

Technology News.

INFORMATION FROM SIK – THE SWEDISH INSTITUTE FOR FOOD AND BIOTECHNOLOGY

April 2007

Processing

Decontamination of powders by infrared (IR) irradiation

This PhD project by Norman Staack was first presented in our April 2006 issue. The aim of the work is to develop a new decontamination process for sensitive powders such as spices using IR radiation. Initial studies with paprika powder showed that IR treatment achieved a 4 log bacterial reduction (inoculated *Bacillus cereus* and natural flora) in powder wetted to a water activity (aw) of 0.95.

At the PARTEC 2007 Congress on Particle Technology in Nuremberg in March, Norman Staack presented a poster, co-authored by Dietrich Knorr (Berlin Technical University) and Lilia Ahrné (SIK) entitled "Study of heat transfer in paprika powder (*Capsicum annuum*) by infrared heating".

In this work, near and medium infrared energy sources at different emitted heat fluxes were used to heat a 1cm thick layer of paprika powder, wetted to three different water activities in the range 0.5 to 0.96. Temperature profiles through the product layer, temperature gradients between 1 and 3 mm in depth and absorbed IR energy at different depths, were determined.

A significantly higher surface temperature was noted at lower water activity for a given emitted IR flux, and energy absorption and differences in heat distribution and temperature gradients were greater. Higher emitted heat flux also resulted in higher temperature gradients.

IR radiation was effective in heating the surface of the powder layer, heat transfer to the interior being mainly due to conduction. However, at low aw a significant percentage of heat flux at a depth of 3mm was due to radiation (high penetration). IR heating is strongly related to the moisture level in the product, high water activities showing lower absorption and longer heating times. Medium IR showed higher surface temperature than near IR at the same emitted heat flux, the difference decreasing with increasing water activity in the product.

Better uniformity in microwave heating of ready meals

One of the work packages within the EU Novel Q project is entitled "Improving the microwave heating uniformity of prepared food products". Here SIK co-operates with a major food company, the overall objective being to demonstrate the applicability of numerical modelling tools for improving the quality related to heating uniformity following microwave heating of ready meals.

In a recent research project at SIK, a novel method for finding the best design for a food product and package for microwave defrosting and heating was developed by combining thermal and electromagnetic models to predict temperature profiles in foods. In the current EU project, a demonstration version of an expert system will be developed with the aim of demonstrating how the design of microwaveable ready meals can be improved with regard to heating uniformity.

In the first phase of this project, a model ready meal was selected by the industrial partner. For the different components of this meal (meatballs, mashed potatoes, mixed vegetables and a lingonberry sauce), density as well as thermal and dielectric properties are determined as a function of temperature and enthalpy, the data needed in the modelling work. The selected meal is being evaluated with regard to heating uniformity, both experimentally in a microwave oven and theoretically using numerical modelling.

Comparing the experimental and simulation results, the improved design of the meal layout will be tested in continued modelling, followed by comparative practical evaluation tests. In addition, microwave heating experiments will be carried out to compare the heating characteristics of the model meal with a number of other similar meals, using different food components.

The formation of acrylamide in bread baking

As referred to in our previous issues of January and April 2006, SIK has been participating in a 3-year EU project,



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The next issue of this newsletter is due in July 2007.

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Heatox, to study acrylamide in heat-processed foods. With partial support from the Swedish government agency VINNOVA, work at SIK has been devoted to studying the baking of bread and the means of reducing acrylamide formation without any loss in product appearance and quality. The project has now been concluded, and a first research report has been accepted for publication in the LWT journal, entitled "Effect of crust temperature and water content on acrylamide formation during baking of white bread: Steam and falling temperature baking", written by Lilia Ahrné, Claes-Göran Andersson, Per Floberg and Hans Lingnert, SIK, and Johan Rosén, Swedish National Food Administration.

In a multifactorial experiment, 200 g pieces of dough were baked in rectangular tins in an oven without air circulation, at oven temperatures of 200°C, 230°C and 260°C, until the crust was fully baked, with the temperature in the crust measured at 1 mm and 2 mm from the surface and in the bread centre. After baking, the effect of crust temperature and water content on acrylamide formation was studied. For baking at 200°C and 230°C, the acrylamide concentration in the top crust increased with temperature and was 2-3 times higher than in the inner crust. At 260°C acrylamide concentration again decreased, but crust colour and product quality were now unacceptable. Both the crust temperature and water content had a significant effect on acrylamide formation.

Additional baking experiments were made in a convection baking oven to assess the effect of steam on water content in the crust and on acrylamide formation, injecting steam after 5, 10 and 15 minutes through to the end of baking time, which was 20 minutes in total. Experiments were also made with falling temperature baking, lowering oven temperature at regular intervals.

Steam and falling temperature baking are simple modifications of traditional baking, which produce bread acceptable in crust colour and quality and with significantly reduced acrylamide content, the lowest values being produced by steam baking. Figure 1 demonstrates the relationship between colour and acrylamide formation for the different baking methods and how the same crust colour as in traditional baking can be achieved by modified baking methods, reducing acrylamide to one-third of that of conventional oven baking.

