

CHILL-ON



**Ideas and solutions to improve
food quality, safety and traceability**





CHILL-ON is partly funded by the European Commission
(Contract No. FP6-FOOD-CT2005-016333)

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What is this brochure about?

You are a food manufacturer and would like to improve the quality and extend the shelf life of your products? Do you need solutions to control temperature in your supply chain and thus guarantee food safety? Would you like to shorten microbial analysis time? Are you interested in novel technologies which add value to your products and make communication with suppliers and customers easier? Or are you a researcher looking for information in a specific field or opportunities for cooperation?

If your answer to any of these questions is yes, then please take a look at our ideas and solutions and get in touch with us.

More detailed information about our results can be found at:

www.chill-on.com



Foreword from the coordinator

Governments have to find ways to protect and inform consumers, ensure food supply, and adhere to international trade agreements. The food industry has to create healthy and safe products that appeal to consumers and ensure that its products comply with legislation, whilst at the same time maintaining its competitiveness both within and outside Europe.

A group of food scientists has developed a holistic approach, which ensures food quality, safety, and traceability throughout the entire supply chain. It underlines the need to support research and development in this area, which was already identified by the European Commission in 2004 and in the subsequent publication of a call for proposals. The CHILL-ON consortium accepted the challenge and submitted a proposal for a research project with the aim of “Developing and integrating novel technologies to improve safety, transparency, and quality assurance of the chilled/frozen supply chain”. To ensure transferability of technologies and applications to other food products, the project was focused on both fish and poultry supply chains.

The project participants aimed to provide stakeholders along the supply chain with systems that ensure fulfilment of European legislation and apply current standards.

As Project-Coordinator, I am confident that CHILL-ON represents a unique opportunity to the Member States to improve safety and documentation of their food chains to a considerable degree and at the same time to increase their competitive position.

Yours sincerely,

Matthias Kück
ttz Bremerhaven
CHILL-ON Project-Coordinator

What does the food industry really need?

Results from focus group meetings with food supply chain representatives regarding the need for technologies to ensure transparency in the food supply chain have highlighted that the industry needs *applied knowledge and simple tools* to verify the quality, safety, and traceability of its products in accordance with regulatory and customer requirements.

The possibility to have access to temperature information in real time is the key to transparency in the food supply chain because temperature is interoperable throughout the entire chain. According to representatives from the fish-processing trade, it would be a real benefit if the temperature profile of their products could be monitored in case something goes wrong in the supply chain, especially during transport. The producer could then intervene much sooner than is possible now and thus take the products off the market if spoiled or transfer them into some other production of less value in order to save as much as possible. If the translation of temperature history could give reliable information on the predicted shelf life and safety of products, then this would be an added advantage. The tools need to have a short detection time in order to give the food industry valid support for decision making in real time for efficient supply chain management. The tools have to be easy to operate and appropriate training and guidelines should be offered.

CHILL-ON has focused on verifying the performance of the developed tools in field trials throughout the entire supply chain in order to demonstrate their functionality and ensure their readiness for application. The industry needs scientifically validated

tools and methods that have been adapted to specific products. Industry will only implement tools that will give added value to their operations, i.e. tools to support cold chain management in food supply chains, resulting in less waste, more sustainable production, and cost reduction.

CHILL-ON surveys have shown different benefits of traceability systems as perceived by a number of fishery companies operating at different links of the supply chain. The results have strengthened arguments on cost distribution among the stakeholders in a supply chain.

The CHILL-ON Project

The 16 million € project was partly funded by the European Commission and carried out by a consortium consisting of 26 partners from 13 different countries. Co-ordinated by ttz Bremerhaven (Germany), CHILL-ON, a European research project, started in July 2006 with the ambitious aim of improving quality, safety, and transparency in the chilled food supply chain.

This was done by implementing an interdisciplinary R&D programme, which included a very wide spectrum of disciplines from biochemistry, genetics and microbiology, through chilling, packaging, and logistics, to information technologies, engineering, statistics, and mathematics.

Duration: 4 years (01/07/2006 to 20/06/2010)
Total budget: 15.6 Mio. €
EC contribution: 10.1 Mio. €
Thematic priority: Food quality and safety
Instrument: Integrated Project
Coordinator: ttz Bremerhaven



SIXTH FRAMEWORK PROGRAMME



Industrial Partners:

Afcon Industries Ltd. – Israel
 Beijing Fishing Company – China
 Motorola Inc. – Israel
 Seara Cargill S.A. – Brazil
 Companhia Minuano de Alimentos – Brazil

SMEs:

