The influence of processing conditions on the weight change of single herring (Clupea herengus) fillets during marinating

One of the main issues in the manufacturing of marinated herring is the variation in yield, which in turn, is affected by the processing conditions and the variance in fat content. In the present work, we study these effects on individual herring fillets, with focus on the intermediate brining process. Brining time, brine concentration, marinade composition and storage time were varied. For brine concentrations 8%, 16% and 26%, the diffusion coefficient was $2.31 \times 10^{-9}$ m$^2$ s$^{-1}$, which was used for model development of salt change prediction in herring during brining. Conducting experiments on single fillets revealed a correlation between the fat content and the weight change after 35 days of marinating. The greatest change occurred within the first few days and only minor changes were seen during the storage period of up to one year. These results contribute to a better understanding of the herring marinating process, which can aid the optimization process in the industry.
Analysis of the production of salmon fillet - Prediction of production yield

The aim was to investigate the influence of raw material variation in Atlantic salmon from aquaculture on filleting yield, and to develop a decision tool for choosing the appropriate raw material for optimized yield. This was achieved by tracking salmon on an individual level (n = 60) through a primary production site. The majority of the salmon exhibited a heavier right fillet compared to the left fillet after filleting. No explicit explanation was found for this observation although the heading procedure was shown to have a large impact. A Partial Least Square model was built to predict the yield after filleting. The model was based on six pre-processing variables and allowed an acceptable prediction of the filleting yield with a root mean square error cross validation of 0.68. The presented model can estimate the slaughter yield for a certain batch before ordering from the slaughterhouse. This may facilitate optimal planning of the production of salmon fillets by ordering and assigning the right batch to the right product category to obtain an optimal yield and quality.

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Organisations: National Food Institute, Research group for Food Production Engineering, University of Iceland, Fast-Q
Contributors: Johansson, G. Ø., Guðjónsdóttir, M., Nielsen, M. E., Skytte, J. L., Frosch, S.
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Research output: Contribution to journal › Journal article – Annual report year: 2017 › Research › peer-review

Muscle Protein Profiles Used for Prediction of Texture of Farmed Salmon (Salmo salar L.)
A soft texture is undesired in Atlantic salmon as it leads to downgrading and reduced yield, yet it is a factor for which the cause is not fully understood. This lack of understanding highlights the need for identifying the cause of the soft texture and developing solutions by which the processing industry can improve the yield. Changes in muscle protein profiles can occur both pre- and postharvest and constitute an overall characterization of the muscle properties including texture. The aim of this study was to investigate this relationship between specific muscle proteins and the texture of the salmon fillet. Samples for 2D-gel-based proteomics were taken from the fillet above the lateral line at the same position as where the texture had been measured. The resulting protein profiles were analyzed using multivariate data analysis. Sixteen proteins were found to correlate to the measured texture, showing that it is possible to predict peak force based on a small subset of proteins. Additionally, eight of the 16 proteins were identified by tandem mass spectrometry including serum albumin,
dipeptidyl peptidase 3, heat shock protein 70, annexins, and a protein presumed to be a titin fragment. It is contemplated that the identification of these proteins and their significance for the measured texture will contribute to further understanding of the Atlantic salmon muscle texture.

**General information**

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**Organisations:** National Food Institute, Research group for Food Production Engineering, Novo Nordisk Foundation Center for Biosustainability, CHO Core, iLoop, University of Iceland

**Contributors:** Johansson, G. Ø., Frosch, S., Gudjónsdóttir, M., Wulff, T., Jessen, F.

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**Source:** FindIt

**Source ID:** 2356235282

**Research output:** Contribution to journal  >  Journal article  >  Annual report year: 2017  >  Research  >  peer-review

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**Variation in some quality attributes of Atlantic salmon fillets from aquaculture related to geographic origin and water temperature**

It is well known that factors like fat content and texture affect the yield when making products from Atlantic salmon (Salmo salar L.). The relation between these factors and other quality attributes like water holding capacity and protein content, however, has received limited attention. To enable an efficient use of the information gathered in the different links of the value chain, a deeper knowledge of the correlations between the various quality attributes and factors like the geographical origin of the salmon, the company and the water temperature of the fish farm, is needed. In the present study a multivariate approach was taken to investigate the variation in some quality parameters (fat, protein, texture, water holding capacity, weight) amongst salmon samples (n = 136) from Norwegian aquaculture in order to establish which parameters were accounting for most of the variation seen in relation to the geographical origin and thereby of the sea temperature at harvest. The protein content of farmed Atlantic salmon sampled at different times of year varied substantially and was significantly correlated to the sea temperature. Fat and water content were also negatively correlated yet the correlation coefficient was numerical lower than what is usually seen in fatty fish, which could be a consequence of the varying protein content. A variation in both texture and water holding capacity was observed between the rearing companies. The present study adds to the existing knowledge regarding texture differences and contributes with new knowledge about the proximate composition of Atlantic salmon from aquaculture. Moreover we show that analysing different parameters holistically may reveal a new dimension in the information regarding differences between companies and regions in relation to the final quality of the filleted salmon.

**Statement of relevance**

This study confirms the differences in texture observed by the industry and adds to the existing knowledge regarding the proximate composition of Atlantic salmon from aquaculture. Moreover, it shows that analysing different quality parameters holistically may uncover a new dimension in the information regarding differences between companies and regions of Norway in relation to the final quality of the salmon.