Departmental news

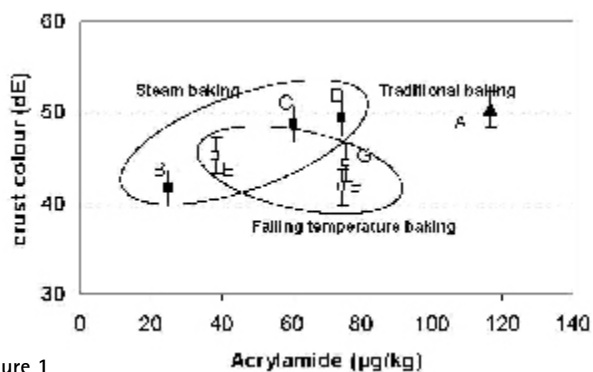


Figure 1

At the PARTEC 2007 congress on Particle Technology in Nuremberg in March, Norman Staak presented a poster on recent work in his doctorate project on powder decontamination by IR heating. Co-authors were D. Knorr, Berlin University, and Lilia Ahrné.

Thomas Ohlsson will present a paper on "Food Factory of Tomorrow" at a conference on "Perspectives for food 2030", on April 17-18 in Brussels, arranged by the European Commission.

At the LMC congress on Innovations in Food Technology in Copenhagen, Denmark, in September, presentations will be given by Thomas Ohlsson, Lilia Ahrné, Emma Holtz and Norman Staack, SIK. Lilia Ahrné is also on the Scientific Committee of the congress, which is organised by the Danish Centre for Advanced Food Studies (LMC).

Microbiology

Pulsed electric field treatment of fluid foods

Within the EU project HighQ RTE (FP6-FOOD-023140; www.highqrte.eu), two parts are currently being run at SIK. Firstly, a new type of treatment chamber for continuous and homogenous PEF (pulsed electric fields) processing has been constructed and is now being tested for the treatment of low-fat milk and whole egg for the inactivation of *Listeria monocytogenes* and *Salmonella sp.* Shortly, we will treat samples to be shipped to our partner Universidad Politecnica de Valencia, Spain, which will analyse the effect of PEF treatment on the microstructure and enzyme stability.

The survival of pathogenic bacteria and the bacterial composition during storage will be analysed at SIK. Secondly, real-time PCR methods are being developed for the separation of living and dead bacteria by the application of propidium monoazid, which prevents the DNA of dead cells from being amplified, and for the quantification of mRNA by RT q-PCR. We are evaluating three housekeeping genes and two genes associated with stress response. The aim is to detect, as early as possible after PEF treatment, the number/activity of surviving bacteria able to grow during subsequent storage.

Biofilm survival on PEF insulating surfaces

In their master's thesis work at Chalmers University of Technology, entitled "The design of a Pulsed Electric Field test chamber for materials, and assessment of biofilm survival in surface cracks in these materials", Siri Secher Myrnel and Emma Jönsson have designed a test chamber for testing the effect of PEF treatment on biofilms of *Pseudomonas fluorescens* on electrically insulating materials commonly used in PEF equipment (Figure 2). The work is part of the EU project Novel Q, which focuses on novel processing techniques in the food industry.

Biofilm was grown on PTFE (Teflon) surfaces, both "new", smooth surfaces and "aged" surfaces with cracks, which were then mounted on a special holder in the treatment chamber and subjected to treatment at different voltages and pulse numbers. The treated surfaces were studied using ATP-luminescence measurement and TTC-agar overlay to compare the effect on "new" and "aged" surfaces. Increasing voltage



Figure 2

and the number of pulses reduced biofilm bacteria slightly, but much less than for bacteria in solution. A suggested explanation is that there is a larger trans-membrane potential over bacteria in a cluster (biofilm) than in a single cell, meaning that biofilms should be more tolerant to PEF treatment. Results indicated that more biofilm remained on "aged" surfaces, cracks evidently having a protecting effect.

Studies like these have not been reported previously, and should be of considerable interest to clarify the hygienic aspects of PEF as a low-temperature, high-quality preservation method.

Real-time PCR methods

Karolina Josefson has presented her master's thesis at Lund University of Technology, entitled "Development of real-time PCR based methods to differentiate between viable and dead *Listeria monocytogenes* cells", with Maria Lövenklev and Elisabeth Borch, SIK as supervisors and Peter Rådström, Lund University of Technology as examiner.

Listeria monocytogenes is a food-borne pathogen, the level of which is not permitted to exceed 100 cfu per gram in ready-to-eat foods. An important task for the food industry is to develop fast, sensitive and specific identification methods. Real-time PCR appears to be just such a method (Figure 3). However, being a DNA-based method, real-time PCR cannot distinguish between viable and dead cells, since DNA is a stable molecule, even if the bacteria it came from is dead. This limitation needs to be overcome.

A real-time PCR assay specific for *L.monocytogenes* was optimised for both cell suspension and genomic DNA. The target (virulence) gene was hlyA, which is well conserved and specific for all *L.monocytogene*. Both assays had good amplification efficiency and could detect low amounts of the pathogenic bacteria.

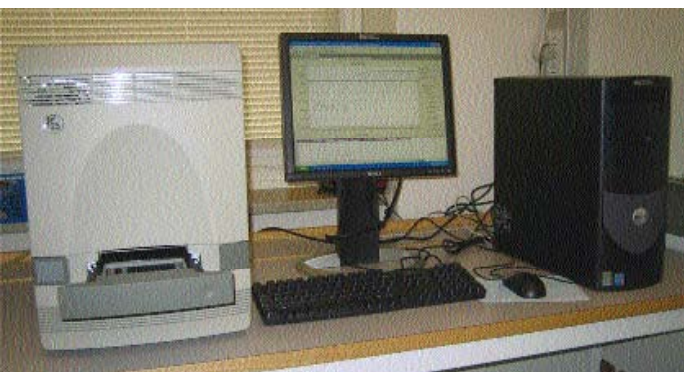


Figure 3

An mRNA assay was developed to differentiate between viable and dead cells, since mRNA is an unstable molecule and thus a marker for viability. The purification to mRNA gave a high yield and the reverse transcription to cDNA gave detection in the real-time PCR. The developed mRNA assay had good amplification efficiency and was sensitive. A ΔC_t of 2.84 was achieved between viable and dead cells, indicating that this method needs further development since the amount of RNA in dead cells should be very low due to fast degradation.