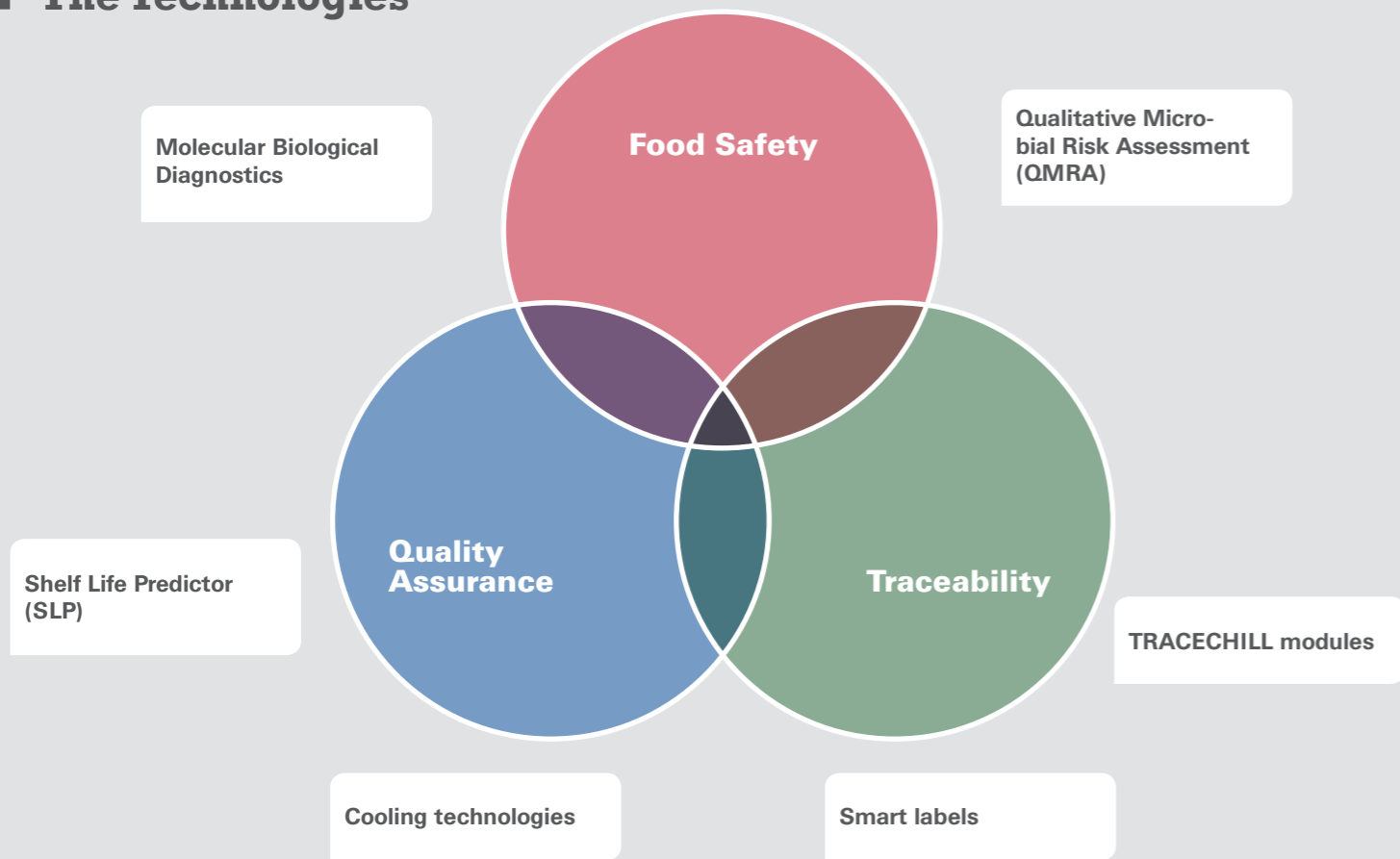
Act Value Consulting & Solutions – Italy
 OpaleSeafood – France
 Q-Bioanalytics GmbH – Germany
 Research relay Ltd. – United Kingdom
 OSM-DAN Ltd. – Israel
 Freshpoint Holding – Switzerland
 Chainfood b.v. – Netherlands
 Traceall Ltd. – United Kingdom
 Research Laboratories – Greece

RTDs:

Technologie-Transfer-Zentrum Bremerhaven – Germany
 China Agricultural University – China
 Wessex Institute of Technology – United Kingdom
 University of Bonn – Germany
 Fundación Chile – Chile
 University of Parma – Italy
 University of Kent – United Kingdom
 Matis ohf - Iceland
 Institute for Packaging, Transport and Logistics Research – Spain
 Fundação Universidade Federal do Rio Grande – Brazil
 University of Iceland – Iceland
 Technion – Israel Institute of Technology – Israel