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**General information**

**Publication status:** Published

**Organisations:** National Food Institute, Research group for Food Production Engineering

**Contributors:** Johansson, G. Ø., Frosch, S., Jørgensen, B. M.
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.
Biological variation of the raw material and processing conditions affect the yield and quality of fast-marinated herring

General information
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Organisations: National Food Institute, Research group for Food Production Engineering
Contributors: Ekgreen, M. H., Jørgensen, B. M., Martinez Lopez, B., Frosch, S., Jessen, F.
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Source: PublicationPreSubmission
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Research output: Contribution to conference › Poster – Annual report year: 2016 › Research › peer-review

Effect of storage on oxidative quality and stability of extruded astaxanthin-coated fish feed pellets
This study examined the stability of extruded and astaxanthin-coated fish feed pellets during storage in a light box at 28°C and 620lx. Seven groups of fish feed pellets were vacuum coated with fish oil that contained levels of astaxanthin ranging from 0 to 100ppm. To equalize differences in the conditions for the fish feed pellets inside the light box, the samples were systematically circulated during the experimental storage period of 183days. The degradation of astaxanthin was monitored using multi-spectral images, captured 28 times in the course of the storage period. Additionally, samples were collected at storage day 8, 15, 22, 92 and 183 for chemical determination of the astaxanthin concentration. The degradation of astaxanthin was shown to primarily be affected by light and limited to occur at the surface of the fish feed pellets, whereas the astaxanthin embedded in the core of the pellets was comparatively protected against degradation. Furthermore, the initial concentrations of astaxanthin influenced the degradation per se, signifying self-protective properties of astaxanthin.

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Organisations: National Food Institute, Department of Systems Biology, Others, Research group for Food Production Engineering, Enzyme and Protein Chemistry
Contributors: Dethlefsen, M. W., Hjermitslev, N. H., Frosch, S., Nielsen, M. E.
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Web of Science (2016): Impact factor 1.755
Web of Science (2016): Indexed yes
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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.

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Organisations: National Food Institute, Research group for Food Production Engineering, Royal Greenland A/S
Contributors: Feyissa, A. H., Bøknæs, N., Nielsen, P., Frosch, S.
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Investigation of ohmic heating for seafood processing

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Research output: Chapter in Book/Report/Conference proceeding › Conference abstract in proceedings – Annual report year: 2016 › Research › peer-review

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.
Hyperspectral imaging based on diffused laser light for prediction of astaxanthin coating concentration

We present a study on predicting the concentration level of synthetic astaxanthin in fish feed pellet coating using multi- and hyperspectral image analysis. This was done in parallel using two different vision systems. A new instrument for hyperspectral imaging, the SuperK setup, using a super-continuum laser as the light source was introduced. Furthermore, a parallel study with the commercially available multispectral VideometerLab imaging system was performed. The SuperK setup used 113 spectral bands (455–1,015 nm), and the VideometerLab used 20 spectral bands (385–1,050 nm). To predict the astaxanthin concentration from the spectral image data, the synthetic astaxanthin content in the pellets was measured with the established standard technique; high-pressure liquid chromatography (HPLC). Regression analysis was done using partial least squares regression (PLSR) and the sparse regression method elastic net (EN). The ratio of standard error of prediction (RPD) is the ratio between the standard deviation of the reference values and the prediction error, and for both PLSR and EN both devices gave RPD values between 4 and 24, and with mean prediction error of 1.4–8.0 parts per million of astaxanthin concentration. The results show that it is possible to predict the synthetic astaxanthin concentration in the coating well enough for quality control using both multi- and hyperspectral image analysis, while the SuperK setup performs with higher accuracy than the VideometerLab device for this particular problem. The spectral resolution made it possible to identify the most significant spectral regions for detection of astaxanthin. The results also imply that the presented methods can be used in general for quality inspection of various coating substances using similar coating methods.
Automatic scatter detection in fluorescence landscapes by means of spherical principal component analysis

In this paper, we introduce a new method, based on spherical principal component analysis (S-PCA), for the identification of Rayleigh and Raman scatters in fluorescence excitation–emission data. These scatters should be found and eliminated as a prestep before fitting parallel factor analysis models to the data, in order to avoid model degeneracies. The work is inspired and based on a previous research, where scatter removal was automatic (based on a robust version of PCA called ROBPCA) and required no visual data inspection but appeared to be computationally intensive. To overcome this drawback, we implement the fast S-PCA in the scatter identification routine. Moreover, an additional pattern interpolation step that complements the method, based on robust regression, will be applied. In this way, substantial time savings are gained, and the user's engagement is restricted to a minimum, which might be beneficial for certain applications. We conclude that the subsequent parallel factor analysis models fitted to excitation–emission data after scatter identification based on either ROBPCA or S-PCA are comparable; however, the modified method based on S-PCA clearly outperforms the original approach in relation to computational time.

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Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, National Food Institute, Division of Industrial Food Research
Contributors: Kotwa, E. K., Jørgensen, B. M., Brockhoff, P. B., Frosch, S.
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Improving the Supply Chain and Food Quality of Professionally Prepared Meals

An increasing share of the daily meals served in Europe is prepared out-of-home by professionals in foodservice. The quality of such meals is highly debated. This paper presents and discusses obstacles to improving quality in a cost-effective way and suggests solutions: 1) Modularisation of the meal production in order to transfer labour-intensive operations from the kitchens to the industry; 2) Systemic use of a new concept: thawing during distribution, which improves shelf-life and reduces waste; 3) Supply chain modelling to improve delivery schedules and reduce environmental impact. Existing food legislation complies with the suggested approaches.