A PMA assay was developed for differentiation between viable and dead cells. PMA is an intercalating dye for inhibiting DNA from dead cells so that the amplification in the real-time PCR only represents viable cells. A factorial design experiment was set up for optimisation of the PMA assay. The best combination gave a ΔC_t of 10.60 between viable and dead cells.

Structure and material design

Rheological properties of doughs of kafirin and zein prolamins

A publication by Anna Oom, Anders Pettersson and Mats Stading, SIK, and John R. N. Taylor, University of Pretoria, South Africa, entitled "Rheological properties of kafirin and zein prolamins", has been accepted for publication in the Journal of Cereal Science.

The aim of the work was to determine whether kafirin has viscoelastic properties in dough-like systems and to compare its dough-forming properties with those of zein and wheat gluten. Laboratory-prepared kafirin and commercial zein were formed into viscoelastic doughs (resins) and their extensional rheological properties determined by means of Contraction Flow measurements. These showed that dough systems prepared from kafirin and from zein had the required rheological properties for baking leavened bread, the extensional viscosity and strain hardening of the kafirin and zein dough systems being similar to those of gluten and wheat flour doughs. However, the kafirin dough systems, unlike the zein systems, rapidly became very stiff, presumably as a result of crosslinking of kafirin monomers.

Characterisation of the kafirin and zein was performed by SDS-PAGE (sodium dodecylsulphate-polyacrylamide gel electrophoresis), showing that the kafirin essentially contained only α - and γ -kafirin, while zein mainly contained α -zein. Since γ -kafirin contains more cysteine residues than the α -prolamin, the formation of disulphide links from cysteine residues in the γ -kafirin was probably the cause of the stiffening behaviour in the kafirin dough alone.

Overall, the kafirin, like zein, appears to have promising properties for making gluten-free leavened dough and the baking of porous bread.

Marine-inspired superabsorbers

This project (acronym JELLYSORB) was first presented in our July 2004 issue as a demonstrator project, financed jointly by the Swedish innovation agency VINNOVA and industrial partners. The aim of the project, run in co-operation between the group for Structure and Material Design at SIK and Polymer Technology at Chalmers University of Technology, has been to serve as a source of inspiration for the development of the next generation of superabsorbents based on renewable biomaterials. Jellyfish (*Aurelia aurita*) was selected as a model system because of its remarkable water-holding ability in salty environment and under pressure, 99% of its matter being salty water.

CLSM and TEM were used to characterise the microstructure, focusing on the mesoglea tissue in order to understand the water management of the jellyfish. A hierarchical structure was revealed, spanning a wide range of length scales. The mesoglea consists of long fibres and a coarse and open network, spanning the space in between and considered responsible for its water-holding ability. (See Figure 4). It consists of proteins and polysaccharides, implying a complex structure of proteoglycans. Cellular structures were also revealed, producing the fibres and the network strands.

The jellyfish was sensitive to variations in salt content, increasing salt content causing volume change, shrinkage and a firmer consistency, with potassium and calcium ions causing paralysis and death of the jellyfish.

The hierarchical structural levels are deemed necessary to maintain structure at varying salt content levels, the coarse

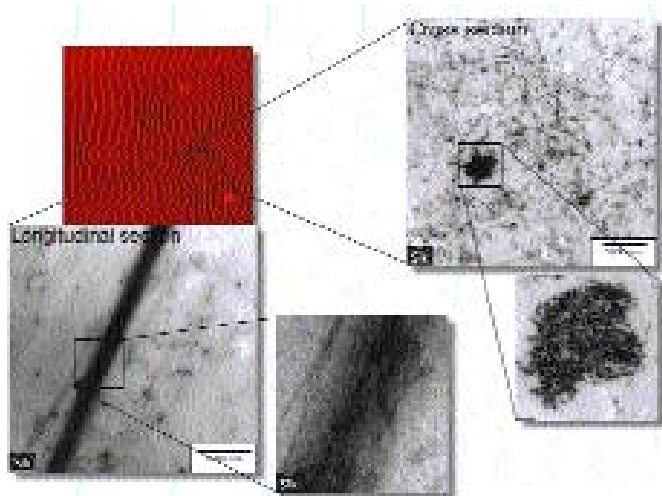


Figure 4.

fibres stabilising the structure, with the network structure being most likely responsible for the water management. By understanding the hierarchy and structures at different length scales, important information can be obtained for the development of a new generation of hierarchically structured biomaterials with tailored mass transport and water-holding properties, for use in a range of industrial applications. Work to this end will continue within the new VINNEx Center "Supramolecular biomaterials - structure dynamics and properties", presented in the previous issue of our newsletter.

Swedish chocolate research centre created

The two industrial research institutes SIK and YKI (The Swedish Institute for Surface Chemistry) have combined their internationally recognised competences in surface chemistry, crystallisation, rheology, microstructure and aroma and sensory properties to create the first Swedish centre for chocolate research. The formation of a consortium with industrial participation is in progress, inviting chocolate manufacturers and related companies, both nationally and internationally, to share in and take advantage of this research and knowledge base.