The Technologies



The Technologies - Overview

You want ...	Solution	Description
to estimate pathogen growth and associated risk for the consumer?	Quantitative Microbial Risk Assessment (QMRA)	Calculates pathogen growth based on temperature data.
to analyse your products for food pathogens?	Rapid detection of food pathogens	Allows fast detection of relevant pathogens.
to calculate the shelf life of your products?	Shelf Life Predictor (SLP)	Calculates remaining shelf life of food products based on temperature data.
to quantify spoilage bacteria to evaluate food quality?	Rapid detection of food spoilage organisms	Allows fast quantification of spoilage indicator organisms.
to evaluate the effectiveness of your hygiene practices?	Rapid detection of hygienic markers	Allows fast quantification of hygienic markers (bacteria from the group Enterobacteriaceae).
an indicator of the food "freshness" of your products?	Time Temperature Indicators (TTIs)	Can indicate the time-temperature history and subsequent "freshness" of food in the form of a colour response.
to implement inexpensive and disposable smart labels for real-time temperature recording?	RFID-TTIs	Allow wireless transmission of a TTI signal through a passive RFID chip.
to improve chilling or implement new chilling technologies?	Comparison of chilling technologies	Guidelines about best practices for chilling of food products.
a holistic approach to manage data transfer and ensure traceability in your supply chain?	TRACECHILL System	Combines different technologies developed to allow communication and data management along the entire supply chain.
a system which warns you if something goes wrong?	Decision Support System (DSS)	Alerts supply chain actors in case of temperature abuse, reduced shelf life, etc.
an efficient data management system?	Supply Chain Management (SCM) software	A web-based software for data processing and sharing.
to know where your products are during each step of the supply chain?	Geographical Information System (GIS)	Determines location of goods during the transport phase.
data loggers allowing real-time temperature monitoring?	Temperature sensors (T-Sensors)	Records and transmits temperature data.
a wireless communication controller?	Mobile Management Unit (MMU)	Receives wireless data from sensors and transmits these data sets to a server.

FOOD SAFETY

Food Safety is a big issue nowadays, pushed by recent food crises and rising consumer awareness. In addition, rapid globalisation as a result of growing international trade exhibits a major food safety problem. Quantitative risk assessment, i.e. identifying hazards and estimating the risk they involve, is therefore becoming increasingly important for the control of food safety. The quantitative microbial risk assessment module developed in the CHILL-ON project calculates the probability of an adverse health effect based on temperature data and product characteristics (e.g. pH, aW, prevalence of pathogens). Besides the modelling of pathogenic bacteria, the model also contributes to quality assurance through estimation of spoilage bacteria growth.

Development of rapid detection methods for identification and quantification of micro-organisms associated to food was also a research topic investigated in the CHILL-ON project. Classical microbiological detection methods are time and labour intensive, and not always reliable. By contrast, molecular detection methods such as PCR offer faster analysis time, lower detection limits, higher specificity, and possibility of automation, allowing implementation in routine food-testing laboratories.



Quantitative Microbial Risk Assessment (QMRA)

The CHILL-ON QMRA software module is based on mathematical models to calculate growth of relevant food pathogens. It estimates the probability of infection after consumption of the food. The risk levels to the consumer at the end of the supply chain can be evaluated at any point in the chain, on the basis of the real-time temperature recordings and historic data for that part of the supply chain where temperature recordings are missing.

The module relies on an internal database which contains data for different microbial species and products. If data for particular microbial species or products are missing, they can be added to the database. The model can be calibrated periodically using supply chain data in order to keep it up to date with conditions in the supply chain.

Advantages offered

- » Estimation of pathogen growth and risk level at point of consumption
- » Integration into software systems (e.g. CHILL-ON TRACEHILL system)
- » QMRA adds quantitative information to the decision process which is currently based on the HACCP, i.e. a purely qualitative approach. It is particularly useful when testing what-if scenarios by changing certain parameters in the supply chain, e.g. the temperature profile. It can also help by adding quantitative information when deciding on the steps to be taken following a disruption in normal operation, e.g. temperature abuse.

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Test Kits for Rapid Detection of Food Pathogens

Test kits for rapid detection and enumeration have been developed for the following food pathogens:

- » Salmonella spp.
- » Salmonella enterica
- » Campylobacter jejuni
- » Clostridium perfringens
- » Listeria innocua
- » L. monocytogenes
- » Vibrio parahaemolyticus
- » V. cholera
- » V. vulnificus
- » V. alginolyticus
- » Legionella pneumophila
- » Escherichia coli
- » Escherichia coli EHEC
- » Pseudomonas aeruginosa
- » Staphylococcus aureus

The test kits are based on quantitative Polymerase Chain Reaction (qPCR), which allows identification and enumeration of relevant pathogens within a few hours, with or without previous enrichment. They include the material and protocols needed to carry out the analysis, including sample preparation through use of specific catching nanoparticles.

Advantages offered

- » Decrease in total analysis time and increase in throughput
- » Simplification of analysis protocol and decrease in analysis unit cost
- » Increase in specificity, reliability, and sensitivity of assay
- » Real-time microbial identification and enumeration possible at the level of bacterial strains, species, and families
- » Possibility of integration of data within an overarching software platform (QMRA) for food quality monitoring and maintenance

