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Nordic Innovation Centre

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# **NORDIC FOOD SAFETY IN A GLOBAL WORLD**

## **PROCESSING FOR FOOD SAFETY**

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**NORDIC FOOD SAFETY IN A GLOBAL WORLD**  
PROCESSING FOR FOOD SAFETY

# Eating safe in a global world



Mads Peter Schreiber



Hilde M. Helgesen

**Fact: The reality is that you can't see, smell or taste harmful bacteria that may cause serious illness. The reality is that you have to trust your food. Safe steps when it comes to producing, processing and preparing food is essential in order to prevent food borne diseases.**

It should be patently obvious that food should not be put on the market if it is unsafe; in other words that it may be injurious to health or unfit for human consumption. In order to ensure food safety, it is necessary to consider all aspects of the food chain, from farm to fork in other words. This is because each element may have potential impact on the food safety.

We want the food to be free of contagious matter, microorganisms, foreign particles or other contamination that can result in damaged health. Even though we eat to stay alive, the danger is always present that the food we eat might make us sick, or potentially kill us. In the middle of 2004, the Nordic Innovation Centre (NICE) launched four food safety related projects within the focus area "Processing for food safety", namely: "A Molecular Safety Approach for Campylobacter (CampyFood)", "Acrylamide precursors; Limiting substrates and in vivo effects (NORDACRYL)", "Company Risk Assessment Network (CRAN)" and "Integrating Food Safety and Traceability (IFSAT)". These projects' final reports are out, and indicate innovative steps in the future of food safety.

## The risk factor

All food contains biological materials and natural chemicals from the plant or animal it originated from. In addition the food may have been exposed to other natural, or artificial, substances when it was processed. All of these are potentially harmful substances, and are called hazards in the food industry. These may include microorganisms, environmental contamination, pesticide, additives, natural chemicals, or chemicals produced by cooking. The chance of being struck with disease by these hazards, is called the risk level.

Deciding if foodstuff is safe or hazardous is difficult. It has the potential to be both. Food can never be proven to be entirely safe, nor can it be proven to be entirely hazardous: The food can only be proven to be hazardous to some degree under certain conditions. It follows that it is unrealistic to demand completely safe food. It is, however, possible to demand food in which potential hazards have been reduced to a minimum.

### Safety cookbook

Food is now traded and marketed on a global basis. When we sit down to enjoy our dinner, the tempting food on the plate might have their roots in five different continents. In a modern society we trust on others to make sure the food is bug free, so that it won't bug us. We depend on the food industry, and the state, to have good routines for maintaining food safety.

Excellence in food safety is built through trust and mutual understanding. When we make food safety decisions, we measure the benefits against the risk level. The globalisation of the food processing industry and the food market from raw material to the finished product, is a challenge when it comes to maintaining an unbroken food safety chain. Numerous people, companies and agencies have been involved; the material is biological and the history is important.

For the food industry it is essential to have access to the latest food safety knowledge. This applies for new knowledge on risk management, new process designs, product development and customer information. Numerous food scandals the last years have reminded us that it is necessary to stay alert and focused. Examples like the outbreak of *Campylobacter* in fresh poultry meat, the discovery of acrylamide in many food products, the discovery of heavy metal pollution in fish or the American rapport on dioxin in salmon, all showed us that. It pays to be safety oriented; poor food safety leads to financial losses for the involved companies, to human suffering and potential mortality.



Mads Peter Schreiber  
Deputy Director  
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### Nordic reputation

Product development regulations are getting increasingly complicated, and some food products have to go through almost the same process as medicines before they can be released on the market. It is important that the Nordic countries have a voice in the making of European and international standards and regulations. Food safety today is an issue of great concern worldwide, and the Nordic food industry faces major challenges in maintaining and justifying its international reputation for safe food. This is especially important in light of the enlargement of the European inner market, meaning that the European market now is open for food products from countries without the same standard of food safety as the rest of Europe.

### Competition through cooperation

In order to ensure the competitiveness of the Nordic food industry, and the safety of the Nordic consumer, it is essential with an open dialog and co-operation between authorities, researchers, consumers and industry. Within the framework of these four NICE financed Food Safety projects, the Nordic food industry, normally strongly competing, has experienced the benefits of collaboration and sharing of knowledge. The authorities and industry also have overlapping needs and have equally profited from joining forces, sharing knowledge and expertise. This can act as an innovative work model for future emerging food safety issues in the Nordic region.