The centre will have advanced equipment, techniques and knowledge

- to study molecular mobility using microscopy coupled to measuring dynamic events
- to use advanced light and electron microscopy and ATM (atomic force microscopy) as well as image analysis for surface structural studies.
- to study rheological properties (deformation and flow properties of materials), sensory properties, aroma and consumer behaviour.

Problem areas to be studied include how the surface structure of chocolate is affected by the composition and processing and fat migration and recrystallisation (fat bloom). Chocolate is also of interest with regard to observed health effects, which may offer exciting possibilities for product development and for support from the Seventh framework programme of the European Commission, which is largely keyed to the health aspects of foods.

Structure and sweetness interaction

Our previous issue included a review of a literature study by Karin Holm, entitled "The relations between food structure and sweetness", the initial part of her PhD thesis at SIK. The main objective of her project is to establish in-depth knowledge of structure design for understanding relationships between sensory perceived sweetness and texture, with information on dynamic sensory responses related to structure, type of sweetener and structure breakdown during consumption being of particular interest.

The first part of the work will be performed on gel systems such as pectin and gelatin gel, where the gel structure can be varied and where the system will allow for new concepts for structure modifications with regard to heterogeneity and encapsulation of sweeteners.

When a good model system has been established it can be used to further explore interactions between sweetness, flavour and texture in sugar-reduced systems as well as to optimise sweetness perception through flavours and other ingredients. Knowledge of such interactions will be used for structure design for optimal sweetness intensity profiles in sugar-reduced systems.

The relationships between rheological behaviour and the sensory-perceived texture of the model systems will also be studied, which will greatly increase our understanding of structure design for sensory perception of texture and the interplay with sweetness.

In the literature review, which provided a broad overview of research in the field, certain model systems were identified which may be of direct interest in the planned experimental work at SIK.

Healthy structuring

This EU project, in which SIK is involved, was presented briefly in our previous issue, the overall aim being to improve the nutritional and structural quality and safety of ready-to-eat fruits and vegetable products and to optimise conditions, from the selection of raw materials through to growth conditions and processing.

Within this project, Evelina Höglund has carried out and reported her diploma work entitled "Effects of cold storage and processing on broccoli with regard to colour, weight, vitamin C and microstructure". The aim of the work is to study the differences in microstructure, nutritional value, water content and product appearance as a result of packaging, storage time at 0°C and processing (blanching).

Broccoli of the *Brassica oleracea* var. *Italica* Marathon, grown in Sweden, was transported to SIK under refrigerated conditions.

Storage study

In a storage study, broccoli samples were stored for up to 40 days at 0°C, MAP packaged in polypropene bags, or stored unpacked at a relative humidity of around 85%, an unpacked reference being stored at room temperature until unacceptable.

Compared to unpacked samples, water content remained higher, weight loss lower and product colour unchanged over 30 days of MAP storage at 0°C, while colour for unpacked broccoli at room temperature was unacceptable after just three days. Vitamin C content, determined by HPLC analysis, was low in the raw material used compared to literature data. An interesting trend was that its content increased over 10-30 days of storage. The microscopy study indicated some difference in cell structure between fresh and stored broccoli, but less clear than perceived by the human eye when observing the whole plant. The cells of the stored broccoli looked less inflated, the cell walls had parted from each other and some cell walls had crumbled. The ageing effect was greater in the broccoli florets than in the stem.

Processing study

In a processing study, broccoli samples were blanched in boiling water or steam for one minute, cooled rapidly and puréed in a mixer. For comparison, unblanched broccoli samples were puréed and purées made from blanched as well as unblanched broccoli were steam-blanched. Blanching prior to purée-making enhanced vitamin C retention, irrespective of the blanching method. The different purées were seen to consist of fragments of broccoli with retained microstructure but little difference between them could be detected in the confocal microscope.

Departmental news

Anne-Marie Hermansson has received a Sir Frederick McMaster Visiting Fellowship in food structural design, and will be visiting research groups active in this field in Australia during April 2007.

She is serving on the organising committee for a EUCHEM interdisciplinary conference, entitled "Structure dynamics in soft condensed matter", to be held at Lysekil, Sweden, on August 20-22 this year. The aim of the conference is to bring together scientists from chemistry, physics, mathematics and biology, the focus being to master inherent structural properties of soft condensed materials, giving rise to desired functionalities such as water management or release. Important topics are mass transport, such as diffusion and flow of solutes, or short or long range molecular mobility in soft condensed materials. Further information can be obtained from the Swedish National Committee for Chemistry (Agneta Sjögren, e-mail agneta@chemsoc.se).

Packaging and coating

Material properties of biopolymer films and foams

This is the title of Thomas Gillgren's licentiate dissertation, of which his literature study in our October 2006 issue, entitled "Mechanical, microstructural and barrier properties of agricultural biopolymer films and foams", formed an initial part.

The special material properties of polymers from renewable raw materials make them suitable for coatings and foams. The aim of this project is to increase our knowledge of these biopolymers, especially with regard to the use of plasticisers and their effect on mechanical, barrier and foaming properties. Planned research comprises the following studies:

- Film-forming and mechanical, barrier and thermochemical properties of cereal proteins.
- Plasticising mechanisms of biopolymers (prolamines, polysaccharides).
- Foam formation and stability of such biopolymers, with special regard to extension rheological properties.
- The effect of filler particles of different viscoelastic properties on foam properties.

New packaging centre formed

SP Technical Research Institute of Sweden and its two subsidiaries, SIK and YKI (Swedish Institute of Surface Chemistry), all have specific expertise in the packaging field. In order to make this expertise more readily available to interested parties, a joint packaging centre has been established, called the SP Group Packaging Centre.