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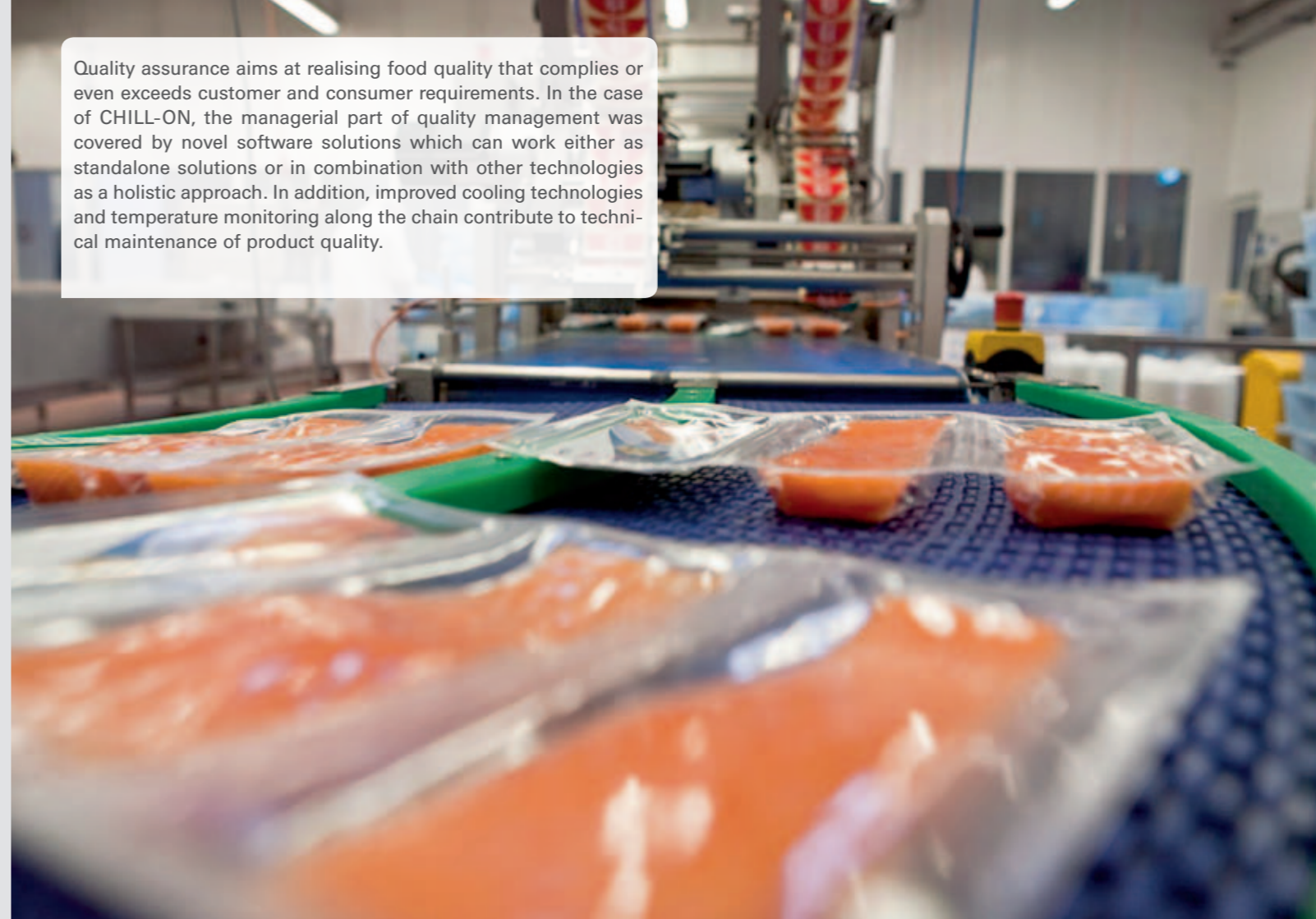
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QUALITY ASSURANCE

Quality assurance aims at realising food quality that complies or even exceeds customer and consumer requirements. In the case of CHILL-ON, the managerial part of quality management was covered by novel software solutions which can work either as standalone solutions or in combination with other technologies as a holistic approach. In addition, improved cooling technologies and temperature monitoring along the chain contribute to technical maintenance of product quality.



Shelf Life Predictor (SLP)

The Shelf Life Predictor (SLP) is a software module for estimation of remaining shelf life in real time for a product at any point in the supply chain. It is based on mathematical models for the microbial growth of specific spoilage indicators, which are based on laboratory data. The software calculates bacterial growth, taking into consideration temperature variations during transport and storage.

As not all bacteria which contribute to spoilage can be taken into account, indicator organisms have been defined (e.g. *Pseudomonas* spp. for poultry or *Photobacterium phosphoreum* for fish). Their growth mirrors the spoilage process in the food product.

Advantages offered

- » Prediction of remaining shelf life at any point in the supply chain, based on real-time temperature recordings or historic data
- » Support for warehouse management by providing more accurate information on the remaining shelf life of the products
- » Possibility for integration into Decision Support System (DSS) software
- » Possibility to insert new microbial growth data in order to calibrate system

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Freshness of Food Rapid Enumeration of Spoilage Organisms

Test kits for rapid detection and enumeration were developed to track food spoilage organisms and assess food quality:

- » *Pseudomonas* spp. (fish, poultry, meat)
- » *Photobacterium phosphoreum* (fish)

The test kits are based on quantitative Polymerase Chain Reaction (qPCR), which allow enumeration of specific spoilage bacteria in food within a few hours. They include the material and protocols needed to carry out the analysis, including sample preparation through use of specific catching nanoparticles.

