equations were estimated using the standard least squares method by comparing the measured with the predicted temperature profile. Good agreement was achieved between model predictions and the experimental values.

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Scopus rating (2016): CiteScore 3.71 SJR 1.476 SNIP 1.837
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Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 3.58 SJR 1.475 SNIP 1.858
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Scopus rating (2013): CiteScore 3.1 SJR 1.348 SNIP 1.891
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Robust Modelling of Heat and Mass Transfer in Processing of Solid Foods

The study is focused on combined heat and mass transfer during processing of solid foods such as baking and frying processes. Modelling of heat and mass transfer during baking and frying is a significant scientific challenge. During baking and frying, the food undergoes several changes in microstructure and other physical properties of the food matrix. The heat and water transport inside the food is coupled in a complex way, which for some food systems it is not yet fully understood. A typical example of the latter is roasting of meat in convection oven, where the mechanism of water transport is unclear. Establishing the robust mathematical models describing the main mechanisms reliably is of great concern. A quantitative description of the heat and mass transfer during the solid food processing, in the form of mathematical equations, implementation of the solution techniques, and the value of the input parameters involves uncertainty. The objective of this thesis is to develop robust models of heat and mass transfer during processing of solid foods. The study consists of formulating the mechanistic models, solving the models by the Finite Element method (FEM), calibrating and validating the models by experimental data, evaluating the models by an uncertainty and sensitivity analysis. In the study, contact baking and roasting of meat in convection oven were chosen as representative case studies. For both representative cases, the experiments were performed and the relevant data such as product temperature, mass loss, and other process conditions were obtained. For roasting of meat in convection oven, the mechanism of water transport during roasting was studied; a theoretical assessment was made on the change in structure, water holding capacity and shrinkage. The mechanism of water transport was tested by measuring the local water content. For the roasting process, 3D and 2D mechanistic quantitative models describing the coupled heat and mass transfer were developed. The governing model equations are based on the conservation of energy and mass. Further, Darcy’s equation was used to describe the pressure driven transport of water in meat during roasting. The change in elastic modulus, evaporation, and
moving boundary were incorporated into the model equations. The arbitrary Lagrangian–Eulerian (ALE) method was implemented to capture the moving boundary during the roasting process. The model equations for coupled heat and mass transfer were solved using the FEM (COMSOL). For the contact baking process, a 1D mathematical model of the coupled heat and mass transfer was developed. The model developed for the contact baking process considered the heat transfer, local evaporation, and multiphase water transport (liquid and vapour). The model equations were implemented in the COMSOL-MATLAB computing environment with the following features: parameter estimations, model validations and uncertainty and sensitivity analysis. The unknown parameters in the model were estimated by comparing the measured and simulated data – using the least square method by comparing the measured temperature against the simulated temperature. Further, the model was validated using the experimental data and a reasonably agreement between the simulated and experimental data were obtained. The uncertainty and global sensitivity analysis method were incorporated for the model of coupled heat and mass transfer. The uncertainty of model predictions due to the uncertainty in input parameters such as thermo-physical properties, heat and mass transfer coefficients, phase change initial and boundary conditions parameters were studied. A Monte Carlo based method of the uncertainty and global sensitivity analysis was used. The sensitivity analysis was performed to determine the relative effect of the different parameters on the model prediction. The relative effects of parameters on the model prediction were indentified, and their relative impact on each model output was ranked. Generally, the developed mathematical models of heat and mass transfer provide better insights about the processes. The proposed robust modelling approach was found to be a useful tool in the model building that help to cope up with different challenges in modelling of heat and mass transfer during processing of solid foods and the potential of using the approach is particularly great for frying and baking operations.
Uncertainty and Sensitivity Analysis of Heat and Mass Transfer in Food Processing

General information
State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Department of Chemical and Biochemical Engineering
Contributors: Feyissa, A. H., Adler-Nissen, J., Gernaey, K.
Publication date: 2010
Peer-reviewed: No
Source: orbit
Research output: Research › Poster – Annual report year: 2010

Mechanism of water transport in meat during the roasting process

General information
State: Published
Organisations: National Food Institute, Division of Food Production Engineering, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
Contributors: Feyissa, A. H., Adler-Nissen, J., Gernaey, K.
Pages: 11-15
Publication date: 2009

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Title of host publication: Process technology
Volume: Part 1
Source: orbit
Source-ID: 250051
Research output: Research › Article in proceedings – Annual report year: 2009

Model of heat and mass transfer with moving boundary during roasting of meat in convection-oven

General information
State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Contributors: Feyissa, A. H., Adler-Nissen, J., Gernaey, K.
Publication date: 2009