At the centre we can provide support all the way from performing standard tests on packaging to selecting packaging for a specific food material or to carry out complex research to develop active packaging solutions or packaging materials with specific properties, such as biodegradable or edible packaging and coatings.

The contact person is Anders Leufvén, SIK. Phone +46-31-3355600, e-mail: anders.leufven@sik.se

Easy opening of packages

Under the title "(Im)possible packaging", a Nordic workshop was arranged at SIK on March 20 with the aim of addressing packaging design in terms of opening ability, access to the product and the need to develop test methods and an international standard as a basis for future packaging development. The workshop was a step in the activities of the Nordic project for easy opening of packages, which was presented in the previous issue of our newsletter. Activity in this field in Sweden has been initiated by the Swedish Rheumatism Association, recognising the fact that a high proportion of consumers (and their members) experience great difficulty opening packages of consumer products to gain access to their contents. The workshop attracted some 50 participants.

Under the heading Design for Progress, Ulrike Rahe, Professor in Industrial Design at Chalmers University of Technology, presented the research activities and multidisciplinary profile of her department; from analysing to synthesising in the design process, the main research areas being methods and tools for eliciting customer/user needs and evaluating design solutions and human-machine interactions. Haptic product properties and affective design, taking into account emotional aspects of product interaction and use, are important to understand the user-object relationship in design. A number of project examples were given from her own design work, including the development of an ergonomic and intelligent tool for opening large packages in canteens, and ideas from design education in Germany, including an intelligent medicine dispenser and easy opening pet bottles, coffee pack, candy bags and preserve jars.

Rolf Greiff of the Swedish Rheumatism Association, discussed accessible packaging under the title Liberate the products. The importance of easy opening is evident from the fact that 1 1/2 million Swedes and 60 million Europeans have reduced hand functionality and cannot on their own open many of the present packages for foods, pharmaceuticals etc. He described the efforts of his association over the years, in co-operation with other organisations, to develop methods to assess the opening ability of packages in a Technical Aid Project and a Consumer Action Project.

A special project, involving the standardisation institute, SIS, is working towards a European standard for the handling and opening, emptying and reclosure of packages, as well as methods to grade performance in these aspects. In the Nordic project, which arranged the present workshop and in which the Rheumatism Associations of Sweden and Finland are participating, researchers are working on structuring and categorising packages with regard to ease of use as well as mapping target groups, all of which will be made available to SIS in their work on standardisation. Such a standard is believed to be a driving force behind development in the field, and industry appears to be well aware of the need for such development, as shown in a market study, where nine out of ten companies felt that consumers demand easy-to-open packages.

The speaker listed the problems involved in opening packages and which specific improvements are needed, such as less need for force, avoiding a round design and a need for support for alternative grips.

Lasse Hamilton Herdeman, The National Consumer Agency,

Denmark, presented the Governmental view, explaining the Danish Consumer Agency's initiative on design for all. The purpose of the working group is to ensure accessibility to packaging for all consumers and to enhance the competitiveness of business in this field. The group will develop a number of business cases with leading companies on the market to clarify the business potential in developing packages accessible to all and to spread the outcome of the work to all relevant industries. They have decided to focus on products being used daily and not on opening aids.

Henric Skou Pedersen, Arla Foods, Denmark, presented the food processor's view on how to meet consumer needs through smart and intelligent packaging, Arla being a global supplier of milk-based products. Among new developments mentioned, novel display technology, such as the Philips Polymer vision, could provide improved readability and clearer information to the purchaser. Emerging intelligent technologies could also provide systems for opening packagings at the push of a button.

Noora Nylander, Stora Enso Packaging, Finland, talked about packaging design from the packaging manufacturer's point of view to satisfy the packaging requirements and logistical demands of the customer: what needs to be considered and choosing the right package structure, machinery etc. The design process, directed at rheumatism patients, was described up to the stage of testing with users. She concluded with a presentation of a new development at Stora Enso of a technique for controlled (electrical) delamination of materials (CDM). This permits two attached surfaces of a package to be separated by applying a low-voltage electric current from an activation unit in the shop (Figure 5) or from a minute battery built into the package.

Group discussions were arranged in which participants were asked to discuss which are the most important target groups for easy-opening packages, and what are the main restrictions for introducing such packages. Finally, they were given a number of packages and asked how they would see an easy opening solution for each one of these. Weak-handed people, made up of rheumatics, the disabled, the elderly and others, were considered an important target group, but other groups, such as those with reduced eyesight, may be equally important. Should we demand design for all or the design of special products for special needs?

Among important restrictions, cost and the demands of the supermarket chains were emphasised, as well as the need for a compromise between the important demands on packaging for protecting the product and consumers.

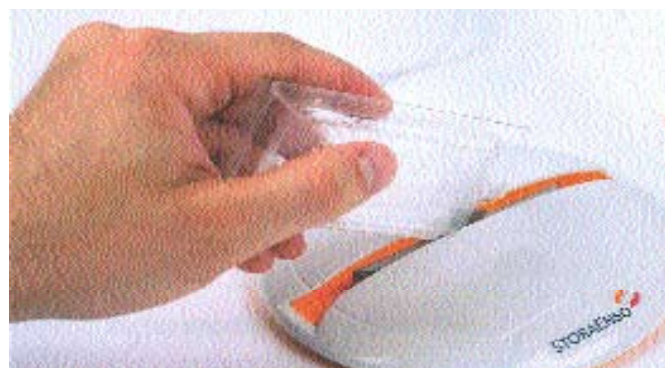


Figure 5.