Advantages offered

- » Unbiased measure of freshness of food
- » Decrease in analysis time
- » Increase in throughput
- » Simplification of analysis protocol
- » Decrease in analysis unit cost

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Rapid Detection of Hygienic Markers

The presence of *Enterobacteriaceae* mirrors the hygienic status of a food manufacturing process. The test kit developed allows the detection of bacteria from the group of *Enterobacteriaceae*, which act as hygienic markers. The test system is based on quantitative Polymerase Chain Reaction (qPCR) and permits the detection and quantification of microorganisms which are relevant to hygiene. The user is given the whole analytical tool, from isolation of the nucleic acid to enumeration.

Advantages offered

- » Time-efficient analysis
- » Increase in cost effectiveness
- » Decrease in manpower and saving of resources
- » Specific detection of hygienic parameters (*Enterobacteriaceae*)
- » Reliable results
- » Easy handling
- » Ready-to-use analysis kit

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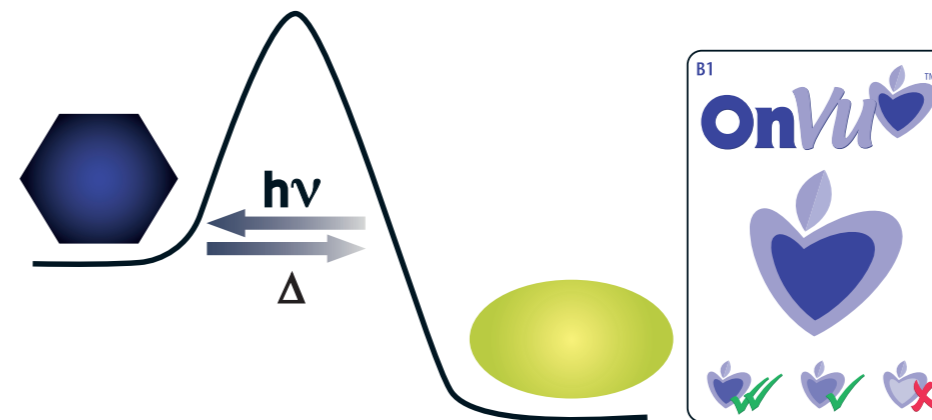
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Time Temperature Indicators (TTIs)

Time Temperature Indicators (TTIs) are simple, inexpensive labels attached to food packages that show the temperature history of a product through a colour. The principle of the different indicators is based on temperature-dependent enzymatic, chemical or microbiological reactions which cause a colour change in the labels in dependence on time and temperature conditions. This means that a high temperature leads to a fast colour change, a low temperature to a slow discoloration process in the labels. The discoloration process can be adapted to the deterioration process of food products. The colour therefore indicates the "freshness" of the food product.



Advantages offered

- » TTIs display a visual summary of the time-temperature history of the product
- » TTIs do not replace the "Use By" date, but are instead meant to complement it
- » TTIs indicate the freshness level of a product based on its temperature history, from production to table
- » TTIs are low-priced and an easy way to indicate temperature abuse
- » TTIs can be applied to a wide range of fresh and frozen products

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TTI-RFID tags: rf-TTI

The combination of TTIs with passive Radio Frequency Identification (RFID) technology allows wireless transfer of shelf life data together with product/batch ID.

The TTI part consists of a dissolving metal layer, the dissolving process of which is dependent on time and temperature. It is integrated into an electronic circuit (capacitor, inductance, resistor, etc.) and the resulting electronic signal can be transmitted via the associated RFID chip.

The time-temperature response of the TTI component can be adapted to different products by changing the characteristics of the reactive layer. The tailor-made TTIs allow digital as well as continuous responses. The rf-TTI prototype successfully proves the concept of TTI – RFID integration, and is ready to become an integrated circuit and therefore a commercial RFID tag.

Advantages offered

- » Low-priced, passive tag (no battery)
- » Wireless transfer of TTI output (remaining shelf life)
- » Display of TTI output / remaining shelf life in database / on website
- » Verifications without opening the insulated box
- » Much faster checkout – labour cost reduction
- » Integration in control systems
(e.g. HACCP, electronic supply chain management)

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Comparison of Chilling Technologies

Fresh fish has a short shelf life even at refrigeration temperatures. The limited shelf life is a large obstacle for the export of fresh fillets. The chilling technologies used onboard fishing vessels during processing, storage and transport have therefore been compared in order to extend shelf life. The most suitable technologies at each step were identified as follows:

- » Slurry ice for fast cooling of fish after catch and prior to processing
- » Crushed ice for long-term storage
- » CBC cooling for lowering the temperature of fillets before transport

The main aim of the various chilling technologies is to maintain a low and steady product temperature between -1 and 0°C throughout the chain from catch to consumer in order to ensure the quality of the product.