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Organisations: National Food Institute, Division of Industrial Food Research, Technische Universität München
Contributors: Adler-Nissen, J., Akkerman, R., Frosch, S., Grunow, M., Leje, H., Risum, J., Wang, Y., Johansson, G. Ø.
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Multispectral Image Analysis for Robust Prediction of Astaxanthin Coating

The aim of this study was to investigate the possibility of predicting the type and concentration level of astaxanthin coating of aquaculture feed pellets using multispectral image analysis. We used both natural and synthetic astaxanthin, and we used several different concentration levels of synthetic astaxanthin in combination with four different recipes of feed pellets. We used a VideometerLab with 20 spectral bands in the range of 385-1050 nm. We used linear discriminant analysis and sparse linear discriminant analysis for classification and variable selection. We used partial least squares regression (PLSR) for prediction of the concentration level. The results show that it is possible to predict the level of synthetic astaxanthin coating using PLSR on either the same recipe, or when calibrating on all recipes. The concentration prediction is adequate for screening for all recipes. Moreover, it shows that it is possible to predict the type of astaxanthin used in the coating using only ten spectral bands. Finally, the most selected spectral bands for astaxanthin prediction are in the visible range of the spectrum.

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Organisations: Department of Applied Mathematics and Computer Science, National Food Institute, Division of Industrial Food Research, Division of Toxicology and Risk Assessment, Statistics and Data Analysis
Contributors: Ljungqvist, M. G., Frosch, S., Nielsen, M. E., Ersbøll, B. K.
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Optimizing chocolate production through traceability: A review of the influence of farming practices on cocoa bean quality
Due to recent developments in traceability systems, it is now possible to exchange significant amounts of data through food supply chains. Farming practices applied by cocoa farmers at the beginning of the chocolate supply chain strongly influence several quality parameters of the finished chocolate. However, information regarding these practices does not
normally reach the chocolate manufacturer. As a consequence, many specifications of the raw material cannot be taken into consideration in the operational decision making processes related to chocolate production. In recent years many studies have been investigating the influence of certain farming practices on cocoa beans and the subsequent chocolate quality parameters. However, no comprehensive analysis of the process variables in the chain and their effects on the quality can be found. In this paper we review and classify the available literature on the topic in terms of process variables throughout the chain, and their effects on quality and flavour aspects of cocoa beans and the eventual chocolate product. After analyzing the literature, we are able to identify potential benefits of using data regarding the farming practices into the chocolate production process. These potential benefits especially concern product quality and production yield, giving directions for the future of chocolate production.

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Contributors: Saltini, R., Akkerman, R., Frosch, S.
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Original language: English
Keywords: Chocolate, Traceability, Cocoa beans, Food quality, Optimization, Supply chain

Classification of Astaxanthin Colouration of Salmonid Fish using Spectral Imaging and Tricolour Measurement
The goal of this study was to investigate if it is possible to differentiate between rainbow trout (Oncorhynchus mykiss) having been fed with natural or synthetic astaxanthin. Three different techniques were used for visual inspection of the surface colour of the fish meat: multi-spectral image capturing, tricolour CIELAB measurement, and manual SalmoFan inspection. Furthermore it was tested whether the best predictions come from measurements of the steak or the fillet of the fish. Methods used for classification were linear discriminant analysis (LDA), quadratic discriminant analysis (QDA), and sparse linear discriminant analysis (SLDA).

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Organisations: Department of Informatics and Mathematical Modeling, DTU Data Analysis, National Food Institute, Division of Industrial Food Research
Contributors: Ljungqvist, M. G., Dissing, B. S., Nielsen, M. E., Ersbøll, B. K., Clemmensen, L. K. H., Frosch, S.
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Publisher: Technical University of Denmark (DTU)
Original language: English
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Multispectral Image Analysis for Astaxanthin Coating Classification

Industrial quality inspection using image analysis on astaxanthin coating in aquaculture feed pellets is of great importance for automatic production control. The pellets were divided into two groups: one with pellets coated using synthetic astaxanthin in fish oil and the other with pellets coated only with fish oil. In this study, multispectral image analysis of pellets captured reflection in 20 wavelengths (385–1050 nm). Linear discriminant analysis (LDA), principal component analysis, and support vector machine were used as statistical analysis. The features extracted from the multispectral images were pixel spectral values as well as using summary statistics such as the mean or median value of each pellet. Classification using LDA on pellet mean or median values showed overall good results. Multispectral imaging is a promising technique for noninvasive on-line quality food and feed products with optimal use of pigment and minimum amount of waste.

Near-Infrared Hyper-spectral Image Analysis of Astaxanthin Concentration in Fish Feed Coating

The aim of this study was to investigate the possibility of predicting concentration levels of synthetic astaxanthin coating of aquaculture feed pellets by hyper-spectral image analysis in the near infra-red (NIR) range and optical filter design. The imaging devices used were a VideometerLab with 20 wavelengths in the range of 385-1050 nm, and a Specim camera with 256 wavelengths in the range of 970-2500 nm. Linear discriminant analysis (LDA), partial least squares regression (PLSR), and a modified stepwise random selection with ordinary least squares (OLS) for filter selection was used for prediction of the concentration level. The results show that it is possible to predict the level of synthetic astaxanthin coating using either hyper-spectral imaging or three bandpass filters (BPF).
Previous bacterial infection affects textural quality parameters of heat-treated fillets from rainbow trout (Oncorhynchus mykiss)

Sensory quality of fish meat is influenced by many parameters prior to slaughter. In the present study, it was examined if previous infections or damages in the muscle tissue influence product quality parameters in fish. Fillets from rainbow trout (Oncorhynchus mykiss) reared in seawater at a commercial fish farm were sensory evaluated for more than a year after recovery following physical tissue damage or infection by the bacterial pathogens Yersinia ruckeri and Vibrio anguillarum. The effect of vaccination was also included as some fish were vaccinated before bacterial challenge. The fish fillets were sensory examined as heat-treated and cold-smoked. Heat-treated fillets from nonvaccinated fish previously infected by V. anguillarum had changed textural characteristics and were less flaky, had a lower oiliness and a higher toughness and fibrousness in comparison with control fish. This article was the first to describe a correlation between previous infections in fish and changes in sensory-quality parameters. PRACTICAL APPLICATIONS. This work contributes with knowledge about sensory-quality parameters of fish meat after recovery from infections and physical-tissue damage. Because the results demonstrate an influence on the texture from previous disease, the practical potentials of the results are valuable for the aquaculture industry. In order to minimize the effects of previous diseases on the sensory quality regarding the texture, these fishes should be processed as cold-smoked instead of being sold as raw meat. The established correlation between disease history stresses the importance of disease prevention in aquaculture production, e.g., vaccination of the fish.