Sustainable food production and environmental management

Increased share of grain legumes in food

Paul-Louis Lafargue has completed his master's thesis, entitled "LCA of Spanish meals with different protein sources" at SIK, with Ulf Sonesson, SIK, as supervisor and Anne-Marie Tillman, Chalmers University of Technology, Gothenburg, as examiner. The work was part of work done within the European project Grain Legumes, which aims to develop strategies to increase the use of grain legume crops in food for human consumption and animal feed in Europe.

As part of this project, SIK is responsible for assessing the impact on the environment of meals for humans. This kind of work on meals was planned for two European regions, Spain and Sweden, this thesis representing the Spanish study. An LCA for the complete product system was performed for the following four products, the purpose being to compare the environmental impact of each product and to identify the most important contributions to total impact for each:

- Two products (sliced pork) in which all protein is of animal origin (with animals fed either with soya or grain legumes).
- One product (sausage) with 10% of the animal protein replaced by vegetable protein.
- One product (vegetarian hamburger) in which all the protein is vegetable protein.

Spanish LCA data were used wherever possible, otherwise suitable corresponding data from other regions. The products were included as components in full meals, following nutritional recommendations.

The overall objectives were to learn more about the environmental impact of product systems in Spain and to evaluate the potential environmental improvement from using a higher proportion of grain legumes in the human food chain. Energy used and emissions were quantified and the potential contribution to global warming, acidification, eutrophication, photo-oxidant formation and ozone depletion were assessed. The great scarcity of environmental data was one of the main problems encountered when applying LCA methodology to food products in Spain.

The results of this LCA show that for all the environmental impact categories studied an increased share of grain legume in the human diet is a sustainable solution. A net reduction can be observed in the environmental loads when the amount of meat is lower. Meat production thus appears to be the main contributor to the various emissions. Pork production at the farm and the slaughterhouse are very energy-demanding processes with high contributions to the environmental impact.

LCA research on seafood production systems

Anna Flysjö, Friederike Ziegler and Ulf Sonesson, SIK, are co-authors of a publication in the International Journal of LCA, entitled "Impact Categories for Life Cycle Assessment Research of Seafood Production Systems: Review and Prospectus" (a complete list of authors is given under Literature below). The sustainability of seafood production is of increasing concern and the relevant but limited suite of impact categories currently used in LCA research fails to capture a number of important environmental and social burdens that are unique to fisheries and aquaculture. The present paper reviews the impact categories used in published LCA research on seafood, reports on a number of methodological innovations and discusses the challenges and opportunities for further impact category developments. Notable examples include the modelling of benthic impacts, by-catches and emissions from anti-fouling paints.

Ulf Sonesson is also co-author of another publication in the same journal, entitled "Co-Product Allocation in Life Cycle Assessments of Seafood Production Systems: Review of Problems and Strategies". The focus of this methodological paper is on the specific allocation problems faced in studying seafood production systems, and how they have been addressed to date. The allocation problems are discussed in the context of ISO recommendations and other published guidance on allocation, discussing also the key lessons to be learned from reviewed studies and recommendations for future LCAs of seafood production systems. A standard set of requirements for how to describe and justify allocation decisions is needed.

LCA of Central American Agro-Food chains

In SIK report 752, entitled "Life Cycle Assessment (LCA) of different Central American Agro-Food Chains", Anna Flysjö and Thomas Ohlsson report on work by SIK within the project "Improved Sustainability of Agro-food Chains in Central America", the aim of which is to identify technological options that make agro-food systems more sustainable from an environmental, food safety and socio-economic perspective. The project is an INCO (International Scientific Cooperation) project financed by the European Union.

In the SIK report, the environmental impact of five different products (eight different chains) from Central America is investigated: coffee, melon and chayote from Costa Rica, coffee and cashew from El Salvador and coffee, cashew and snow peas from Guatemala. For comparisons an LCA was used. The inventory data, the quantity of input, was collected by partners from Central America and SIK and the calculations were performed by SIK, using the LCA software SimaPro.

The environmental impact categories studied are energy use, global warming, eutrophication, acidification and use of pesticides, land and water. It is difficult to draw any overall conclusions but the main improvement possible in several cases is to reduce the use of pesticides. However, crop disease and infestation are often more problematic in tropical countries, making the need for pesticides greater. The amount

of fertiliser should be adjusted to better balance the needs of the crop in order to reduce eutrophication.

For coffee, the cultivation and the preparation at the consumer were the stages that contributed most except for the milling stage in Guatemala. In cultivation, less energy might be used, mainly by reducing the use of fertilisers, but since all coffee is picked by hand it is difficult to make other improvements. Figure 6 demonstrates the primary energy use for producing 1 kg of roasted coffee, cultivated in El Salvador and roasted and consumed in Sweden.

For melon, the main impact was at the cultivation phase and the high use of pesticides, although it is difficult to estimate possible improvements, since pests will then have to be tackled using other methods of unknown impact.

For chayote, cultivation was the most contributing step only for eutrophication, while the different transport steps contributed more for the other categories. Because of the relatively high yield for chayote, the impact per kg was rather low.

