



TTI-MEAT SAFETY SYSTEM

SMAS

Development and application of a TTI based
Safety Monitoring and Assurance System
for Chilled Meat Products



QLK1-CT-2002-02545

A European Commission
Research and Technology
Development Project



FIFTH FRAMEWORK PROGRAMME
Quality of life and management of living resources

<http://smas.chemeng.ntua.gr>



Meat Chill Chain - Need for better management

The European industry, retailers, food authorities and consumers themselves, recognize that the temperature conditions maintained in the food chill chain affect directly the quality and the risk level of chilled products.

Meat products are perishable and, even when they are properly processed and packaged, they can spoil in relatively short time, unless they are distributed and stored appropriately. Overgrowth of incidental pathogenic bacteria, like *Listeria monocytogenes*, *Salmonella sp.* and *Escherichia coli*, followed by undercooking or inadequate preparation, may pose a potential hazard for the consumer. Despite the focus of the European authorities on food safety regulations and the application of safety management systems such as HACCP, risk assessment studies show that foodborne disease remains an issue of concern.

The systematic management of the chill chain and the improved evaluation of safety, quality and shelf life of meat can lead to reduced safety risk and increased quality, with a significant health and economic impact to the European society and market. These were the goals of SMAS.

SMAS and TTI

SMAS is an integrated chill chain management system, that leads to an optimised handling of products in terms of both safety and quality. It is based on the ability to continuously monitor the storage conditions of each product, from production to consumption, with the use of **Time Temperature Integrators (TTI)**.

TTI are inexpensive, active "smart labels" that show a gradual visual change with time and temperature. This change, e.g. a colour that gradually changes from green to red, accelerates when temperature increases, in a similar way that spoilage phenomena in the food do. Thus TTI response reflects the time-temperature history of the food product. It can be correlated to meat safety and quality status at any point of the distribution chain providing an effective decision tool.

The SMAS project

The acronym **SMAS** stands for "*Development and application of a TTI based Safety Monitoring and Assurance System for Chilled Meat Products*", a 3 year project, carried out by 7 European Institutes/Companies and co-ordinated by the National Technical University of Athens. Funded by the EC Fifth Framework Programme, it belongs in the key action of Food, Nutrition and Health and the thematic priority "Quality monitoring and traceability in the food chain".

SMAS is based on verified mathematical models of the growth of the predominant meat microbes and of the response of selected TTI. An expanded TTI application scheme translates TTI response to meat microbiological and quality status.

The main tangible outcome of the SMAS project
was the development of a reliable and practical
decision and management tool for an optimized handling of meat products



MAIN SMAS ACHIEVEMENTS

STUDY OF THE FOOD

Quantitative microbiology of target meat products

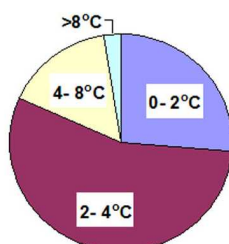
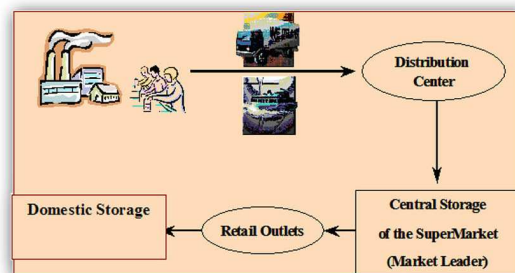
Accurate, validated mathematical models for safety and quality related microorganisms of ready to cook meat products were developed.

They provide the meat industry with a tool for product development and safety assurance and the European authorities with a quantitative means for meat product risk evaluation.