Determination of astaxanthin concentration in Rainbow trout (Oncorhynchus mykiss) by multispectral image analysis.

Astaxanthin is the single most expensive constituent in salmonid fish feed. Therefore control and optimization of the astaxanthin concentration from feed to fish is of paramount importance for a cost effective salmonid production. Traditionally, methods for astaxanthin determination include extraction of astaxanthin from the minced sample into a suitable solvent such as acetone or hexane before further analysis. The existing methods have several drawbacks including being destructive and labour consuming. Current state-of-the-art vision systems for quality and process control in the fish processing industries are typically based on traditional trichromatic (Red Green Blue) imaging. The relative presence of some wavelengths and absence of others is a specific characteristic of many material properties. Consequently, the adaption of multispectral imaging technology can reveal relevant information and measurement of more biological quality parameters such as fat, astaxanthin and cartilage content, simultaneously. A multispectral image may also be referred to as a surface chemistry map where a set of neighbouring spectra are recorded, revealing information about the surface chemistry to a larger degree than in a trichromatic image. In this study multispectral imaging has been
evaluated for characterization of the concentration of astaxanthin in rainbow trout fillets. Rainbow trout's (Oncorhynchus mykiss), were filleted and imaged using a rapid multispectral imaging device. The multispectral imaging device captures reflection properties in 19 distinct wavelength bands. Subsequently, the astaxanthin concentration was determined by a traditional chemical method. The astaxanthin concentration of the analysed samples ranged from 0.20 to 4.34 ppm. In total 7 samples were detected as outliers and removed from the data set before further analysis. A partial least squares regression (PLSR) model was build to predict the astaxanthin concentration from novel images. The obtained model was evaluated with a test set. The root mean square error of prediction obtained from the test set was 0.27 ppm and a goodness of fit of 0.86. The PLSR model made it possible to predict the astaxanthin concentration in each pixel of the image – surface chemistry map - and thereby show the astaxanthin distribution in the fillet. The projected images clearly show a difference in astaxanthin distribution, showing that the upper part of the fillet contains the highest concentration of astaxanthin. This study has shown that multispectral imaging is a promising method for rapid and non-destructive analysis of astaxanthin concentration of rainbow trout, and thereby a qualified candidate for replacement of traditional laborious and destructive analysis of the astaxanthin concentration.

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**Image Analysis of Pellet Size for a Control System in Industrial Feed Production**

When producing aquaculture fish feed pellets, the size of the output product is of immense importance. As the production method cannot produce pellets of constant and uniform size using constant machine settings, there is a demand for size control. Fish fed with feed pellets of improper size are prone to not grow as expected, which is undesirable to the aquaculture industry. In this paper an image analysis method is proposed for automatic size-monitoring of pellets. This is called granulometry and the method used here is based on the mathematical morphological opening operation. In the proposed method, no image object segmentation is needed. The results show that it is possible to extract a general size distribution from an image of piled disordered pellets representing both length and diameter of the pellets in combination as an area.

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Multi-spectral Image Analysis for Astaxanthin Coating Classification

Industrial quality inspection using image analysis on astaxanthin coating in aquaculture feed pellets is of great importance for automatic production control. In this study multi-spectral image analysis of pellets was performed using LDA, QDA, SNV and PCA on pixel level and mean value of pixels for each pellet. Classification using LDA or QDA on pellet mean or median values showed better results than using the pixel values or PCA.

Multispectral Imaging for Determination of Astaxanthin Concentration in Salmonids

Multispectral imaging has been evaluated for characterization of the concentration of a specific carotenoid pigment; astaxanthin. 59 fillets of rainbow trout, Oncorhynchus mykiss, were filleted and imaged using a rapid multispectral imaging device for quantitative analysis. The multispectral imaging device captures reflection properties in 19 distinct wavelength bands, prior to determination of the true concentration of astaxanthin. The samples ranged from 0.20 to 4.34 µg per g fish. A PLSR model was calibrated to predict astaxanthin concentration from novel images, and showed good results with a RMSEP of 0.27. For comparison a similar model were built for normal color images, which yielded a RMSEP of 0.45. The acquisition speed of the multispectral imaging system and the accuracy of the PLSR model obtained suggest this method as a promising technique for rapid in-line estimation of astaxanthin concentration in rainbow trout fillets.
Oxidative stability of frozen mackerel batches – A multivariate data analysis approach

Mackerel are usually caught in the autumn and often frozen either on board the fishing vessel or soon after landing. Due to the seasonality of the catching period, mackerel can be stored frozen for a long time period before entering the production chain. However, frozen storage of fatty fish such as mackerel can lead to a significant loss in fish quality primarily due to oxidation of the long chain omega-3 fatty acids. These quality changes result in significant loss for the fish processing industries and in fish with poor eating quality. In order to investigate batch-to-batch variation due to different catching methods and different freezing procedures 6 batches of frozen mackerel were obtained from the local producer of canned mackerel. Fish were processed as soon as possible after landing i.e. headed, gutted and individually frozen at the industry. However, one of the catch was abused and stored on ice for 8 days before entering the production line.