This Nordic platform of food safety, is also extended into a European setting, by the establishment of SAFEFOODERA 2004 - 2007: a leading European network coordinated by NICE. The primary objective is to establish a European platform for protecting consumers against health risks from the consumption of food through a co-ordinated action. What started as a bottom-up movement with its base in a pure Nordic collaboration has grown to a Europe-wide collaboration involving more than 30 countries.

The trust and mutual understanding built in these two platforms could prove to be a way forward, for future excellence in Nordic and European food safety.



Hilde M. Helgesen  
Senior adviser  
Nordic Innovation Centre

# 4 PROJECTS

8

## **Company Risk Assessment Network (CRAN)**

- Tools for decision support and quantitative microbial assessment of food processes

Food should not contain microorganisms in quantities that entail an unacceptable risk to human health, microbial hazards not receiving due attention from the food industry, may seriously affect human health. Estimating the extent and likelihood of a specific microbial hazard in food safety management systems can be improved by using computer-based tools for quantitative microbial hazard analysis and decision-making. The Company Risk Assessment Network has developed such tools; useful for training, and the development of new processes and products.

10

## **IFSAT**

- Integrating Food Safety and Traceability

Traceability has traditionally dealt mostly with in-house documentation of information relating to one's own processes and products. Lately, however, the focus has been on chain traceability, where the goal is to eliminate or reduce information loss between the supply chain links. Improved traceability awareness and practices in the whole chain such as limiting batch sizes, can minimize costs in case of a real recall. To achieve complete internal traceability in a processing company, all batch transformations must be recorded.

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## CampyFood

12

### – A Molecular Safety Approach for Campylobacter

Microbiological agents contaminating food can cause acute illness in humans, not to mention lead to considerable costs for society as a whole. Preventing such contamination is a fundamental task of highest priority. Implementation of effective control measures within the primary production phase, and further processing, requires that one knows the quantity of campylobacter's at various stages throughout the entire production chain.

The campylobacter network project has resulted in harmonization of ongoing research among the five participating Nordic laboratories through exchange of research personnel, and integrated research projects. Through this potential duplication of work has been avoided, and valuable synergies between the laboratories has been achieved.

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## NORDACRYL

14

### – Acrylamide precursors; Limiting substrates and in vivo effects

The human neurotoxin acrylamide, classified as a probable human carcinogen by the International Agency of Research on Cancer (IARC), is formed during heat treatment of starch rich food. These findings caused a lot of concern among consumers, retailers, authorities, - and within the food industry itself. The NICE induced collaboration regarding the acrylamide issue between normally strong competitors in the food industry, can act as an innovative work model for future emerging food safety issues. The food authorities should continue its monitoring programme of acrylamide in commercial food products, and further studies on humans regarding the risk of acrylamide in common foods.

# CRAN

## – Company Risk Assessment Network

The following researchers have participated in the project:

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## Background

Food should not contain microorganisms in quantities that entail an unacceptable risk to human health. Microbial hazards not receiving due attention from the food industry, may seriously affect human health. The food safety management system HACCP (Hazard Analysis Critical Control Points) has been implemented in most food industries to control hazards at critical processing points, which could otherwise negatively affect the safety of the food produced. It is however open to debate how effective these plans are in maintaining and improving food safety. HACCP needs to be further developed, and the hazard analysis needs to be improved. The main shortcomings of current hazard analysis are difficulties estimating the extent and likelihood of a specific hazard occurring in the production chain, and quantifying the control effects. This creates uncertainty regarding correct hazard identification requiring control, and the best way to implement such control.

Risk management relating to microbial hazards requires substantial knowledge of processing, legislation and microbiology. Many food companies are small, and have limited expertise and resources when it comes to risk management. Efficient management tools are important aids to better comply with safe food requirements, and for effective measures. Going from a hazard-based approach to risk-based management, has brought new challenges to the food industry. By understanding hazards, and quantitative risk assessment, industrial control can be greatly improved. The present project aims to illustrate how quantitative and structured methods can be applied to microbial hazard analysis, and to decisions regarding the control of microbial hazards.