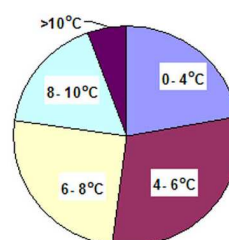
- Modelling and model validation for growth of pathogenic bacteria incident to meat was systematically carried out with a series of experiments on meat products. These included pork, beef and lamb products.
- The growth of the targeted pathogenic bacteria *Listeria monocytogenes*, *Salmonella enteritidis*, and *E. coli* O157:H7 on different meat products, with or without natural microflora, stored under aerobic or modified atmosphere packaging, was studied and modelled at different temperature conditions from 0 to 20 °C.
- Growth models of spoilage bacteria (*Pseudomonads*, *Brochothrix thermosphacta*, lactic acid bacteria and *Enterobacteriaceae*) and shelf life models were also established and validated within the project, as a basis for correlation with the response of the TTI and the chill chain management system.
- Pathogen and spoilage bacteria growth was studied and modelled under **dynamic temperature conditions**. Temperature dependence of growth was expressed by a mathematical parameter, E_a , in the range of 70 to 150 (kJ/mol). Values of the E_a parameter were used for the development of the TTI.

STUDY OF THE CHILL CHAIN

- Monitoring of real-time temperature conditions in different European countries (Netherlands and Greece), for ALL steps of the actual chill chain of meat products was conducted.
- A data-base with statistics of TEMPERATURE conditions was built. Data base includes retail and home conditions.
- Main weak points were identified.
- The chill chain showed variability. Product handling on the average is acceptable but suffers from temperature fluctuations.
- Home refrigeration conditions exceed 8° in 20% of cases.



Distribution of average temperatures in retail cabinets



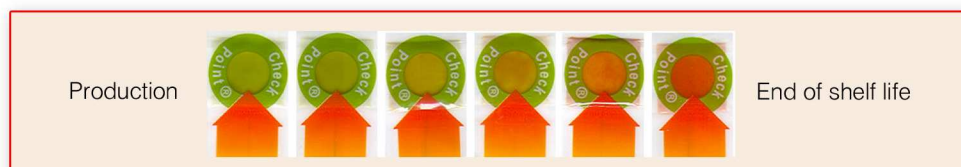
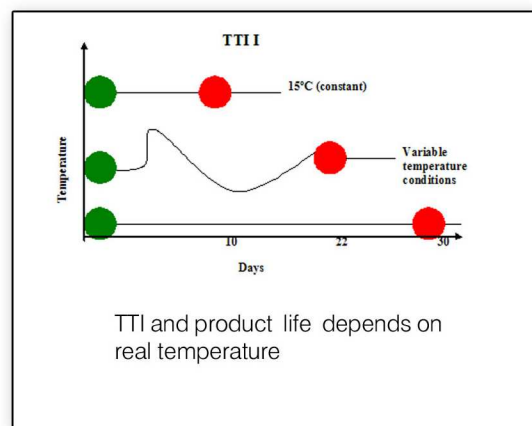
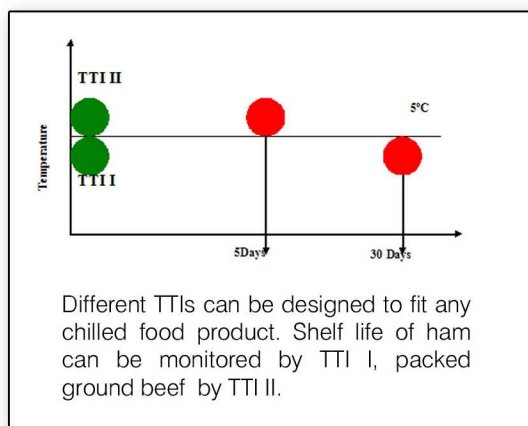
Distribution of average temperatures in home refrigerators



DEVELOPMENT AND STUDY OF TTI

An assortment of enzymatic Time Temperature Integrators (TTI) suitable for meat quality and risk monitoring was developed and studied. These TTI will provide the meat industry and retail business with effective tools to monitor the chill chain.

- Different designs of enzymatic Time Temperature Integrators of various response characteristics were modelled and validated under variable temperature conditions. Response ranged from hours to several weeks at refrigeration temperatures.
- A new tricolour configuration (green-yellow-red) was developed.
- The TTI temperature sensitivity ranged in terms of the E_a parameter from 50 to 200 (kJ/mol) covering the respective range of bacteria growth in meat products.
- A user friendly TTI software that correlates TTI response to meat quality was produced.
- Alternative methods of measuring TTI response (colour change) were tested. These included instrumental and visual measurements. Instruments such as chromameters, digital imagers and a low cost device developed in the project allow monitoring of the chill chain. Different colour scales allow accurate visual reading of the TTI.