Subsequently, samples from the catches were sent to our laboratory where they were stored frozen at -30 °C for a period of 12 months. At intervals of 6 weeks samples were taken and analysed for proximate analysis as well as for oxidative deterioration and texture changes. The aim was to investigate the correlation between the raw material history and the quality loss observed during frozen storage using relevant multivariate data analysis such as Principal Component Analysis (PCA) and Partial Least Square Analysis (PLS). Preliminary results showed that it was possible to differentiate between the different batches depending on their history and that some batches were more oxidised than others. Furthermore, based on the results from the data analysis, critical control points in the entire production chain will be identified and strategies to prevent quality loss proposed.
Using image analysis to monitor biological changes in consume fish

The quality of fish products is largely defined by the visual appearance of the products. Visual appearance includes measurable parameters such as color and texture. Fat content and distribution as well as deposition of carotenoid pigments such as astaxanthin in muscular and fat tissue are biological parameters with a huge impact on the color and texture of the fish muscle. Consumer-driven quality demands call for rapid methods for quantification of quality parameters such as fat and astaxanthin in the industry. The spectral electromagnetic reflection properties of astaxanthin are well known and have in previous studies been shown to change as a function of astaxanthin concentration. This may be utilized to quantify the amount of astaxanthin contained in salmonid fishes by assessing a spectral measurement of the fillet. Existing ways of assessing the amount of astaxanthin and fat in salmonid fishes is based on highly laborious chemical analysis. Trichromatic digital imaging and point-wise colorimetric or spectral measurement are also ways of estimating either the redness or the actual astaxanthin concentration of the fillet. These methods all have drawbacks of either cumbersome testing or lack of spectral or spatial information. The use of multispectral imaging to assess the variation in fat and astaxanthin concentration both between fish and within fish is investigated. Since reference values cannot be obtained corresponding to pixel-wise measurements, sub areas of the fillet are predicted and averaged in order to establish correlation to reference measurements. In the present experiment salmon fillets were sampled at different locations. Each sample consists of a biopsy which was cut in three layers in order to understand the depth distribution of astaxanthin as well as the spatial distribution. For each layer in each sample, chemical fat and astaxanthin determination was carried out as a reference value and a multispectral image was acquired to establish a correlation. A prediction model has been calibrated to predict the astaxanthin concentration on a pixel-wise level resulting in an astaxanthin-map of the fillet reflecting the intra fillet variation in astaxanthin concentration. The model is validated according to spatially varying samples across the fillet.
Visualizing wound healing in fish

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Analysis of Astaxanthin in Fish Feed Pellets

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Cod and rainbow trout as freeze-chilled meal elements

Meal elements' are elements of a meal, e.g. portions of pre-fried meat, sauces, frozen fish or pre-processed vegetables typically prepared industrially. The meal elements are distributed to professional satellite kitchens, where the staff can combine them into complete meals. Freeze-chilling is a process consisting of freezing and frozen storage followed by thawing and chilled storage. Combining the two would enable the manufacturer to produce large quantities of frozen meal elements to be released into the chill chain according to demand. We have studied the influence of freeze-chilling on the quality attributes of cod and rainbow trout portions. Sensory profiling and chemical analyses were used to determine the changes in quality after slow thawing and subsequent chill storage and to find the high-quality shelf life. RESULTS: Cod had a consistent and high sensory quality during the first 6 days of chilled storage, and the corresponding time for rainbow trout was 10 days. After this period the sensory quality decreased and chemical indicators of spoilage were seen to increase. CONCLUSION: The consistent quality during storage and the high-quality shelf life are practically applicable and cod and rainbow trout seem potential candidates for freeze-chilled meal elements. (C) 2009 Society of Chemical Industry

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Determination of ice-glaze content of individually quick frozen prawns by acoustics - the sound of frozen prawns.

Effect of astaxanthin concentration and origin on color setting in Danish trout aquaculture measured by multi-spectral vision analysis.

Multispectral image analysis in seafood
A fully robust PARAFAC method for analyzing fluorescence data

Parallel factor analysis (PARAFAC) is a widespread method for modeling fluorescence data by means of an alternating least squares procedure. Consequently, the PARAFAC estimates are highly influenced by outlying excitation-emission landscapes (EEM) and element-wise outliers, like for example Raman and Rayleigh scatter. Recently, a robust PARAFAC method that circumvents the harmful effects of outlying samples has been developed. For removing the scatter effects on the final PARAFAC model, different techniques exist. Newly, an automated scatter identification tool has been constructed. However, there still exists no robust method for handling fluorescence data encountering both outlying EEM landscapes and scatter. In this paper, we present an iterative algorithm where the robust PARAFAC method and the scatter identification tool are alternately performed. A fully automated robust PARAFAC method is obtained in that way. The method is assessed by means of simulations and a laboratory-made data set.

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Development and application of image analysis and multivariate statistics in industrial production of aquaculture feed

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Digitale fotos afslører fiskekvalitet

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Organisations: Division of Food Production Engineering, National Food Institute, Division of Seafood Research, Innovation and Sustainability, Department of Management Engineering
Quality effect of freeze-chilling in cod and rainbow trout

‘Meal elements’ is the name of a concept in which elements of a meal, e.g. portions of pre-fried meat, sauces, fish or pre-processed vegetables are prepared industrially. The meal elements are distributed to professional satellite kitchens for instance in hospitals and canteens, where the kitchen staff combines the different meal components to a complete meal.

Freeze-chilling is a process consisting of freezing and frozen storage followed by thawing and chilled storage and could be
an ideal technique to combine with the concept of meal elements. Freeze-chilling would enable manufacturers to produce large quantities of frozen meal elements to be released into the chill chain according to market demands. This procedure would allow the products to thaw during transport, and by arrival the thawed meal elements would be ready for use or chill storage.