Event information
Event: European Comsol Conference 2009
Location: Milan, Italy
Source: orbit
Source-ID: 255887
Research output: Research › Sound/Visual production (digital) – Annual report year: 2009

Model of Heat and Mass Transfer with Moving Boundary During Roasting of Meat in Convection-Oven

General information
State: Published
Organisations: Division of Food Production Engineering, National Food Institute, Center for BioProcess Engineering, Department of Chemical and Biochemical Engineering
Contributors: Feyissa, A. H., Adler-Nissen, J., Gernaey, K.
Publication date: 2009

Host publication information
Title of host publication: European Comsol Conference 2009
Innovation consortium: Innovation consortium - Optimized heating and cooling of meat, shellfish and cheese products
One of the biggest challenges facing the Danish food industry is to retain the current level of domestic production at a time where high wage levels, relatively low increase in productivity and high manufacturing costs are forcing the outsourcing of production, leading to a loss of Danish jobs. The Danish agriculture and food sector is among the world’s most export-intensive, and investments in new production methods or smarter use of existing equipment are needed to ensure and improve the Danish position as one of the world’s leading exporters of food. However, without a strong learning basis from production in Denmark this position is in danger of being eroded. Research and development in production technology is crucial for the food industry in order to increase productivity and competitiveness and create jobs in the future. For over a century the heating and cooling of solid food products have been performed using traditional technologies which have not evolved. The consortium involved in the current proposal aims to exploit the commercial potential of new heating and cooling technologies and identify new industrial approaches involving their usage. Based on a more systematic understanding of a selection of novel heating and cooling processes, this will increase the possibilities for improving process productivity, energy economics and reduce carbon footprint while also improving product yield, quality, safety and batch uniformity and allowing the development of new product types. Specifically the aim of the consortium is to optimize time consuming heating and cooling processes in the food manufacturing area concurrently with an improvement in quality and a reduction in environmental load. The work will be based on case studies from three different food areas: cooling of cream cheese from the dairy industry, heating and cooling of logs of sausage and cold cuts from the meat industry and heating and cooling of shrimps and seafood from the fishing industry. The potential impact of optimizing heating and cooling in Danish food plants is enormous. The different companies in the market manufacture at least 200,000 tonnes of heat treated meat, shellfish and cheese products annually with more than 85 % thereof destined for export. For companies manufacturing equipment to the food industry the results from the consortium will furthermore show a ‘proof of concept’ of innovative, new use of not adapted equipment and of new technologies, capable of optimizing either heating or cooling processes. The consortium will improve the innovative possibilities of the participating companies in a wide range of business areas, just as development possibilities in non-participating companies will be created based on generic results and knowhow. New products lie within the areas off: Equipment for improved heating and cooling Concepts for minimally processed food Software for temperature profiling of novel manufacturing methods Probes for online temperature measurement These innovative concepts will be created on the basis of results from trials in existing, but not adapted, equipment, and in new equipment in close cooperation between the participating food and equipment companies, universities and DMRI – Danish Technological Institute.

Feyissa, A. H., Project Participant, National Food Institute, Research group for Food Production Engineering
An improved physical understanding of the production of extruded fish feed will enable an optimized raw material utilization (ImProFeed)

Dethlefsen, M. W., PhD Student, National Food Institute
Jørgensen, B. M., Main Supervisor
Feyissa, A. H., Supervisor
Nielsen, M. E., Supervisor
Chronakis, I. S., Examiner
Kristensen, J. B., Examiner
Harthøj Hjermitslev, N., Supervisor
Colovic, R., Examiner
Industrial PhD
01/08/2014 → 05/12/2017
Award relations: An improved physical understanding of the production of extruded fish feed will enable an optimized raw material utilization (ImProFeed)
Project: PhD

Robust Modelling of Mass and Heat Transfer in Food Processing
Feyissa, A. H., PhD Student, National Food Institute
Adler-Nissen, J., Main Supervisor
Gernaey, K. V., Supervisor
Friis, A., Examiner
Ahrné, L. M., Examiner
Borggårд, C., Examiner
Globaliseringsmidler
01/02/2008 → 22/06/2011
Award relations: Robust Modelling of Mass and Heat Transfer in Food Processing
Project: PhD