## Scope

The project's objective was to increase knowledge of quantitative microbial hazard analyses in the Nordic food industry, and to develop computer-based tools to be used for quantitative microbial hazard analysis and decision-making. The project has provided opportunities for both the industry and its scientific partners in the Nordic countries to increase and share knowledge of quantitative hazard analysis. This has been done during workshops organised by the project. Tools for demonstrating a methodology for decision-making and microbial hazard analysis were developed and evaluated during the project.

Demonstrations of these tools are available at the project's website ([www.sik.se/cran/](http://www.sik.se/cran/)). The tools include a decision-making tool that provides help during systematic evaluation of microbial hazards, and as an aid for finding required data and information during the decision-making process. In addition there is a calculation tool for simulating bacterial levels along the production chain. This takes into account process and product parameters variations. Databases for systematic collecting of the microbial and process data important for assessing

bacterial concentrations in the production chain, have also been created. All the tools has been demonstrated for and tested by the dairy industries the Nordic countries during the workshops.

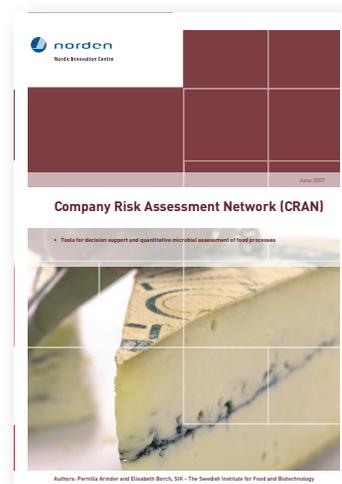
## Conclusions and policy implications

Tools to be used by the industry needs to be educational and easy to use. More training in the areas of predictive modelling and risk assessment was requested by the dairy industry during this project. The tools developed can be used for such training, and can lead to a broader understanding and application of quantitative microbial risk assessment. Due to the industry's lack of time for accessing news in international research publications, there are a need for easily accessible databases on bacterial properties, - such as the one developed in this project. Several computer-based tools have been developed in order to demonstrate methodologies that will help food companies improve their food safety.

These tools will provide guidance during quantitative microbial risk assessment, and may be used for estimating bacterial levels in products along processing lines. This allows for evaluation of various process parameters' effect on the behaviour of a specific microorganism, or the contamination effects at different locations along production chain. The developed tools are useful during training, and will provide a broader understanding of benefits and usefulness of quantitative microbial risk assessment.

The tools are also useful when new products and processes are developed; since it facilitates computer-based simulations of bacterial responses. This result in better identification and understanding of relevant hazards and critical control points, ultimately leading to improved control. The tools were all well received by the Nordic dairy industries. They supported the need for quantitative calculations, and simple tools to help during the decision-making and calculating processes. Further development and adjustment of the tools are required. They are not yet validated for commercial application, and at present the industry can only use it with expert back-up.

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# IFSAT

## - Integrating Food Safety and Traceability

The following researchers have participated in the project:

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### Background

Traceability has traditionally dealt mostly with in-house documentation of information relating to one's own processes and products. Lately, however, the focus has been on chain traceability, where the goal is to eliminate or reduce information loss between the supply chain links. To achieve complete internal traceability in a processing company, all batch transformations must be recorded. This means in practice that ID's of all received batches must be linked to the related production batches, and the IDs of produced batches must be linked to the related dispatched batches. Internal traceability data from all companies a product, or fraction of the product, has been through must be linked together, preferably via electronic systems, in order to obtain chain traceability.

Risk analysis has traditionally been tied to in-house data, in particular to data from food safety oriented systems. In addition to obvious deficiencies in risk assessment when data is missing, there are related problems with risk management and risk communication. Risk management relates to the social and political aspects of risk, and aims to determine an acceptable level of protection. There is a common agreement among the Nordic countries that the EU Commission will join the viewpoint that traceability and risk analysis are to be an integrated part of the HACCP system/"Own check system".

### Scope

The project set out to integrate food safety and traceability by finding common features in the two systems that could benefit each other. Achieved synergetic effects were to be documented by integrating food safety and traceability in the management systems. The aim of the sub project "ChainTrace" was to develop, implement and test food safety oriented traceability systems in the food industry in order to help users to carry out product recalls in a fast and efficient manner. The aim of the second sub project "Multitask", was to provide advice and guidelines for chain traceability implementation in the fish industry, and to serve as liaisons to the many ongoing national and international traceability efforts, projects and networks. Internal and external dissemination of findings have been an important objective, in addition to the harmonization of work and practice among the project participants.