Detailed chilling guidelines are available at www.chill-on.com/publications.

Advantages offered

- » Optimised chilling during processing, transport, and storage
- » Prolonged shelf life of the fish
- » Opening up of marketing opportunities
- » Choice of alternative transport solutions (ship-air)

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TRACEABILITY

Traceability along food supply chains is required by EU Regulation 178/2002, which took effect on 1st January 2005: *food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal or any substance intended to be, or expected to be, incorporated into a food or a feed. Moreover, food business shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.* However, food operators are free to choose how to implement these requirements.

Indeed, one of the major weaknesses of agri-business supply chains is the information gap between entities, which arises from the inability to share information (due to lack of supporting technology) or the unwillingness to share it. CHILL-ON aimed to provide suitable, affordable solutions which furthermore provide an additional added value for the stakeholders through the possibility of improved supply chain management.



TRACECHILL system

The CHILL-ON TRACECHILL system is a complete and integrated Chain Information Management System for the entire supply chain from “farm to fork”. The objective of the TRACECHILL system is to tackle the most crucial points within a full supply chain: continuous temperature monitoring, temperature abuse identification, food contamination, quick tracking and tracing of products.

By collecting all relevant data along the full supply chain, the system is able to provide important safety and quality information in real time for various user levels, including calculated current remaining shelf life of the product and its location, hence minimizing the time needed to identify a product’s hazards and for any action to be taken to remove it from the chain.

The TRACECHILL system is designed in such a way that all modules are fully transparent for the user. The user is required to log into a single dedicated website where all the information processed by the different modules is available (based on user’s authority level) through simple and user-friendly menus and tabs. An advanced user interface provides both tabular and graphical views of analysed data along with embedded hyperlinks.

Modules which can be coupled to the CHILL-ON TRACECHILL system are:

- » Quantitative Microbial Risk Assessment (QMRA)
- » Shelf Life Predictor (SLP)
- » Decision Support System (DSS)
- » Detection methods for relevant bacteria (based on qPCR)
- » Smart labels for temperature monitoring (RFID-TTIs)
- » Supply Chain Management (SCM)
- » Geographical Information System (GIS)
- » Mobile Management Units (MMUs)
- » T-Sensors

Advantages offered

- » Integrated system supports inputs from various sources: dedicated hardware, software, files
- » Web-based – can be accessed from any computer connected to the internet
- » Highly secure system with single sign-on login
- » Advanced user management based on companies and roles
- » All information can be accessed (based on user authorization level) from same application
- » User-friendly interfaces – simple operation at all user levels

Contact

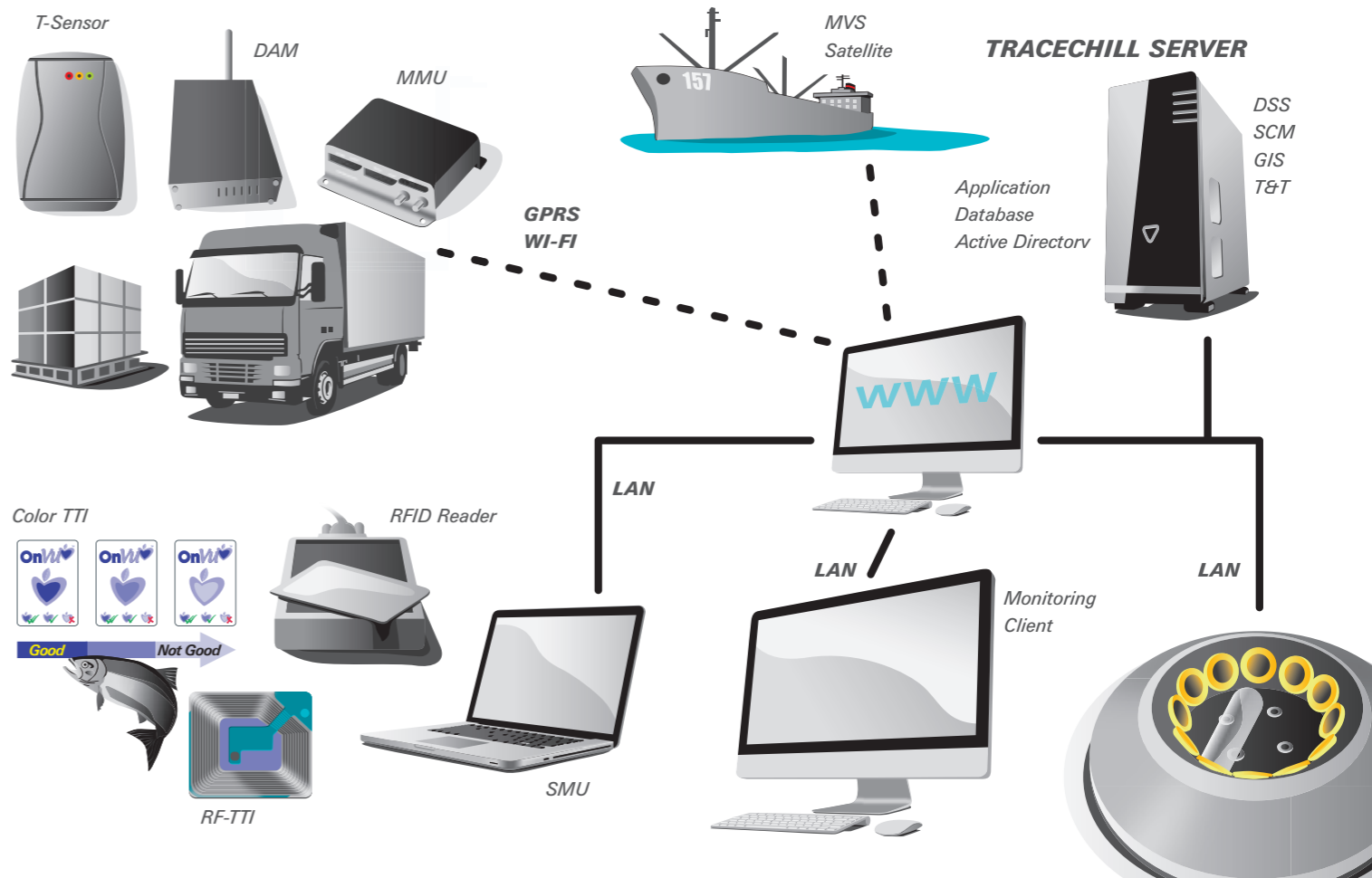
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TRACECHILL system - Overview