Integrated Modelling of Food Production Chains (a part of the inSPIRe Food)
A current challenge in the food industry is to improve both flexibility and productivity in the production and supply chain. In Integrated Modelling of Food Production Chains, generic, robust models suitable for industrial use will be researched and developed in a long-term collaboration with a consortium of industry partners. The models are primarily developed as tools for improving productivity and flexibility in addition to reduce waste in the food production chain. Focus will be entirely on the production line and individual unit operations e.g. cooking, baking, frying, chilling and freezing, within the factory and abandon from integrating out-of factory logistics, as this appears not to be an urgent need for the involved industrial partners. The overall objective of the project is to develop a cross-disciplinary framework for studying and developing process optimization in relation to the food production industry. It requires an interdisciplinary approach combining food science, food engineering, industrial statistics, management and industrial production knowledge. The objective is to develop and validate through experiments robust models, which are easy to use in industry and which describe important processes. The important processes will be identified through comprehensive production analysis. A parallel objective is to encourage production managers in the Danish food industry to systematically apply such models, whether existing or developed in this project, for improving productivity and flexibility in addition to reduce waste. The output of the project will be multifaceted and cover both scientific and innovative issues. •Exploring the need for data / information. •Describing and discussing tools and techniques for the improvement of productivity and flexibility in addition to reduce waste. •Generic, robust models and methods suitable for industrial use will be researched and developed.
Frosch, S., Project Participant, National Food Institute, Research group for Food Production Engineering
Adler-Nissen, J., Project Participant, National Food Institute, Research group for Food Production Engineering
Feyissa, A. H., Project Participant, National Food Institute, Research group for Food Production Engineering
Pedersen, S. J., Project Participant, National Food Institute, Research group for Food Production Engineering
Christensen, M. G., Project Participant
Danish Council for Strategic Research: DKK10,444,444.00
01/01/2011 → 31/12/2016
Award relations: Integrated Modelling of Food Production Chains (a part of the inSPIRe Food)
Project: Research

ImProFeed: An improved physical understanding of the production of extruded fish feed will enable an optimized raw material utilization
Metal or plastic pipes, snackfoods and animal feeds are all products which are possible to manufacture by extrusion. The increased popularity of extruders over the years can be explained by their versatility and productivity (Riaz, 2000; Guy, 2001; Hydraulicsonline.co.uk, 2012). Also, the ability to sell voluminous air-interlarded breakfast products and the low processing costs of the extrudates are properties of interest in terms of marketing and finance (Chessari & Sellahewa, 2001; Guy, 2001). Extruders are characterized by their continuous nature, making it theoretically possible to fabricate infinite solids. However, the production will practically be limited by lack of raw materials or incomplete knowledge of how to adjust the input variables. Even though extrusion is a multivariate phenomenon and the understanding of the interactions between the raw materials, the processing within the barrel of the extruder, and the extrudate have been developed during the recent years, the models are often build on empirical data and confined to specific set-ups (Riaz, 2000; Guy, 2001; Cheng & Friis, 2010). The recipe for fish feed is complex, and the raw materials vary with season and market prices. Changing one ingredient is known to influence important characteristics of the final extrudate (Moraru & Kokini, 2003). Besides the nutritional value of the feed, its physical properties are important as well: An unintended size of the extruded and pelletized feed is known to adversely affect the growth of the fish (Ljungqvist et al., 2011), and uncontrolled feed densities influence its willingness to sink and the amount of lipid possible to add through coating (Kraugerud et al., 2011). Company relevance: Controlling the extrusion process makes intended adjustments of input variables possible. From previous work and the master’s thesis work performed by the candidate in corporation with BioMar A/S, the parameters and mechanisms of importance for description of extrusions are well-known. However, to control and optimize extrusion processes, an understanding and measuring of the involved physical mechanisms and their interplay are crucial. Company relevance: Optimized extrusion processes ensure better utilization of raw materials. Some salmonid species show problems when pellets are dissolve quickly in their stomach and release nutrients in the stomach cavity where muscle activity can force this soup out of the mouth again which is today known as fat belching because the fat part will float to the surface and be very visual. Other salmonid species have the opposite problem where the pellets are difficult to dissolve resulting in malabsorption and poor feed performance. Understanding the underlying physicochemical processes inducing the different degrees of pellet dissolving ensures optimized feed performance. Company relevance: Enhanced pellet quality and feed performance are clear competitive advantages. • References Cheng, H. & A. Friis (2010): Modelling extrudate expansion in a twin-screw food extrusion cooking process through dimensional analysis methodology. Food and Bioproducts Processing. Vol. 88, pp. 188-194.


01/08/2014 → 31/07/2017

Keywords: Fish feed, Extrusion, Physical parameters

Collaborators: BioMar A/S

Award relations: An improved physical understanding of the production of extruded fish feed will enable an optimized raw material utilization

Project: Research

Activities:

Cost Action CA15118 - Mathematical and Computer Science Methods for Food Science and Industry (FoodMC) (External organisation)

Period: 1 Apr 2016 → 31 Mar 2020

Aberham Hailu Feyissa (Participant)

National Food Institute

Research group for Food Production Engineering

Description

Management Committee Member

The agriculture and food processing sector (agri-food) is facing sustainability challenges of growing complexity, from...
consumer expectations to concerns over food security, right through to environmental regulations. In such a context, innovation is becoming a decisive factor of competitiveness for companies in this field. Methodologies and tools from Maths and Computer Science (MCS) are emerging as key contributors to modernization and optimization of processes in various disciplines: the agri-food sector, however, is not a traditional domain of application for MCS, and at the moment there is no community organized around solving the issues of this field.