Systems and standards for chain traceability are now possible to put into operation in the Nordic food industry, with the consequence that a lot of previously unavailable functionality now becomes possible. Chain traceability enables food safety by providing access to data elements that are relevant for risk analysis, relevant for identification of contamination source, and necessary for targeted recall. The challenge in the near future is to integrate food safety aspects and traceability in an operational way.

## Conclusions and policy implications

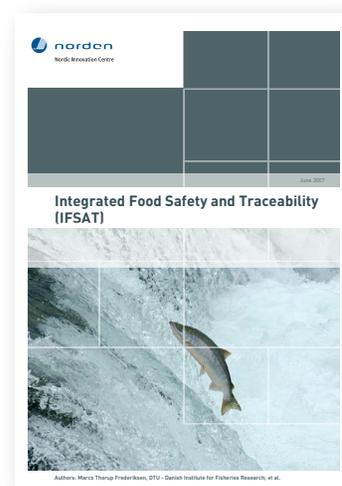
More than 80 IFSAT-related conference/seminar/meetings and presentations have been held during the project period. An IFSAT web site has been set up, and practices and methods have been discussed and harmonized between the participants. IFSAT has had representatives from, or liaisons to, all the existing 6FP food traceability IPs. More than 15 EU projects have been contacted in particular through the PETER forum (an EU traceability coordination project), and several Nordic and EU projects have been generated as a direct result of the IFSAT collaboration, where the IFSAT-partners have key roles.

Guidelines for food safety oriented traceability recordings are implemented in a software solution for the pelagic industry, and a scientific article on integration of food safety and traceability has been written. The QIM (Quality Index Method) has been verified by three studies of salmon from Norway to Denmark. The conclusion is that QIM is verified as a very important tool to settle quality-related discussions in a chain by objective means. This means that the management of the observed cool chain can be improved extensively. The SSSP (Seafood Spoilage and Safety Predictor) program has been tested by three series of temperature measurements in the whole chain, from fishing vessel to retailer shop. The conclusion is that the program is very suitable to validate freshness product information provided by a traceability system, when a temperature record is available.

The ChainTrace project group has worked on a food safety oriented traceability analysis method. Several tests have been made on RFID-tags, and international workshops on data capture technology have been arranged. In addition a traceability software solution for generating data on pelagic fishing vessels has been completed.

A guideline called "Recommendations for Good Traceability Practice (GTP)" has been developed. In addition a food safety oriented preparedness test has been conducted in the Nordic countries. The conclusion is that the Nordic industry in general is not prepared for a recall (a situation where the products have to be removed from the market, e.g. the supermarket shelves). The traceability of fish products can also be improved. The study has been submitted for publication in Food Control.

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# CampyFood

## - A Molecular Safety Approach for Campylobacter

The following researchers have participated in the project:

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## Background

Microbiological agents contaminating food can cause acute illness in humans, not to mention lead to considerable costs for society as a whole. Preventing such contamination is a fundamental task of highest priority. Implementation of effective control measures within the primary production phase, and further processing, requires that one knows the quantity of microorganisms such as campylobacter's at various stages throughout the entire production chain. The traditional detection of microorganisms uses culture-based methods; a time consuming and arduous process. In addition it is also a method that is difficult to adapt to scientific quantitative analyses, and viable non-cultivable cells are not detected.

Despite its shortcomings, culture-based methods are still the most widely used tool for assessing contamination in chicken flocks, animal herds or food. At present the production of chickens free of campylobacter depends on information regarding the chicks' status from samples taken several days before the slaughter. In addition, account of *Campylobacter* spp. is useful for monitoring the intervention effect of procedures ultimately aimed at reducing, or eliminating it from the food. Knowledge of the nature, regulation and action mechanisms of virulence determinants is indispensable in formulating new strategies for food safety, - and potentially for the development of innovative control strategies.

## Scope

The project CampyFood had as its overall objectives the implementation of novel molecular techniques concerning food safety, the accurate detection and quantification of virulent *Campylobacter* spp. in food samples, and generating a better understanding of the matrices showing expressions of the food-borne pathogen. This is seen as a step towards creating new strategies for food safety and hazard characterization for quantitative risk assessment.