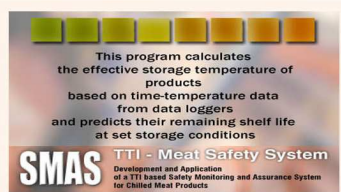


DEVELOPMENT AND VALIDATION OF SMAS FOR CHILL CHAIN MANAGEMENT

SMAS was developed and validated. SMAS could replace the current "First In First Out" (FIFO) practice and lead to risk minimization and quality optimisation by improving distribution logistics and management of the meat chill chain.

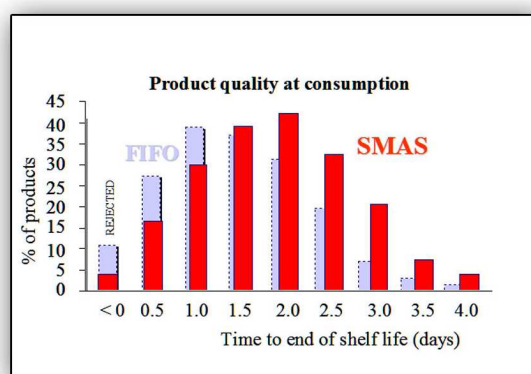
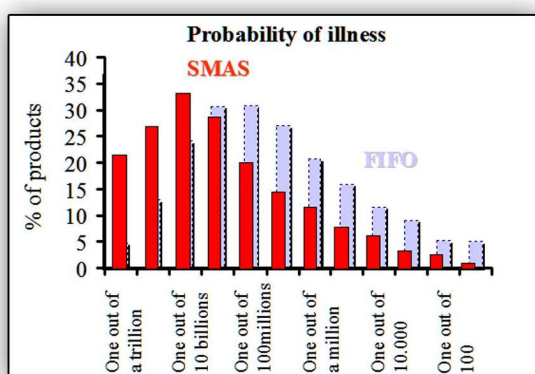
- SMAS uses the information from the TTI, at appropriate points of the chill chain (e.g at a central distribution center), to make decisions for the further management of products based on their quality and safety status.
- The user friendly software, "SMAS Decision Maker", was developed. "SMAS Decision Maker" uses as input the TTI response, calculates the microbiological status of the products and recommends their further handling in the chill chain.
- SMAS was tested and validated by using both experimental and mathematical tools. Significant improvement of the final quality and risk distribution was demonstrated.

SMAS aims not only to monitor but to achieve improved product rotation from production to home storage!



SMAS improves stock rotation in selected points of the chill chain. It ensures that the temperature burdened products are consumed before they reach unacceptable risk.

SMAS practice when recommended chill chain conditions are maintained does not differ from FIFO practice. However in case of incidental temperature abuses, SMAS manages the chain by diverting abused products so that the final rejection and risk is minimized.



The contribution of SMAS in the chill chain management can be visualized as a minimization of risk for illness and optimisation of the meat product quality at the time of consumption.

SMAS from the consumer and industry viewpoint

- 800 surveyed consumers in 4 European countries, Greece, Ireland, Netherlands and Sweden were overwhelmingly in favour of TTI use. 80% considered the TTI response more reliable than just the expiration date. 85% replied that the TTI message is easy to understand and will not be confused with the parallel use of the mandatory expiration date.
- The attitude of the industry was more mixed. Industry overwhelmingly recognizes the benefits from improving the chill chain. It accepts the advantages from the use of TTI and SMAS. It expresses however reservations for the potential misapplication that could unfairly increase their responsibilities rather than improve the chill chain, all the way to the consumers' table. It agrees that research can contribute to alleviate these reservations.

SMAS - source of information

- State of the art information from the project and other reliable sources on the chill chain, TTI and SMAS application and Risk Assessment of meat products are available in the effectively designed and user friendly Web address of the Project.

<http://smas.chemeng.ntua.gr>

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EC FIFTH FRAMEWORK Programme – Quality of life and management of living resources
Key Action 1. Food, Nutrition and Health - Area 1.1. Development of safe and new and/or improved manufacturing processes and technologies - Thematic priority 1.1.3.
Quality monitoring and traceability throughout the food chain

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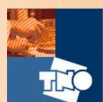


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