We have studied the influence of freeze-chilling on the quality of raw fish portions as an example of a meal element. The thawing of frozen products during transport was mimicked by placing cardboard boxes with frozen, vacuum packaged portions of fish in a chilling facility and allowing them to thaw slowly. To mimic possible subsequent chill storage at the satellite kitchens the quality was also followed during a storage period. The quality changes were evaluated on the basis of the results from descriptive sensory analysis and analysis of different chemical parameters. The high quality shelf life was determined from these results. As the quality changes are known to differ among fish species, the present study included the popular species cod (Gadus Morhua) and rainbow trout (Oncorhynchus Mykiss).

Principal component analysis of the sensory results clearly showed that after frozen storage at -30 °C for 1 month and subsequent chill storage at +2 °C, trout had a shelf life of approximately 10 days as a high quality product which was perceived indistinctly from the freshly thawed samples by the sensory panel. The corresponding high quality shelf life for cod was 6 days.

In conclusion, the consistent quality during storage and the high quality shelf life is practically applicable and cod and rainbow trout seem potential candidates for freeze-chilled meal elements.

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Auto-fluorescence of fish muscle juice. Resolution into components by robust PARAFAC with automatic scatter correction
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Opportunities for the herring industry to optimize operations through information recording, effective traceability systems, and use of advanced data analysis
Simulated recalls of fish products in five Nordic countries

Simulated recalls of fish products sampled in retailer shops were conducted in five Nordic countries to indicate the effectiveness and accuracy of chain traceability systems. The results suggested poor traceability practices at the vessels/auctions and revealed that batch sizes at the last traceable step of the raw material vary considerably. However, the existing traceable information seemed to be easily accessible. Altogether, the fish industry in the Nordic countries seems not to be fully prepared for a recall. Improved traceability awareness and practices in the whole chain can limit the batch sizes and minimize costs in case of a real recall. (C) 2007 Elsevier Ltd. All rights reserved.

Automatically identifying scatter in fluorescence data using robust techniques

First and second order Rayleigh and Raman scatter is a common problem when fitting Parallel Factor Analysis (PARAFAC) to fluorescence excitation-emission data (EEM). The scatter does not contain any relevant chemical information and does not conform to the low-rank trilinear model. The scatter complicates the analysis instead and contributes to model inadequacy. As such, scatter can be considered as an example of element-wise outliers. However, no straightforward method for identifying the scatter region can be found in the literature. In this paper an automatic scatter identification method is developed based on robust statistical methods. The method does not demand any visual
inspection of the data prior to modeling, and can handle first and second order Rayleigh scatter as well as Raman scatter in various types of EEM data. The results of the automated scatter identification method were used as input data for three different PARAFAC methods. Firstly inserting missing values in the scatter regions are tested, secondly an interpolation of the scatter regions is performed and finally the scatter regions are down-weighted. These results show that the PARAFAC method to choose after scatter identification clearly depends on the data, for example signal to noise ratio and overlap between signal and scatter.

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Peak alignment and robust principal component analysis of gas chromatograms of fatty acid methyl esters and volatiles
Gas chromatograms of fatty acid methyl esters and of volatile lipid oxidation products from fish lipid extracts are analyzed by multivariate data analysis [principal component analysis (PCA)]. Peak alignment is necessary in order to include all sampled points of the chromatograms in the data set. The ability of robust algorithms to deal with outlier problems, including both sample-wise and element-wise outliers, and the advantages and drawbacks of two robust PCA methods, robust PCA (ROBPCA) and robust singular value decomposition when analysing these GC data were investigated. The results show that the usage of ROPCA is advantageous, compared with traditional PCA, when analysing the entire profile of chromatographic data in cases of sub-optimally aligned data. It also demonstrates how choosing the most robust PCA (sample or element-wise) depends on the type of outliers present in the data set.

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Simulated recalls of fish products in five Nordic countries

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Simulerede tilbagekaldelser af fiskeprodukter i fem nordiske lande

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Sporbarhed og kvalitetssikring i fiskekæden

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Værdioptimering af fiskebranchen gennem: Matematisk modellering, informationsudnyttelse, kædesamarbejde, markeds- og omsætningskendskab

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The importance of data quality and traceability in data mining. Applications of robust methods for multivariate data analysis. A case-study conducting the herring industry

The general aim of the thesis was to develop a documentation system and to improve the background upon which the decision-making process for quality and production control is founded within a herring processing industry. Furthermore, the possibilities of utilizing multivariate data analyses were investigated conducting data from catch to final product throughout the production chain. When generating vast amount of data, as in the case of processing herring, various samples turn out to deviate from the majority of samples, also designated outliers. Due to the nature of outliers, they posses the ability to impair analysing models based on traditional multivariate methods using least squares estimation. For that reason, possible advantages or drawbacks employing robust multivariate methods were investigated as a favoured alternative to the traditional methods.