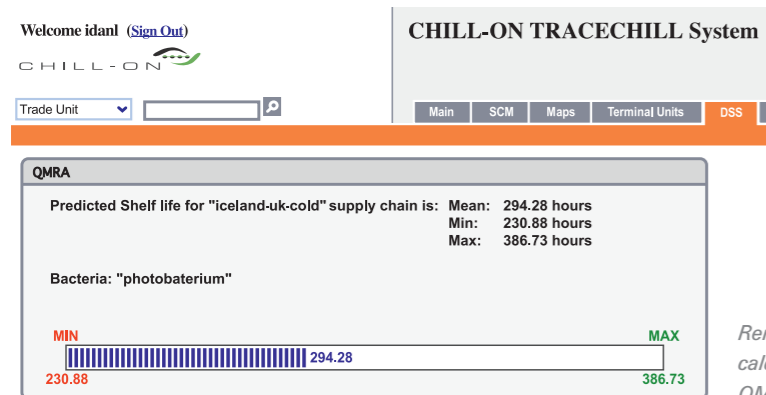


Decision Support System (DSS)

The Decision Support System (DSS) module provides the user with the critical information required to make an appropriate decision regarding a product, by predicting the risks to which the food can be exposed during the distribution process. Based on the environmental, microbial, and QMRA model of the supply chain, it predicts the remaining shelf life of the product at each stage in the supply chain. The DSS alerts and notifies the user whenever there is an indication that a product is deteriorating. The user is able to define a set of criteria for each supply chain and therefore customize the alerts and notifications made by the system to best fit the product as it moves through the supply chain. The DSS supports manual and automatic inputs mode of operations and therefore provides greater flexibility to fit a wide range of goods and products.

Advantages offered

- » Automatic and immediate notification of remaining product shelf life
- » Smart algorithm which takes into consideration multiple stages and delays in the supply chain
- » Manual mode for anticipating remaining shelf life prior to shipment
- » User-friendly interface for determining criteria for alerts and notifications
- » Integrated with a geographical information system to identify the location from which the alert stems



Remaining shelf life calculated by the QMRA and DSS.

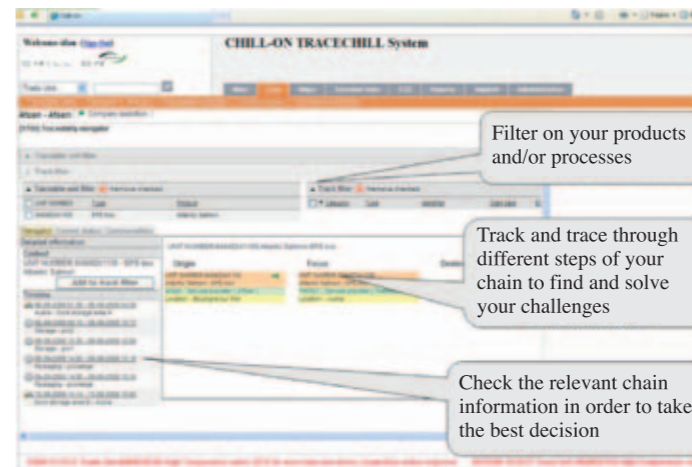
Supply Chain Management (SCM)

The SCM module of the TRACECHILL system supports chain coordination by

- » Registering and providing an insight into product flows and processes
- » Delivering analysis functionalities, e.g. for faster and more efficient risk management
- » Ensuring maximum use of the existing IT infrastructure, including online registration of relevant data via a web interface where necessary
- » Delivering a generic structure which means chain-specific adaptation of the system instead of time-consuming programming

Advantages offered

- » Monitoring of all relevant quality and risk aspects throughout the chain
- » Full traceability functionality
- » Efficient recall management
- » Detection of commonalities between products
- » Collection of data needed for other TRACECHILL modules
- » Creation of a data platform for customer-specific reports, e.g. for mass balance



Example:

Analysis functionality for the track and trace of monitored products through all processes in the chain.