The scope of the project was to harmonise ongoing research among the five participating Nordic laboratories through the exchange of research personnel, web pages, integrated research projects, newsletters and workshops. This was done in order to prevent possible work duplication, and to ensure synergies between the laboratories. The vehicle for knowledge transfer was mainly the exchange of research personnel, post-doctoral fellows, PhD students, MSc students and senior staff members within the mobility program.

Obtained results will be of considerable interest to the scientific community, food manufacturers and regulators and so will be widely disseminated. This will include refereed scientific publications, presentations at international conferences and articles in national/international magazines. Members of the CampyFood-network will be involved in the organisation of two upcoming international scientific conferences; The FEMS Congress 2009 and The Food Micro 2010. Both conferences will highlight microbial food safety/virulence.

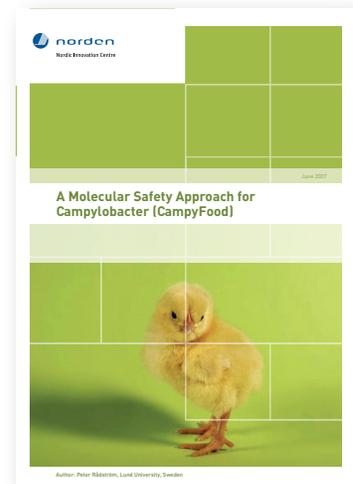
## Conclusions and policy implications

CampyFood will continue the ongoing network activities in order to prevent duplication of work, and to ensure synergies. There is a need to improve and adjust molecular techniques for formulating new strategies for food safety, and potentially for developing novel control strategies. In addition, we see a need to improve the knowledge of virulence characteristics, and for a rapid detection/quantification of virulent strains/species in foods, as a novel approaches for risk assessment studies.

The project's network activities have generated a webpage at [www.campyfood.org](http://www.campyfood.org), newsletters, two workshops and the mobility programme. All workshops were open for attendance for representatives from the food industry in the Nordic countries, private and governmental laboratories, food control authorities and companies marketing technologies for nucleic based analysis. The workshops disseminated the project, presented the developed molecular methods and discussed implementation of the results.

Recently a European Integrated Research Programme was initiated with Jeffrey Hoorfar as coordinator. The project named BIOTRACER consists of 47 partners, including several of the CampyFood organisations. The scope of the project is to improved bio-traceability of unintended microorganisms, including Campylobacter, and their substances in food and feed chains. In addition, BIOTRACER will integrate global microbial expression and survival data from food systems into existing empirical mathematical models, which will allow a holistic approach of these biological systems. The use of physiological data with information on virulence, gene expression and metabolite composition experienced in food-relevant conditions will generate data to model the behaviour of microorganisms introduced into the food chain. This will result in model systems in which the influence of physiology matrix and detection will be investigated.

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Marianne Lindblom  
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## NORDACRYL

### - Acrylamide precursors; Limiting substrates and in vivo effects

#### Background

In Sweden in 2002 it was discovered that the human neurotoxin acrylamide, classified as a probable human carcinogen by the International Agency of Research on Cancer (IARC), is formed during heat treatment of starch rich food. These findings caused a lot of concern among consumers, retailers, authorities, - and within the food industry itself. In the Nordic countries the consumption of heated potato and cereals is relatively high compared to the rest of the world. We have a strong tradition in eating bread, - especially crisp bread. Therefore the NORDACRYL project focused on acrylamide in cereal and potato products. Acrylamide has proven to be a carcinogen in experimental animal trials. Results from long-term animal studies carried out by the U.S. Food and Drug Administration (FDA) is expected in 2008.

There is a direct link between the level of heat treatment (temperature and time), and the formation of acrylamide. The formation parallels the browning of the product, and acrylamide is formed during steps in what is known as the "Maillard Reaction". The formation is highest in the parts of the product that reaches humidity less than 98%, and processing above 120°C.

#### Scope

This project joined the forces of both the food industry and academic researchers. The task was to study acrylamide in food. The main objective was to determine the influence of precursors regarding acrylamide formation in potato and cereals, and to develop methods for monitoring the bioavailability of this neurotoxin. This is to be added to the evaluation of possible health effects. The objectives were achieved in laboratory models, as well as in industrial scale processing experiments.

Important precursors for heat induced acrylamide formation are reducing sugars as fructose and glucose (but not sucrose), and the free amino acid asparagine. For potato products, the limiting substrates are generally the reducing sugars, and these vary considerably between cultivars, growing seasons and storage conditions. The content of asparagine is also important, although less than reducing sugars. For the cereal products, the potential for acrylamide formation is mostly determined by the asparagine content in the flour. Rye contains more free asparagine than wheat, and germ and bran contains more than sifted flour.