For cashew in El Salvador the processing produced the highest impact in all categories, except for eutrophication for the organically grown cashew. In Guatemala, cultivation and

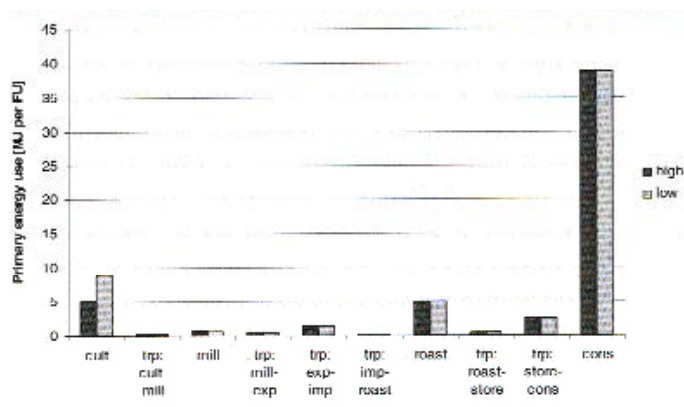


Figure 6.

transport to processing gave the highest impact.

For snowpeas, cultivation must be considered to have the overall highest environmental impact.

One of the greatest difficulties has been the collection of data, which makes it difficult, especially for conventional cashew, to make a fair comparison between the different options.

Departmental news

At the 5th International conference on LCA in Foods at SIK, April 25-26, Anna Flysjö will speak on "Improved sustainability of Agro-Food Chains in Central America - How to use Socio-economic Indicators (SEI) as a complement to LCA" and Johanna Berlin will speak on modelling in LCA, "A dynamic simulation tool for a productive and environmentally efficient food production".

Overview of current SIK research

On February 7, a member conference was held at SIK, highlighting aspects of new current research at SIK, with the aim of giving participants new impulses for practical applications and establishing mutual contact between SIK researchers and member participants. A similar overview, arranged a year ago, was much appreciated by attending members.

The three themes of the conference were:

- Product design of tomorrow
- Product safety and consumer confidence
- Technical development and production

In addition, four new and ongoing PhD projects were presented along with a poster display of current areas of expertise, combined with guided tours of the facilities.

Product design of tomorrow

Anne-Marie Hermansson gave an overview of the new VINNOVA Centre of Excellence for long-range interdisciplinary research on the properties of supramolecular biomaterials and structure dynamics. At the Centre, SIK's structure researchers co-operate closely with a number of divisions at Chalmers University of Technology in structure design and dynamics, mass transport and solid state physics as well as with companies in the sectors of foods, pharmacy, hygiene products and cosmetics with applications in all these areas in mind. The Centre will have a total budget of SEK 8 million a year for eight years, of which one-third comes from industry.

Niklas Lorén talked on the controlled release of substances in foods and pharmaceutical products from the point of view of mass transport by hydrodynamic and capillary flow and diffusion. He demonstrated the influence of structure on diffusion at different length scales and diffusion studies with microscopy and NMR in gel structures. Simulations were shown of diffusion in gels and the influence of obstructions in the structure, concluding that diffusion can be controlled by appropriate structure design.

Susanna Edrud presented an African co-operative project on gluten-free bread based on the indigenous crop sorghum. Africa imports large quantities of wheat for baking white bread, while the surplus of gluten-free sorghum is not suitable for baking, other than of sour dough bread, and is mostly used for porridge and suchlike, despite the fact that many people in Africa suffer from gluten intolerance. The reason for the poor baking ability of sorghum appeared to be that its protein is poorly hydrated, while the pure sorghum protein demonstrates better extensional rheological properties than wheat protein. The problem is to find an inexpensive way to extract pure sorghum protein as a baking additive.

Anna Sverkén reviewed a study comparing descriptive consumer testing by an analytical panel, a central localised consumer test (CLT) and a home usage test (HUT) for chocolate bars of the meal substitute type. Cluster analysis and preference mapping showed higher acceptance scores in the HUT study, while the CLT study resulted in more consumer comments.

Annika Åström discussed results from a unique

European project on food habits and lifestyles of European adolescents under the acronym HELENA. For the first time, a comprehensive study is being made of lifestyles, food habits, preferences and attitudes of young people aged 13-17 years, from all over Europe, using the same methodology. Group discussions with over 300 young people dealt with factors influencing their food choice, what they associate with health and healthy food and who or what has the greatest influence on their food choice. An important part of the project comprises consumer-directed product development.

Product safety and consumer confidence

Birgitta Bergström's subject was microbiology in real time and new genetic methods for rapid and exact identification. SIK is concentrating on the detection of low levels of *Listeria monocytogenes*, a serious pathogen in products such as vacuum-packed chilled cheese, salmon and cold-smoked items, where 100 bacteria are sufficient to cause infection. A specific property of *L.monocytogenes* is very stable DNA, so that dead cells will also be detected. Ongoing development is based on the fact that messenger-RNA is a good marker for living cells.

Pernilla Arinder demonstrated a simulation tool for microbial growth called LOGISAFE, developed at SIK, which is being used to predict microbial development and ensuing health hazards in the production and distribution chain, as a function of raw material quality and processing and handling conditions, such as if the raw material is more heavily contaminated or if time-temperature conditions are more severe than normal.

Technical development and production

Hans Lingnert and Claes-Göran Andersson reported results from work at SIK within the European project on the formation of acrylamide in the heat processing of foods. SIK has studied acrylamide formation during the baking of bread as a function of time-temperature profile, moisture content and water activity as well as the baking method, including IR-heating and the addition of steam. It was possible to reduce the formation of acrylamide in the bread crust to less than one-third without lowering product quality and appearance. More details are given above in the separate part dealing with "The formation of acrylamide in bread baking" in this issue.