The first part of the exploratory work was carried out as a case-study, exploiting the multiplicity of empirical and biological data, intended for quality determination in one of the leading businesses within the herring industry in Denmark. The work started out constructing a database to save all registered information, this being extended to be automatically imported, transmitted as e.g. measured weights to the database. In the case of non automatic transmission of data, the import of data to the database was manually recorded as soon as they were generated. The preliminary screening of data demonstrated that traceability could be confirmed from vessel unto the finished marinated produce of herring with the smallest unit of traceability being a batch of topped product. This finding revealed that it was possible, at any time, to track and trace any given product back to the vessel that originally caught the fish, and do extraction of all data connected to that specific product. Unfortunately, a great part of the multiple registrations lacked variability and suffered from uncertainties caused by the lack of traceability and/or misgivings, related to the actual registering of analysis. This, in combination with missing information of relevance, lead to that data at its present form neither had any relevance nor was representative for any further multivariate data analyses. For that reason, it was not possible to identify and link any relations between, for instance the quality characteristics of the raw material and yield, and thereby improve the basis for the decision-making process concerned with quality and production control, within the herring processing industry.
In place of the fact that the data had to be discarded, in relation to multivariate data analyses, they proved useful in the sense that they could be informative in relation to what information needed to be improved or added to be profitable to the business. A few to mention is registration of belly bursting and waste, along with implementation of an on-line determination of fat content on single fish level and consecutive sorting of the raw material based on this fat determination. Additionally, a quality evaluating system of the marinated herring would improve the significance of the data.

Gas chromatograms of fatty acid methyl esters (GC-FAME) and of volatile lipid oxidation products (GC-ATD) from fish lipid extracts were analysed by multivariate data analysis (principal component analysis). Peak alignment was necessary in order to include all sampled points of the chromatograms in the data set. The ability of robust algorithms to deal with outlier problems, including both sample-wise and element-wise outliers, and the advantages and drawbacks of two robust PCA methods, robust PCA (ROBPCA) and robust singular value decomposition (RSVD) when analysing these GC data were investigated. The results showed that the usage of robust PCA is advantageous, compared to traditional PCA, when analysing the entire profile of chromatographic data in cases of sub-optimally aligned data. It was also demonstrated how the robust PCA method – sample (ROBPCA) or elementwise (RSVD) – depended on the type of outliers present in the data set. The potential of removing Rayleigh and Raman scatter from fluorescence data (excitation – emission landscapes), by employing robust PARAFAC, were investigated. A PARAFAC algorithm was made robust by substitution of least squares estimation by least absolute error (LAE). The conclusion was that LAE PARAFAC cannot be considered as a confident method for handling scatter, as a result of the systematic nature of scattering. However, by taking advantage of the systematic nature of the scatter an automatic method based on robust techniques for identification of scatter in fluorescence data were developed. This method can handle both Raman and 1st and 2nd order Rayleigh scatter, and do not demand any priori visual inspection of the data before modelling.

The investigation of using robust calibration methods for prediction of fat content of fish by NIR measurements in a data set with no extreme outliers present showed that the advantages of employing robust methods for prediction was ineligible. A slightly better prediction was obtained with robust SIMPLS (RSIMPLS) compared to classical PLSR, but further investigation is needed to test the performance on an independent test set. Focusing on the drawbacks of the robust methods, especially the lower statistical efficiency and the time-consuming computations, the advantages of robust methods seems to be eliminated, when the dataset contains no obvious outliers.
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.

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Frosch, S., Project Participant, Division of Industrial Food Research
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Prediktiv modellering af kvalitetstab af laks gennem værdikæden
Johansson, G. Ø., PhD Student, National Food Institute
Jørgensen, B. M., Main Supervisor
Frosch, S., Supervisor
New analytical process programs- and technologies for optimisation of acid marinated herring production
Laub-Ekgreen, M. H., PhD Student, National Food Institute
Jessen, F., Main Supervisor
Frosch, S., Supervisor
Jørgensen, B. M., Supervisor
Jacobsen, C., Examiner
Rustad, T., Examiner
Martinez Lopez, B., Supervisor
Szymczak, M., Examiner
01/05/2014 → 30/09/2018
Award relations: New analytical process programs- and technologies for optimisation of acid marinated herring production
Project: PhD

Kvalitetstyrings- og dokumentatikonssystem i sildeindustrien. forbedret dataopsamling og multivariat analyse
Frosch, S., PhD Student, Department of Systems Biology
Jørgensen, B. M., Main Supervisor
Bro, R., Supervisor, Department of Biotechnology and Biomedicine
Frisvad, J. C., Examiner
Bassompierre, M., Examiner
Ridder, C., Examiner
Bro-Jørgensen, R., Supervisor
Ansat ekstern
01/04/2001 → 30/05/2006
Award relations: Kvalitetstyrings- og dokumentatikonssystem i sildeindustrien. forbedret dataopsamling og multivariat analyse
Project: PhD

Food process modeling with integration of process impact and quality mapping
Christensen, M. G., PhD Student, National Food Institute
Adler-Nissen, J., Main Supervisor
Løje, H., Supervisor
Frosch, S., Examiner
Ahrné, L. M., Examiner
Jensen, B. B. B., Examiner
Institut, samfinansiering
01/12/2009 → 04/02/2015
Award relations: Food process modeling with integration of process impact and quality mapping
Project: PhD

Engineering Strategies for improving the convenience food production- industry Case
Pedersen, S. J., PhD Student, National Food Institute
Frosch, S., Main Supervisor
Kulahci, M., Supervisor
Geoffrey Vining, G., Supervisor
Jørgensen, B. M., Examiner
Christensen, L. B., Examiner
Vanhatalo, E., Examiner
Technical University of Denmark
15/11/2012 → 21/04/2016
Award relations: Engineering Strategies for improving the convenience food production- industry Case
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
FluidChip: Proof of Business opportunity with FluidChip at Danæg Products A/S

Danæg has an urgent need to compensate for varying egg quality that is due to varying conditions such as the age of the hen, the age of the egg, time of year, feed or geographical location of the farm. Because of the non-uniform quality of the eggs, the company currently faces a considerably production waste in the production of their processed egg product "long eggs". To reduce production costs and maintain its market position Danæg needs to reduce this production waste.