Mitigation strategies are in general coupled to lowering the temperature, and/or reducing the processing time. This must be carefully monitored in order to maintain the product quality. Blanching potatoes in order to reduce the precursors is also quite efficient, but the results do vary and in some instances the quality can be influenced. The cereal precursors cannot be removed, but replacing amino-based leaving agents, increasing the yeast fermentation time or increasing the thickness and final humidity of the products, can reduce the formation in the products.

## Conclusions and policy implications

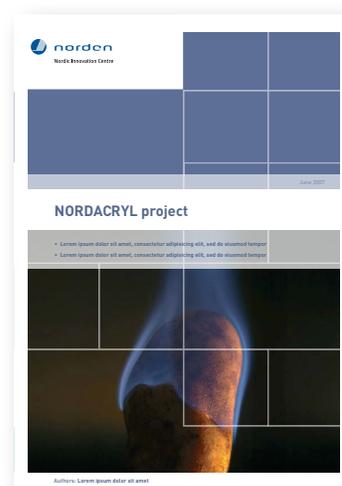
There has been a continuous exchange of information with the National Food and Health authorities, the European Commission and the European Food Safety Agency (EFSA). In addition approximately 25 scientific papers stemming from within the project group has been published in peer-reviewed journals. NORDACRYL was a key platform for connecting the Nordic food industries to other research activities at Nordic research institutes, universities and national projects. It also tied in with European research projects such as HEATOX.

Acrylamide level reductions have been achieved by optimizing the heat load during processing of potato and cereal products. Further reduction has been obtained in lab scale experiments by using additives that compete with the acrylamide formation in the product, fermentation modification and oven conditions, - and by air-drying the potato chips. The feasibility of such modifications on industrial scale, and the potential effect on overall product quality, is yet to be evaluated. Some varieties of potatoes tested in the products, but not commercially available, showed promising results.

Other actions might be adding natural compounds competing with the asparagine in the reactions forming acrylamide, or by removing this precursor from the raw material. The former can be achieved by adding the naturally occurring amino acid glycine, and the latter by using the enzyme asparaginase. More work is needed, since some of these additions might induce sensory effects in certain products, and due to regulatory aspects still pending. Additions of such active constituents are more feasible for cereal-based products, since they can be added in the dough.

Further research is needed to develop varieties with lower precursor levels, adapted to the Nordic climate. The developed method for determination of biomarkers in urine seems a valuable tool for determining the internal dose of acrylamide exposure resulting from food. In addition, more details about human exposure and internal dose of acrylamide are also needed. In a mouse model we studied how urinary metabolites of acrylamide could be used as short time biomarkers of exposure and internal dose. A linear relationship was demonstrated between the intake of acrylamide from crisp bread (experimentally baked to give different content of acrylamide) and urinary biomarkers. The bioavailability was approximately 100%. These urinary biomarkers are valuable tools in order to determine real human exposure, and also to extrapolate toxicological data from animal studies to humans. Results are awaited from human epidemiological studies using biomarkers to measure the acrylamide intake.

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Nordic Innovation Centre

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The Nordic Innovation Centre is the Nordic Council of Ministers' single most important instrument for promoting an innovative and knowledge-intensive Nordic business sector.

Our basic assumption is that each of the Nordic countries possesses knowledge, which through increased co-operation significantly will improve innovation capabilities and competitiveness for Nordic businesses.

**Nordic knowledge platforms**

Today, the Nordic Innovation Centre is an important player in Nordic knowledge platforms within the areas of Innovation Policy, Creative Industries, Biotechnology, Food Safety, Functional Food,

Micro- & Nanotechnology and Innovative building & construction. Establishing common Nordic knowledge platforms on strategically important areas give Nordic businesses access to the best knowledge possible and greatly enhance their innovation capabilities.

We believe that building common Nordic knowledge markets are vital to all Nordic business life, enabling us to compete in a global market which is becoming more and more knowledge driven.

**Investments**

The total project portfolio of the Nordic Innovation Centre consists of approximately 120 ongoing projects and networks. These projects involve the Nordic Innovation Centre in nearly all strategically important Nordic innovation areas.

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