Sustainable and profitable food production was the subject of Karin Östergren's talk on the food industry and production systems of the future, requiring flexible production, high equipment availability, short change-over and lead times, reduced costs and sustainable development. SIK is involved in two large projects, REELIV and REPRO. In the first project, SIK is co-operating with Chalmers University of Technology and Swedish food companies to develop a new tool, combining environmental system analysis with the simulation of product flows. In the EU project REPRO (Reducing Food Processing waste), processes are being developed to utilise food by-products. SIK is working on a process-driven simulation model, where process economy, environmental influence and hygienic status are continuously being evaluated. Work at SIK on lean production was also commented on, developing a way of working where the focus is on creating value for the consumer and eliminating non-value-creating factors.

Friederike Ziegler discussed how more sustainable consumption of fish can be achieved by more conscious

choices on the part of the consumer. This is made possible either by giving the consumer more detailed information on sustainability of species, the volume of by-catches and seafloor damage for wild caught fish as well as the density of population and use of chemicals for farmed fish, or by providing reliable labels as a guarantee of sustainability, such as the MSC label (Marine Stewardship Council).

Ongoing PhD projects

Karin Holm presented her project on the importance of structure for experienced sweetness, a project described earlier in this issue of our newsletter.

Emma Holtz is studying microwave-assisted dehydration of cellular and porous biological materials such as food, with the aim of achieving mild and rapid dehydration with high energy efficiency. Specially designed microwave drying equipment is being used as well as technology for determining energy use and efficiency. The results of experimental work will be used to develop a mathematical model for the optimisation of the drying process by simulation, to be validated in later experimental work.

Norman Staak is studying means of raising the microbiological quality of spice powders while maintaining product quality by killing spores with infra-red heating, presenting experimental work with paprika powder. Details of his work are presented early on in this newsletter.

In her project, Maria Petersson is studying waxes as protective barriers in or on food products and for controlled release of, for example, antimicrobial substances. Different types of waxes of interest in the project were described as well as the experimental and analytical methods to be used to clarify which factors influence/restrain the transport of moisture, and how the storage stability of the treated products is affected.

New research strategies in progress at SIK

The current SIK research programme for 2005-2007 is into its last year and the development of its successor is in full progress, in co-operation with our members' industrial committee. The new research strategies will be presented for acceptance in autumn 2007. In the meantime, we welcome a dialogue with individual members, fellow researchers and other parties interested in giving their views on present and future research at SIK.

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Current conferences

AERC 2007, Fourth Annual European Rheology Conference, Naples, Italy, April 12-14, 2007.

The 5th International Conference on LCA in Foods, Gothenburg, Sweden, April 25-26, 2007.

Functional Foods in Europe-International Developments in Science and Health Claims, La Valletta, Malta, May 9-11, 2007.

Workshop on Merging Experiment with Theory in Rheology, Stavanger, Norway, June 12-13, 2007.

HELENA-IDEFICS-ProCHILDREN Joint Symposium, Stockholm, Sweden, June 19, 2007.

Nordic Rheology Conference 2007, Stavanger, Norway, June

13-15, 2007.

7th Pangborn Sensory Science Symposium, Minneapolis, USA, August 12-16, 2007.

EUCHEM conference on Structure Dynamics in Soft Condensed Matter, Lysekil, Sweden, August 20-22, 2007.

Innovations in Food Technology, Copenhagen, Denmark, September 19-20, 2007.

Biofoams 2007, Capri, Italy, September 26-28, 2007.

Food - New options for the industry, EFFoST/EHEDG joint conference, Lisbon, Portugal, November 14-16, 2007.

Nordic and European news

A Swedish research group at the Royal Institute of Technology, Stockholm, has found a method of making a biodegradable foam plastic from potato starch, reinforced with nanofibres of cellulose. In principle, a mix of potato starch and ultra-thin nanofibres, produced using another novel process, is cooled to -80°C to give a solid foam, which is then freeze-dried to give a strong plastic foam that can replace present oil-based plastic foams. The development of an industrial process is now being discussed. (Reference: *Ny Teknik*).

In the CCFRA New Technology Bulletin No 33, three interesting new European developments are presented:

The German company Wild Indag in Heidelberg claims to have developed a novel heating process for foods, combining Ohmic heating at mains frequency with high-frequency heating at 27 MHz, thus combining the advantages of both methods. A prototype plant has demonstrated an output of three tonnes of foodstuff per hour with a peak temperature of 140°C within 90 seconds. Details of application areas were not given on their site. (Ref: *Food Production Daily* and company website).

Researchers at the University of Birmingham compared the drying of carrots using supercritical carbon dioxide and using conventional air drying. Conventionally dried carrots showed a collapse of the microstructure and slow rehydration ability, while the supercritical method gave a very porous structure, similar to that in freeze drying, and with good rehydration properties and a higher product quality. The new method is believed to be safe and relatively inexpensive. (Ref. Abstract from IUFoST 13th World Congress, Nantes, France).

A new technique for adequate reduction of harmful microorganisms in processing water for the food industry is being developed at the University of Abertay, Scotland. It is based on a combination of ozone treatment and hydrodynamic cavitation, achieved by rapidly pumping water through a pipeline and forcing it through small holes to

create microbubbles or cavities, which then implode to cause localised elevated pressure and temperature, which is lethal to microorganisms. It is claimed that a 6-log reduction in *E.coli* numbers could thus be achieved. (European Food Processor, Dec 2006).

SIK website

On the SIK website www.sik.se you will find links to abstracts of SIK-Reports and SIK-Documents and listings of publications at SIK and at our sister organisation CCFRA as part of the overall information about the organisation, ongoing research and other activities.

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