Activities in the project will follow three tracks:
- A customization of the FluidChip to optimize its sensitivity in distinguishing between varying qualities of raw egg.
- Incorporation of a self-cleaning capability to avoid fouling. This is important to make the apparatus long-time functional.
- Building and testing an off-line prototype. After successful testing, the apparatus is implemented in-line directly in the production facility and will constantly monitor egg quality.

The technological objectives are to develop the apparatus towards in-line analysis at production site and to develop a self-cleaning function that will ensure long-time functionality. This is crucial not only for the implementation of the FluidChip at Danæg, but for all future in-line monitoring of fluidic properties of other fluids. This is the first time the FluidChip will be developed for use in food production. We will prove that the apparatus can be implemented as a production-monitoring tool as referred to in the project-title.

It is the intention that this technology will be the backbone in a future start up. We will in this project prove that the FluidChip is commercially viable. The implementation made possible with this GAP-project will be a "lighthouse example" to convince other mass market manufacturers in the food and biotechnology industry.

This GAP-project does not represent the full commercial potential of the FluidChip. But it proves that the technology is able to meet a need of an industrial manufacturer. The project is crucial in the commercialization of the apparatus. Showing the long-term and in-line functionality of the FluidChip will be the most important steps in proving that the FluidChip is a commercially viable technology.

Frosch, S., Project Participant, National Food Institute, Research group for Food Production Engineering
DTUs GAP funding: DKK381,241.00
01/04/2014 → 30/09/2014
Award relations: Proof of Business opportunity with FluidChip at Danæg Products A/S
Project: Research

Control & Surveillance of Automated Production Steps (a part of the inSPIRe Food)

Summary of project: Automation of many manual operations in the food industry is difficult, because the criteria for process control are often based on tacit knowledge of the operator. Our hypothesis is that a route to optimal automation of such operations is to register how the trained process operator makes decisions from observations of the process and combining this knowledge with predictive modelling of input/output of the process units.

Larsen, R., Project Participant
Ersbøll, B. K., Project Participant, Department of Applied Mathematics and Computer Science, Statistics and Data Analysis
Frosch, S., Project Participant, National Food Institute, Research group for Food Production Engineering
Clemmensen, L. K. H., Project Participant, Department of Applied Mathematics and Computer Science, Statistics and Data Analysis
Larsen, A. B. L., Project Participant, Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Danish Council for Strategic Research: DKK5,218,000.00
01/01/2011 → 31/12/2016
Award relations: Control & Surveillance of Automated Production Steps (a part of the inSPIRe Food)
Project: Research

Optimal fødevarekvalitet vhj online akustiske metoder og robust kemometri

Frosch, S., Project Manager, National Food Institute, Division of Industrial Food Research
Jørgensen, B. M., Project Participant, National Food Institute, Division of Industrial Food Research
Schönemann-Paul, L. D., Project Participant, Royal Greenland A/S
01/04/2008 → 31/03/2011
Collaborators: Royal Greenland A/S
Project: Research

Innovationskonsortiet : Innovationskonsortiet - "Optimeret opvarmning og nedkøling af kød-, skaldyr- og osteprodukter"
Blom, K., Project Manager
Frosch, S., Contact Person, National Food Institute, Division of Industrial Food Research
Innovationsfonden: DKK1,500,000.00
01/10/2012 → 30/09/2015
Award relations: Innovationskonsortiet - "Optimeret opvarmning og nedkøling af kød-, skaldyr- og osteprodukter"
Project: Research
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 of:

- 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.

Blom, K., Project Manager
Frosch, S., Contact Person, National Food Institute, Division of Industrial Food Research
Danish Agency for Science and Higher Education: DKK1,500,000.00
01/10/2012 → 30/09/2015
Award relations: Innovation consortium - Optimized heating and cooling of meat, shellfish and cheese products
Project: Research

BOPFISK: Follow the fish – Sustainable and optimal resource utilization in the Danish fish industry
Frosch, S., Project Participant, National Food Institute, Division of Industrial Food Research
Johansson, G. Ø., PhD Student, National Food Institute, Division of Industrial Food Research
Nielsen, M. E., Project Participant, National Food Institute, Division of Industrial Food Research
Adler-Nissen, J., Project Participant, National Food Institute, Division of Industrial Food Research
Dissing, B. S., Project Participant, National Food Institute, Division of Industrial Food Research
Grønt Udviklings- og Demonstrationsprogram: DKK5,309,520.00
01/07/2012 → 30/06/2016
Collaborators: Danish Seafood Association, Skagerak Salmon A/S
Award relations: Follow the fish – Sustainable and optimal resource utilization in the Danish fish industry
Project: Research

Optimal food quality by on-line acoustic methods and robust chemometrics
Frosch, S., Project Manager, National Food Institute
Forskningsprojekter - Fødevareministeriet
01/04/2008 → 30/09/2010
Award relations: Optimal food quality by on-line acoustic methods and robust chemometrics
Project: Research

Activities:

Acoustic measurements for grading of ice-glaze content of single frozen prawns
Period: 1 Nov 2012
Stina Frosch (Lecturer)
National Food Institute
Division of Industrial Food Research
Description
Frosch S, Ekgreen MH and Jørgensen BM.

Related event
4th TransAtlantic Fisheries Technology Conference
30/10/2012 → 02/11/2012
Clearwater, FL, United States
Activity: Talks and presentations › Conference presentations

Acoustic measurements for grading of ice-glaze content of single frozen prawns.
Period: 1 Nov 2012
Stina Frosch (Lecturer)
National Food Institute
Division of Industrial Food Research
Description
Acoustic measurements for grading of ice-glaze content of single frozen prawns. Frosch S, Ekgreen MH and Jørgensen BM.

Related event
4th TransAtlantic Fisheries Technology Conference
30/10/2012 → 02/11/2012
Clearwater, FL, United States