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Geographical Information System (GIS)

The CHILL-ON Geographical Information System (GIS) module integrated into the TRACECHILL system provides the user with a map-based view of the current and historical location of a product as it moves through the supply chain. The multi-source information is displayed on various types of maps, which can be easily customised to any area in the world. At a quick glance, the user can see the location of the product and when alerts/notifications are issued. The easy-to-use interface enables the user to pan and zoom the map, as well as viewing all the locations of a specific shipment.

The coupling of the GIS module with other modules such as the DSS has the advantage of being able to foresee developing events, such as unscheduled stops or delays, and calculate their immediate effect on the shipped products. By knowing the exact location of the product in such an event together with its current freshness status, a user (i.e. quality assurance manager) can decide whether re-routing of the product is required in order to achieve the maximum value for its quality condition.

Advantages offered

- » Displays location of product
- » Calculates (in combination with the DSS module) the effect of unscheduled stops or delays on shelf life

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Mobile Management Unit (MMU)

MMU – Mobile Management Unit is an innovative “all-in-one system solution” for monitoring and control applications within cold chain management systems. It is a standalone wireless communication controller based on state-of-the-art GSM/GPRS/EDGE/WiFi/GPS hardware with configurable multiple-interface connectors, remote control and diagnostics managed by downloadable application. MMU incorporates Motorola RF coexistence design with an SW development platform which allows OTA (Over the Air) HW configuration and settings with SW configuration and updates.

The MMU allows connection of different sensors, data (such as temperature) capture from the sensors, local data processing and analysis. Being on the road and within the yard, MMU automatically transmits location and temperature data to the back office. Thanks to its continuous online data-processing capabilities, the MMU system can broadcast a temperature or other predefined alert immediately upon the event occurring. By feeding the temperature data in real time to the company’s central database and allowing the company’s quality manager to reject the load even before the truck has parked, the MMU system facilitates decision making and control of the cold chain.

The MMU system helps in permanent improvement and cost saving in the cold chain through the real-time identification of the “trouble spots” within the delivery chain and thus guarantees visibility and granularity of a product’s quality. A cold chain manager can learn how long the cold shipment exceeded the allowed degree at the distribution channel at only the price of low-cost communication.

Since it features fixed hardware and flexible software, MMU represents an open and easily adaptable platform for cold chain management products and services.

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T-Sensors

A fundamental part of the CHILL-ON TRACECHILL system is the technology able to sample temperature values and transmit them to the system in real time. Many devices are already able to record temperature during goods' transportation, but such values are available only at the end of the journey when it is too late to save a load that has been affected by temperatures outside the right range.

This is the main reason why a novel active tag family has been designed and developed. This class of tags, which has been named T-Sensors, aims at providing something new and which is not yet available on the market. These tags, in conjunction with suitable readers, represent an innovative system which is based on the relatively new ZigBee communication standard @2.4GHz, a frequency which is available almost worldwide for this kind of application and without limiting national regulations. The system relies on three components: the active tag (T-Sensor), the reader (DAM – Data Acquisition and Management) unit and the Mobile Management Unit (MMU).

Advantages offered

- » Real-time knowledge of the temperature condition of the load
- » Monitoring of the temperature even during loading – unloading phases
- » Plug and play
- » No set-up needed inside the container
- » Time and GPS information are linked to the temperature samples

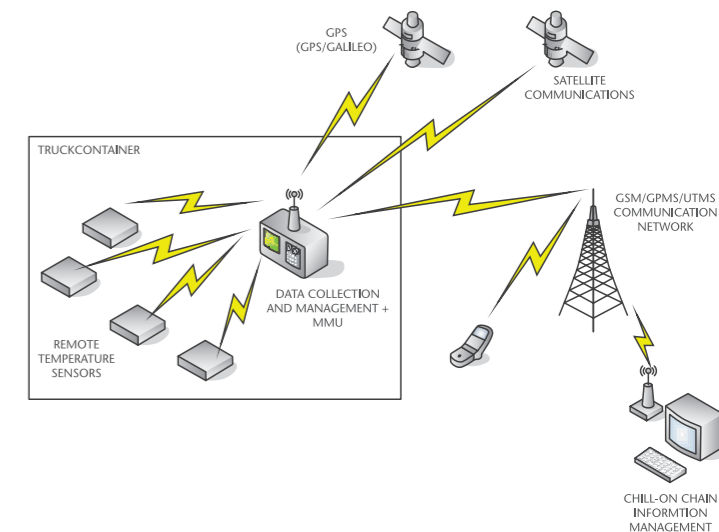
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