This COST Action brings together scientists and practitioners from MCS and agri-food domains, stimulating the emergence of new research, and structuring a new community to coordinate further investigation efforts. Exploiting approaches originating at different sub-fields of MCS, from applied mathematical models to knowledge engineering, this COST Action will cover two main topics: understanding and controlling agri-food processes; and eco-design of agri-food products.

Management Committee
Degree of recognition: International
Links:
https://www6.inra.fr/foodmc/About-FoodMC/FoodMC-who-s-who
http://www.cost.eu/COST_Actions/ca/CA15118

Related external organisation
Cost Action CA15118 - Mathematical and Computer Science Methods for Food Science and Industry (FoodMC)
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

12th International Congress on Engineering and Food
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Description
Modelling of coupled heat and electric field distribution during ohmic heating of solid foods with varying sizes

Related event
12th International Congress on Engineering and Food
14/06/2015 → 18/06/2015
Québec City, Canada
Activity: Talks and presentations › Conference presentations

Journal of Food Engineering (Journal)
Period: 2015 → …
Aberham Hailu Feyissa (Reviewer)
National Food Institute
Research group for Food Production Engineering

Related journal
Journal of Food Engineering
0260-8774
Central database
Activity: Research › Peer review of manuscripts

28th EFFoST International Conference | 7th International Food Factory for the Future Conference
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Description
Developing and modelling of ohmic heating for solid food products

Related event

28th EFFoST International Conference | 7th International Food Factory for the Future Conference
Uppsala, Sweden
Activity: Talks and presentations › Conference presentations

Energy saving using Food process modeling
Period: 13 May 2014
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Description
SUSTAINABILITY, RESOURCE SAVINGS AND ENERGY / ENVIRONMENTAL EFFICIENCY WITH FOCUS ON SAFETY DESIGN

Related event

Technology Update: hygiejnisk design
13/05/2014 → 13/05/2014
Denmark
Activity: Talks and presentations › Conference presentations

Trends in Food Science & Technology (Journal)
Period: 2014 → …
Aberham Hailu Feyissa (Reviewer)
National Food Institute
Research group for Food Production Engineering

Related journal

Trends in Food Science & Technology
0924-2244
Central database
Activity: Research › Peer review of manuscripts

11th Conference of Food Engineering
Period: 2 Apr 2012 → 5 Apr 2012
Aberham Hailu Feyissa (Speaker)
National Food Institute
Division of Industrial Food Research

Description
Investigating fluid to food particle heat transfer in a laboratory scale half-vessel through video-recording and modeling

Related event

11th Conference of Food Engineering
02/04/2012 → 04/04/2012
Leesburg, VA, United States
Activity: Talks and presentations › Conference presentations
Related journal

Applied Thermal Engineering
1359-4311
Central database
Activity: Research › Peer review of manuscripts

LMC MEAT NETWORK Workshop and Symposium"Future Trends in MuscleFoods"
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Description
Modelling and monitoring of heat and mass transfer during a meat roasting process

Related event

LMC MEAT NETWORK Workshop and Symposium"Future Trends in MuscleFoods"
12/10/2011 → 13/10/2011
Greve, Denmark
Activity: Talks and presentations › Conference presentations

11th International Congress on Engineering and Food
Period: 22 May 2011 → 26 May 2011
Aberham Hailu Feyissa (Participant)
National Food Institute
Research group for Food Production Engineering

Related event

11th International Congress on Engineering and Food
22/05/2011 → 26/05/2011
Athens, Greece
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

5th International Conference on the Food Factory for the Future : Smart process control and automation
Period: 30 Jun 2010 → 2 Jul 2010
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Related event

5th International Conference on the Food Factory for the Future : Smart process control and automation
01/01/2010 → …
Gothenburg, Sweden
Activity: Talks and presentations › Conference presentations

Model of Heat and Mass Transfer with Moving Boundary During Roasting of Meat in Convection-Oven
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Related event
European Comsol Conference 2009
14/10/2009 → 16/10/2009
Milan, Italy
Activity: Talks and presentations › Conference presentations

55th International Conference on Meat Science and Technology
Aberham Hailu Feyissa (Speaker)
National Food Institute
Research group for Food Production Engineering

Description
Mechanism of water transport in meat during the roasting process

Related event
55th International Conference on Meat Science and Technology
16/08/2009 → 21/08/2009
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations