Preface

Food quality and safety is a top priority all over Europe. The fast development of technology, combined with increased global competition and more stringent customer demands put strong pressures on companies to improve the quality of their products and processes. The EU's demanding rules have been further toughened since 2000 to ensure that Europeans' food is extremely safe. The new approach is more integrated: feed and food are carefully tracked from farm to fork or from stable to table, respectively. EU authorities carefully evaluate risk and always seek the best possible scientific advice before banning or permitting any product, ingredient, additive or GMO. This applies to all feed and food, irrespective of whether it comes from inside or outside the EU.

Considering the EU´s ambition seven regions from Denmark, The Netherlands, Germany, France, Italy, Switzerland, and Bulgaria have launched a project called "PromSTAP" (promotion the stable to table approach) to establish a European expert network on food safety and quality in the beginning of 2005 (www.promstap.org).

One of the main goals of this network is to develop new approaches and transparent hygiene policies applicable to all food operators right through the food chain "from stable to table", together with effective instruments to manage food safety and any future food crises throughout the food chain. PromSTAP traces the different stages of the food chain system and examines the practices and procedures that ensure the safety of our food. The purpose of several interregional sub-projects within PromSTAP is to explain the complex process by which food reaches the consumer's table and the systems and technologies that ensure the quality and safety of food. In addition project participants elaborated incentives for initiatives to build up chain oriented quality management systems and supported integrated quality management systems in enterprises of the agricultural and food industry.

Combining the widespread interests of diverse regional organisations with the new approaches and instruments being developed by public regional authorities relies heavily on successful cooperation across the EU territory as well as across international borders.

Thus the overall objective of PromSTAP is to "promote the innovation, implementation and internationalisation of the stable to table approach" as a way to improve the effectiveness of regions' policies and instruments for regional development and cohesion. For the 7 participating regions in this RFO it is an excellent opportunity to widen and to deepen their existing inter-regional links and co-operation and to reduce barriers, enhance a sustainable and balanced development in the regions and to offer new alternatives for new co-operation with partners from third countries. In particular the objectives of PromSTAP are:

1. Promoting public private partnerships to support the implementation of new approaches in food safety and quality;
2. Promoting innovations and flexibility of Small and Medium Enterprises in food chains in fast changing markets and legal environment;
3. Improvement of integrated food safety and monitoring systems in international food chains.

This report outlines a number of promising new results to guarantee a high level of human health and consumer protection within the European Union.

We would like to thank the European Union for their financial support and all who have contributed to the success of PromSTAP and therefore to the final report by their competent work:

- the staff of the INTERREG IIIC West JTS in Lille for the competent advice in all financial and administrative questions
- the staff of the Lead-Partner (MUNLV) for initiating the project, the valuable advice and support in the administrative management
- all main partner organisations for their patient engagement in PromSTAP
- and more than 90 experts from 30 organisations for their ambitious participation in different interregional sub-projects

Additional information about project activities and experts will be available, even after the end of the project, at the PromSTAP homepage under: www.promstap.com and www.giqs.org.

Dr. Martin Hamer

Prof. Dr. Brigitte Petersen

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Promote European regions' experience exchange on quality information management in food chains

Schütz, V.[1], Petersen, B.[1], Backus, G.[2], Gardère, E.[3]

[1] University of Bonn, Institute of Animal Science, Preventive Health Management Group, Katzenburgweg 7 – 9, D-53115 Bonn, E-mail: vschuetz@uni-bonn.de

[2] Wagenigen UR, LEI, P.O. Box 29703, NL-2502 LS Den Haag, The Netherlands

[3] PEACRITT, Rue Jean Baldassini 23, F-69364 Lyon, France

Keywords: documentation and information system, food chains, control of control principle

Abstract

Supervision of Control relates to new supervisory arrangements whereby the private sector is assigned more responsibility for compliance with statutory regulations. Companies can qualify for less intensive public food safety inspections within Supervision of Control. The reduced costs of less public inspection are assumed to outweigh the costs of own control systems.

1. Introduction

The EU food law demands traceability and own control systems of every food producer. The legal guidelines enable enough leeway on how to structure these systems. However there are certain guiding principles, which have to be forwarded to the upstream or down stream production stages or that is to say presented to the authorities, in the form of data stored in documents. The respective chain actor can then on its own decide how the actual implementation should proceed. Especially small and mid-sized enterprises consider these requirements as a huge bureaucratic effort. They are the once that therefore need particular support within the customer supplier relation.

A great amount of information which is sector specific enables, according to PETERSEN and co-authors (2002), the control and regulation of processes with the aim to avoid mistakes in the production of foods. This applies to biological, technical and organisational processes. Control and regulation is carried out on the basis of indicators from the production process. The discrepancy between the desired value and the actual value triggers measures for a constant improvement of processes within quality management. The value chain in order to assure quality assurance requires on the one hand information from its own sector and on the other hand from the up and downstream enterprises. Here it is important to make information available during time-critical decision-making processes within a chain.

The developments in the area of Information-Communication-Technology (ICT) make it possible to unite and assess data and information from the entire production process through a number of involved actors. These Data Warehouse solutions (SCHULZE ALTHOFF, 2006) admittedly presuppose inter-organisational coordination centres, which control, organize user specifically and save this data on a long-term basis (PETERSEN et al., 2007). On top of the technical tools and processes, organisational requirements for the coordinating centres and the involved actors have to be provided in this kind of network.

The different regions of Europe show a great variability in regards to the current development of chain oriented information and communication systems. It was therefore aim within the scope of the subproject PromInfo Management (Promote European regions' experience exchange on quality information management in food chains) to get together with experts from the regions Gelderland (NL), Rhône-Alpes (F), North Rhine Westphalia (NRW) (D) and Vidin (BG) and to deal with the following questions:

A. How can production chains be characterized in the agri and food industry and be described with clear concepts from the quality management?

B. Which information demand do actors in the food retail chains have with regard to the quality relevant aspects?

C. How do service providers of the food primary production assess their need for quality relevant information for their task fields?

D. How can an inter-organisational, cross-level system be conceived and implemented in pilot activities?

E. Which tasks do actors of the food retail chains have to assume in the inter-organisational quality management regarding information exchange?

F. How does an efficient innovation culture arise to realize technical and organizational innovations?

G. How do own control systems of the economy effect the reorganisation of the state food control?

The article outlines expert knowledge of the involved regions to the thematic complex of inter-organisational information and communication systems for the food retail chains. One core theme is to show implementation and field of application of inter-organisational ICT-Systems in a variety of different sectors of the agri and food industry. Furthermore the article examines the connection between set-up of cross-level own control systems and the establishing of “Control of Control Principles” within the scope of governmental food monitoring.

2. Materials and Methods

The involved experts of the organisations (LEI, University of Wageningen (NL); PEACRIT (F); University of Bonn, Institute for Animal Science, Preventative Health Management Group (D) and Vidin District (BG)) put emphasis on the following: During the situation analysis priority was given to the information demand in different organisations of pork producing chains. The seven studies and empirical elevations listed in table 1 were the methodical and theoretical background. Besides the internal experts of the organisations involved, those who were in particular surveyed and involved in the discussion included farmers, production technical advisers, veterinaries, associations of farmers, employees of unions and as well as ICT-organisations. The elevations and workshops range over the entire duration of the project from August 2005 - December 2007. During PromSTAP events (e.g. Annual Congress Genoa and Vidin as well as 4 component workshops) the partial and final results were presented to the project partners and discussed constructively. Furthermore the results were presented in the scope of scientific events, exhibitions, articles and newsletters of specific user groups.

Table 1: Used Methods

Steps	**Experts**	
	intern	**extern**
Problem A Characteristics of quality management in agriculture and food industries		
Method: Process analysis [1]		
Stakeholder Workshop in Lyon: - structure of food chains - ICT-Systems for inter-organisational quality management	PEACRITT, University of Bonn, Region Vidin	Representative of an association, food producer; Veterinarian administration; ICT-Organisations
Workshop in NRW: Information- and communication systems in pork chains of NRW	University of Bonn	1 animal feed producer, 3 veterinarian, 10 farmer, 2 farmer associations, 2 representative of an administration, 3 ICT-Organisations
Standardised questionnaire: purchase and distribution ways of pig fatteners	University of Bonn	400 farmers, 6 farmer associations, 1 animal feed producer
Expert interviews: structure and the flow of information in local producing chains	PEACRITT	Each with a representative of pig-, cattle-, sheep- and poultry meat chain as well as milk production (cattle, sheep)
Discussion of the expert interview results and the flow of information in local producing chains	PEACRITT, University of Bonn	Each with a representative of pig-, cattle-, sheep- and poultry meat chain as well as milk production (cattle, sheep)
Problem B and C		
Method: Information demand analysis [2]		
Standardised questionnaire: evaluation of communication structures and the use of internet by farmers	University of Bonn	200 fattener 200 piglet producer
Expert interviews and group discussions: Analysis of inter-organisational data exchange and design of an online pre- and feedback systems in pork chain	University of Bonn	adviser, veterinarian
Standardised questionnaire: information exchange between piglet producing and fattening	University of Bonn	pig fattener, piglet producer, Adviser farmer association, adviser, veterinarian
Standardised questionnaire: variance analysis for implementation of inter-organisational information and documentation systems iin pig fatting	University of Bonn	400 farmer
Expert interviews: demand and claim of animal feed advisers at internal and inter- organistional documentation and information systems in quality management	University of Bonn	16 animal feed adviser, 6 animal feed producer
Expert interviews: demand and claim of veterinarians at internal and inter-organisational documentation and information systems in quality management	University of Bonn	10 veterinarian, German Association of practising veterinarians (bpt) (membership ~ 4.000 veterinarians)

Steps	Experts	
	intern	extern
Problem D		
Method: Best practice demonstrator		
Conception, Development of a specification sheet	University of Bonn	2 ICT-Organisations
pilot implementation	University of Bonn	10 farmers, 2 ICT-Organisations
Problem E		
Method: Process analysis		
Included in the in the activities of point A, B und C		
Problem F		
Method: technology and organisational road mapping		
Creation of innovation teams	University of Bonn, PEACRITT, Vidin District, LEI	GIQS
Technical forecast of developments	University of Bonn, PEACRITT, Vidin District, LEI	GIQS
Creation of innovation processes and structures	University of Bonn, PEACRITT, Vidin District, LEI	GIQS
Problem G Reorganisation of food monitoring		
Method: Principal agent theory		
Literature review [3]	LEI	Industry representatives
Expert interviews	LEI	Representatives from public authorities
References (description of methods and procedure) [1] Meyer et al., [2] Meffert 2000; Strauch 2002; Schütz et al. 2006; Schütz et al. 2008 [3] King et al. 2007; Ellerbroek 2007; Bondt et al. 2007		

3. Results and Discussion

3.1 Process, Information and Communication structure of food retail chains

Chain characteristics

Generally food retail chains in all regions can be characterized using the following points (VAN BEEK, 1990; BLOEMHOF-RUWAAND et al., 1995)):

- Compliance with quality requirements at all production steps, from the primary production, processing, trade up to the end-consumer. This means that livestock husbandry or that is to say later the storage, incoming goods control and process control are of great importance.
- Lasting effect of environmental impacts in all production stages.
- Discrepancy in quality as well as quantity of products emerges due to biological processes and these are in turn influenced by environmental factors such as temperature, precipitation, hours of sunlight.

- High bulk sale
- Bunch function between primary production and end-consumer through stages of processing and trade. This entails that particular requirements of trade are established indirectly through the stage of processing in the primary production. These are on the one hand norms and standards, but also on the other hand specific requirements of the customer.
- A minor probability of detection in the primary production is in contrast a high probability of detection at the stage of processing.
- A high interest in manufacturing conditions through politics and consumer with the focus on environment, animal and consumer protection.

Core and support processes

The production of foods takes place in the chain this refers to the finishing (refinement) of products from one stage to the other. Due to the variety of interactions within a single stage but also trade channels form stage to stage, food retails chains can be regarded as networks (SCHULZE ALTHOFF et al., 2005). Taking a closer look for example at the pork processing chain, one can see that at the stage of primary production there is a variety of farmers versus a small number of processing enterprises and further manufacturing. These prepare the products for an even smaller amount, for big and international grocers (KNURA et al., 2006).

Table 1 shows possible chain actors as well as producers and service providers for the pork producing chain. If one takes a closer look at this particular example and pays attention to the primary production till the slaughter, five partial processes can be identified. These processes support the biological core process “reproduction and growth” on the technical and organisational basis.

- Sperm production and fertilization
- Hygiene and health management
- Climate control
- Food production and feeding control
- Dung storage and spreading of liquate manure

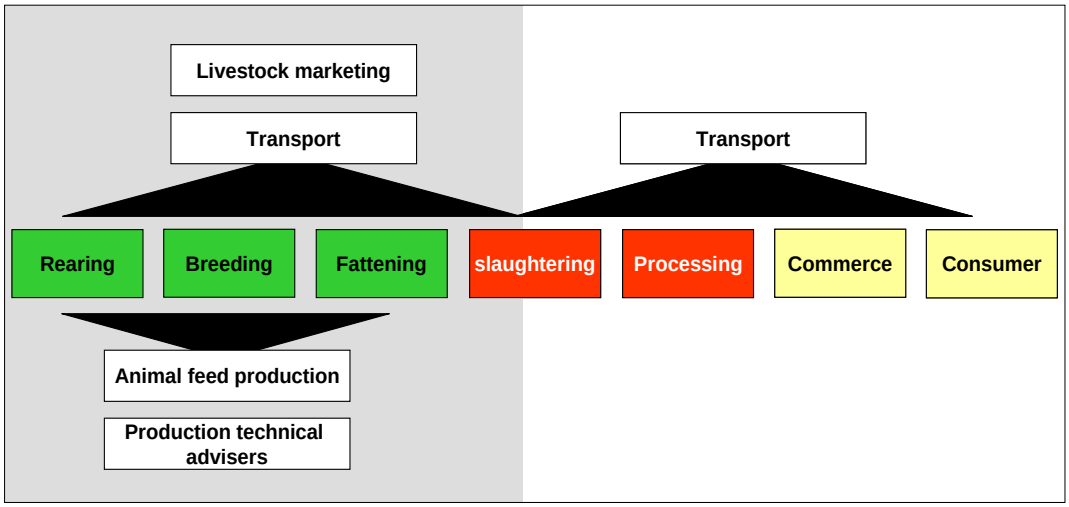

Figure 1: Actors of the pork production chain

The livestock owner takes over a steering and managing function. In order to avoid undesirable development of processes, the livestock owner requires knowledge about the possible target value and disturbance: Within quality management one can see that all the partial processes are influenced by inter-organisational customer-supplier relations. Besides the single processing steps and relations within the chain, it is essential to identify communication and information structures within the entire production process using the corresponding systems. Further more it is important to point out to any possible gaps which might exist in the system.

Communication and information structure

In general 3 different types of inter-organisational databases were identified in the four regions which were involved (figure 2). User as well as state of implementation is different form region to region or that is to say from country to country.

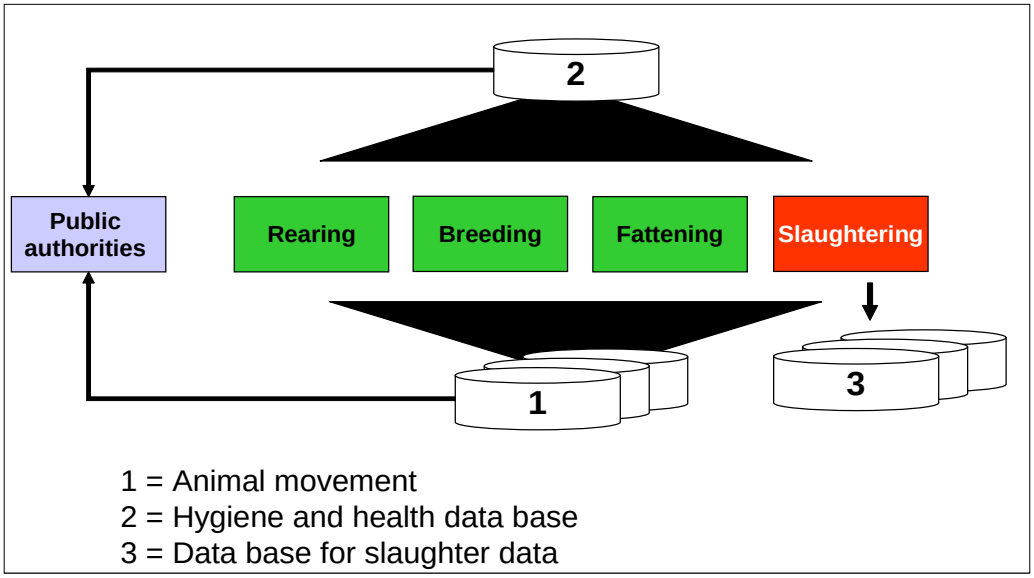

Figure 2: Overview type of different data bases for the pork chain

Privately initiated systems integrate only a particular subset of all the possible data that could be used because only a subset of suppliers and / or costumers is associated to these kinds of systems. Therefore for instance if one takes a look at dates of slaughter (analysis) it is evident that parallel system are established with the same or very similar goal setting.

Table 2: State of the art of different interplant data beases in the four regions

	Operator g (government) p (private)	Status		
		established	At the development stage	Under consideration
Animal movement TRACES (cross boarder) and national solutions like HIT in Germany	g	NRW, GE, RA, VI		
Hygiene and Health management				
Salmonella data base	p	NRW		GE
Health data base	p	GE		NRW
Slaughter data	p	NRW, GE, RA		VI
Trace and tracking systems	p	NRW, GE, RA		
Suppler assessment	p		NRW, GE	

NRW = North Rhine Westphalia; GE = Gelderland; RA = Rhône-Alpes; VI = Vidin

The pork producing chain in the Rhône-Alpes region stands out due to a very high integration of actors involved. Through the closeness compared to other food retail chains there is an intensive information exchange that takes place. This information exchange focuses on the aspects of traceability, analysis of slaughter and quality information for the area of brand meat production.

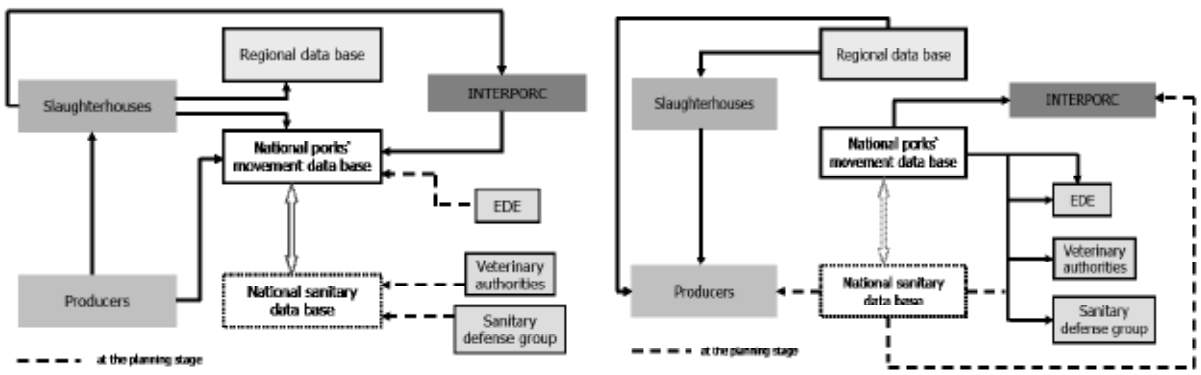

Figure 3: The information flows to and from the data base in Rhône-Alpes

Central elements of the data exchange are the national databases for the recording of animal movement, a regional one and the database of Interporc. Interporc is in the Rhônes-Alpes region one of the most significant organisations in the pork production. On top of that setting up a national hygiene database is also planned.

The already established systems enable an information exchange between the different production stages, however are only partly applicable when it comes to inter-organisational quality management systems. The information which is discarded there only represents a minor portion of the information which is required in the decision making process within quality management. This information primary refers to the transport as well as to the analysis of slaughter. In Germany and the Netherlands there are also national databanks for the backup of animal movement as well as for the salmonella status (only in Germany) and are to be set up in Bulgaria. These also pursue the objective, due to epidemic and food safety legal specifications, to show the national and regional registration of animal moments and epidemic status. These are not suitable for the support of inter-organisational own control systems. For quality management it is important to exchange continuous process information between the customers and suppliers involved. From the actors perspective in the value chains it is important to edit the multiplicity of information for the single decision making situations. The experts are concluding that these data have to be reserved to the business partners. An organisational and technical division between governmental systems and systems of economy is therefore a prerequisite. Despite this division experts from the public and private organisations suggest to use the current parallel running building phases for data warehouse solution in governmental and private area. This way a temporary predefined data exchange in times of crisis is enabled. For this purpose the University of Bonn has developed a concept for a “intrusion and exchange model” (RISIKEN, 2007), in collaboration with LANUF (State Agency of Nature, Environment and consumer protection NRW) as well as a farm cooperative for piglets and slaughter pigs within the scope of an Interreg III A project.

The intrusion and exchange model is based on a two-stage system. In the first stage there is the extended information transfer in the scope of the inter-organisational quality assurance systems of the economy in the period of peace. The second stage entails the time limited exchange of epidemic relevant information in time of crisis. The basic idea of the exemplary suggested concept for pork producing chains is to be able to use the predefined passive area of the current in set-up situated internet based Data Warehouse System of the economy and authorities, together in data exchange in times of crisis. Figure 4 illustrates the set-up of the system in the period of peace and figure 5 in the case of crisis.

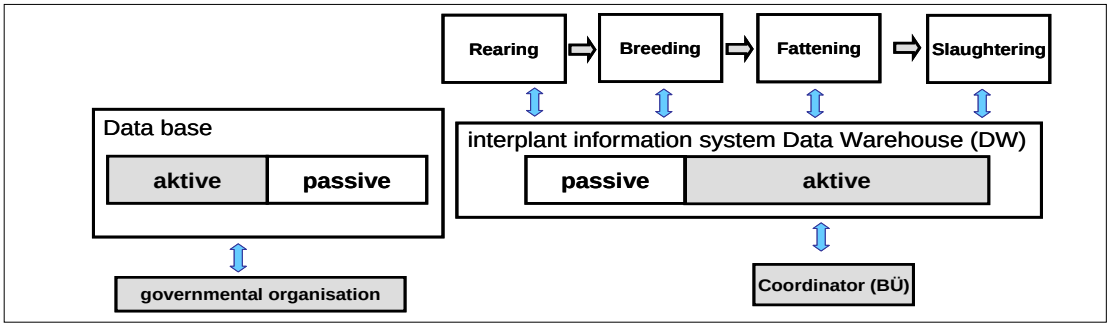

Figure 4: Concept of continues data collection during period of peace

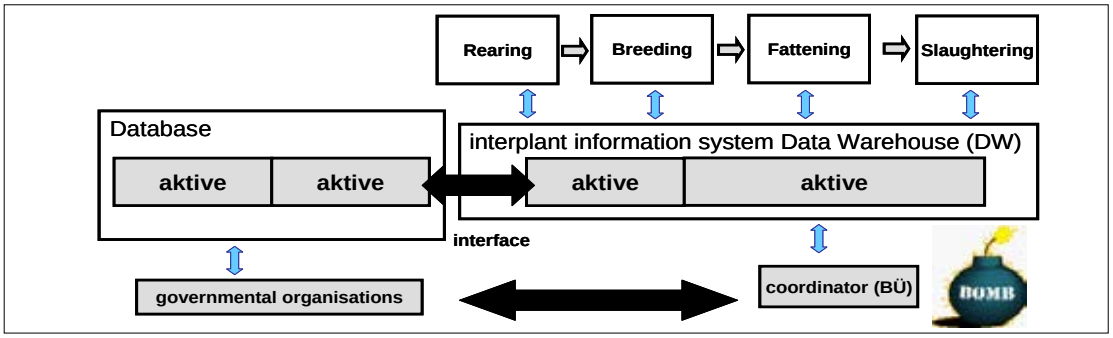

Figure 5: Concept of risk oriented data exchange during crisis

In the case of an epidemic it is intended, besides the continuous data assessment from authorities and the economy, to temporarily survey additional risk-oriented data. Documents, such as transport authorizations can be centrally and up-to-date made available on a joint internet platform such as the IDV. Prior passive data bank segments are then activated in a second step. This makes it possible to exchange selected and rehashed data for the crisis management over an interface system between the private and public data banks. Network coordinators take on a role as mediators between the data banks and the actors.

3.2 Information demand of producers and service providers

Surveys of about 1.000 **farmers** by the University of Bonn show that currently 64% of them document notes handwritten. 36% apply self-designed (self-conceptualized) software solutions, for instance Excel basis that is to say specially tailored software to meet these requirements. However using these planer programs the legally required documents are only partially prepared and those data important for the quality and health management are only partially captured. Legally prescribed documentation requirements for instance bookkeeping of the inventory, 83% of the interviewees do this using paper documentation. The entire daily documentation effort: 43% of the questioned pig fatteners estimate max 5 minutes, 48% require 5-10 minutes and the remaining 9% require more than 10 minutes. With regard to the frequency of the documentation these 28% of the interviewees document daily. 35% devote their time 2-3 times on a weekly basis to this task, 37% once a week or more seldom. Against the trend of the documentation 75% of the questioned companies used computer-supported feeding systems, again 83% of them as isolated systems. Future demand of inter-organisational information is estimated in the area of feeding, preventive health management and assessment (evaluation) of carcases as very important. The interviewees estimate the tractability of flow of good as well as binding to existing systems as not so important. 44% of the questioned pig fatteners support (favour) a networking of data from offshore and post stored steps of pork production chains. Provided that these are compatible with existing systems and important inter-organisational information is made available. The decision concerning the way preparation of information from the fattening farm will be handled in the future, half of the interviewees see the information handled via e-mail and an online system, the other half persists furthermore using written documentation or by verbal means.

The empirical study showed that **veterinarians** supported by inventory as well as **animal feed advisers** apply individually configured information systems as a supportive tool when carrying out their work as advisers. Same applies for the group of farmers who also use written records, self-conceptualized excel lists up to special programs. In regards to special software there are software programs which can be assigned to veterinary practices as well as operating programs from animal feed companies. Central elements of the program include the basic claims data maintenance, key point visiting that is to say contact documentation as basis for accounting that is to say verification of the accomplished tasks and on top of that at veterinarians accounting system and the maintenance of the medicine chest. The last mentioned module is based on nationally determined legal requirements, which prescribes a documentation of cession of pharmacy-only drugs. In the area of animal feed advisors an interlinking takes place with the central inventory control system, from which most daily replication costumer data from the area of animal feed supply and activity areas are pulled and pushed. Internet based communication is to be currently found between the operational systems that is to say salmonella data banks and assessment of slaughter. A combination of data from independent data sources is only possible by a manual support in the limited evaluation framework. Advisors as well as veterinarians see a clear increase in the future in the demand of descriptive, comparative / controlled, predicting and prescribing information for the support of their service providing fields (Figure 6). Both groups describe all the single tasks as important (4) and very important (6). Surprisingly the interviewees did not see the demand to increase the information status in quality management. Already now the advisors feel sufficiently provided with information, although especially here very dynamic changes in the increase of additional data are noticeable and will be noticeable. In the future both groups have an extended demand of information that are continuously made available in digital form and task specific.

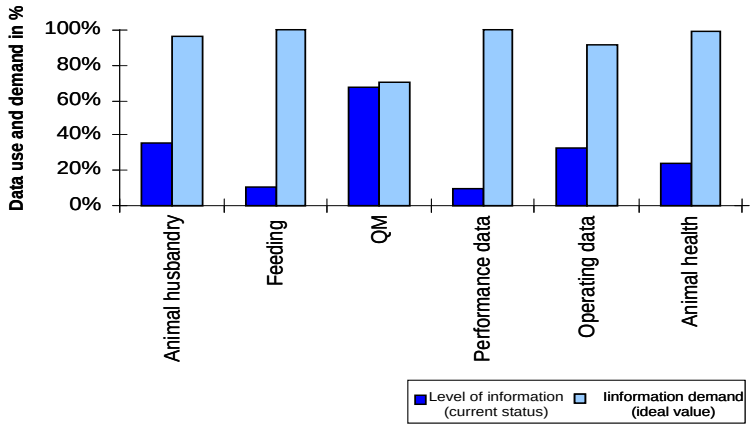

Figure 6: Comparison of the percentage value of current information need and the information need in the future of six different points from feed advisors; n = 10 advisors

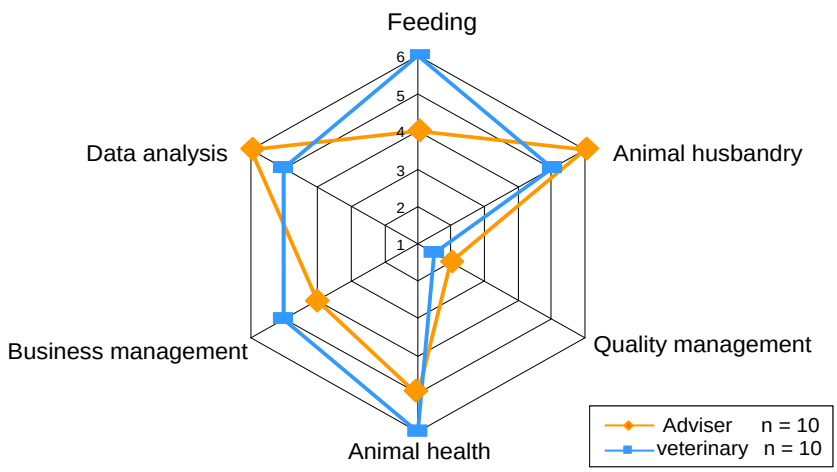

Figure 7: Evaluation of the inspected points (1 = very unimportant and 6 = very important)

Both groups are very open-minded towards external support in from of service providing agencies. Advisors expressed different requirements in regards to the intensity of service providing support. This means for the service providing companies which are illustrated in table 3 that they have to prepare the data which is available in such a way that it is tailored individually to the demands.

Both groups give clear statements about the fact that they need the support for their tasks with continuous data and high repetition character from the production process in the future. They will adduct the data to be able to carry out their tasks, preparation, implementation and follow-up of inventory support, inventory visit or customer contact via phone. Advisors as well as veterinarians see each other as users of the chain information.

Table 3: Possibilities of service provider (coordinator) and service adaptor of a inter- and enterprise information system for pork chains

Service provider (coordinator)	Service adaptor
Feed producer	Pig Fattener
Trade organisation	Farms of the breeding and rearing stage
Farm cooperative	Service provider
Slaughterhouses	Veterinarian
Neutral organisations	Slaughterhouses

Experts from all the regions see a trend which has been emerging for years that traditional service providers (table 3) have adjusted or are adjusting their tasks to the legal and marked based framework for the agricultural enterprise. An elaboration of their area of activity for the coordination function is due to technical reality but also organisational structure not without huge changes and therefore effort realizable.

3.3 The best practice demonstrator

As already showed in chapter 3.1 and 3.2 there is a variety of digital but also written tracked systems that at present only partly intertwine and are not suitable for the communication within the chain. Data Warehouse solutions enable the joining of independent operative data sources (figure 8). At this it is important that during the formation of later usage one or more actors which are in the network take over the coordination. The implementation of the model into practise dependents on the requirements of the single user groups, number of actors and on those processes which have to be supported.

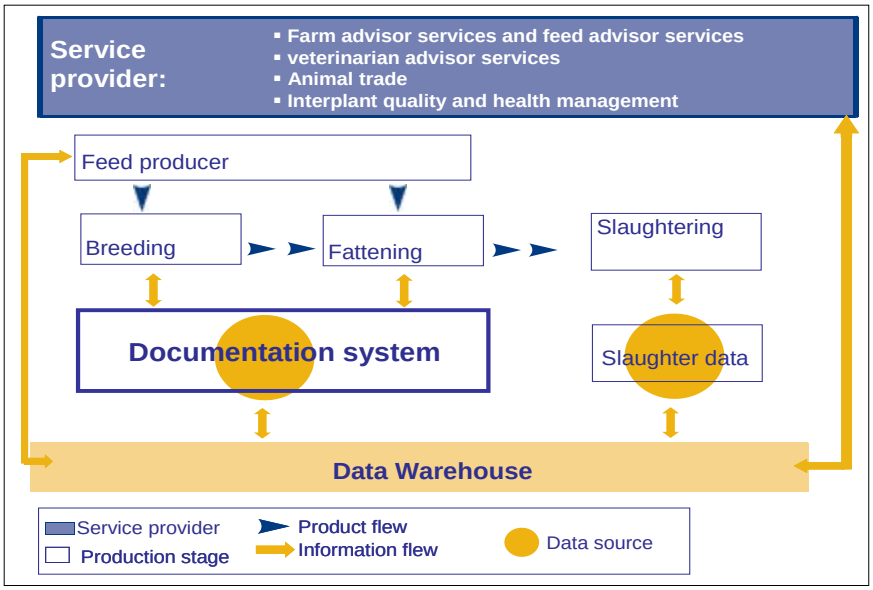

Figure 8: Interplant information model for pig fattener and service providers

Exemplary a model has been created for the pork producing chain. In this model there are four production stages of service providers of this stage which have to be taken into consideration. Central element of the model is a data warehouse solution. From the technical perspective this data warehouse solution consists of one or multiple databanks, in which the predefined data and information from independent operating data sources (for instance documentation system, data of slaughter, inventory control system) are added using interfaces.

During the implementation of the model in the „practice demonstration application" it was secured that the data that needs to be saved is assignable to particular units. In the pork producing sector there are no single animal labelling therefore it is the possibly small unit of the group of animals. During piglet production the assigning is done per sow or to the date of birth. When leaving the inventory an animal can due to its legal prescribed marking only be assigned to the farm. Within the pig fattening farm is an assigning to the housing unit, pen, compartment, or stable possible. A group includes all the animals which are included in this group. From transport to slaughter and slaughtering process the marking takes place using the marking punch, which entails the number of the farm plus extendable areas. This makes a subdivision of transport groups possible.

The different user groups which on the one hand make data available from their sub-process, they need data prepared for information for different problematic and decision evolving situations. For this purpose standardized queries, reports or OLAP-tools are available. With the new tools analysis of inter-organisational information in connection with own data for pig fatteners, advisors and veterinarians are made available without a great expenditure of time and without computer literacy. In the pilot application a system provider took over the task of the coordinator. Besides the data storing and preparation he makes sure that the continuous intake of data as well as preparation of assessment is secured. A continuous data exchange can take place through internet based solutions but also decentralized programs with consistent replication of data per internet. First of all this is of advantage because the user does not to make a storage capacity available and therefore is relieved of the data securing. Updates are directly installed by the service provider and are made available for the user right at the next log-in. Disadvantages of this solution are on the one hand the development effort, on the other hand the gain of trust by service provider companies. Basic prerequisites are contractual agreements which determine the duties and rights of all partners. The discussion with those individuals who carry out the pilot projects showed that the protection of data misuse is an essential factor of success in regards to the acceptance and establishing of that kind of systems. Nevertheless the agreements do not offer a 100% protection against data misuse. Another addressed aspect was the costs of service for coordinators and that these therefore cannot be offered free of charge.

The integration of existing peripheral systems for example sow planer enables the advantages that the users not have to be trained on how to use the new programs because the existing programs are already directly available and the programs are already established. For data and information from tracing systems of slaughter data, inventory control systems of farmer associations and trade organisations as well as sow planer is the integration of decentralized systems the best alternative. These programs frame the inter-organisational requirements for users "good till very good", at the same time fulfilment of legal and private frame works. Already existing or through adaptations established interfaces, the data which is stored there can be made available to the data warehouse and therefore to the chain actors.

The results of the analysis show that all chain actors without pig fatteners use appropriate software protected solutions for the fulfilment of legal requirements. There are however for pig fatteners no software products that are being offered for the fulfilment of traceability. The recent introduction of the Farmingnet system makes the Netherlands an exception. To fulfil customer demands data and information from upstream and downstream productions stages is required. The development of a "Best Practice Demonstrator" in the region NRW, an internet based documentation systems for pig fatteners has already been implemented. This demonstrator enables exemplary the documentation process of relevant data during the mast. The way process relevant data for the pig fattener is brought together in an internet based systems, this can be transferred onto other processes.

The following processes have been dealt with concretely.

Table 4: Process and example of process data of the best practice demonstrator

Process	Process data
Feeding	producer[1]; tons, kind of feed, number of silos, [2]
Storage of the feed	Data of cleaning, kind of cleaning, fulling and clearing
House in	Origin, weight, number of identification, place, date [3]
Move animals out	Buyer, weight, number signification date, [3]
Move to another house	Place, option of further significations
Apply medicaments	Date, medicament1, doses, kind of implication, person[1], [4]

[1] Further data, like address date will completed automatically
[2] With interface option to the merchandise planning and control management this data are involved in the program directly
[3] Labelling of the stable and so on are completed automatically
[4] With interface to the veterinarian the data involved in the program automatically

The combination of the three systems, inventory control systems of an animal feed supplier, veterinarian accounting systems and the newly created stable book (brand of the best practice demonstrator) reduce the documentation effort as well as key errors. Prerequisites for the use are:

- provision of a computer with internet access
- provision of an internet connection, minimum ISDN-Connection
- Registration application

After having registered every farmer obtains a login and password. This enables a user specific login and access to his farm data. During every login a starting page appears as demonstrated in figure 9, where then with the help of the navigations measurements can be started accordingly. In the images that follow an exemplary mast entrance with all the involved processes can be shown.

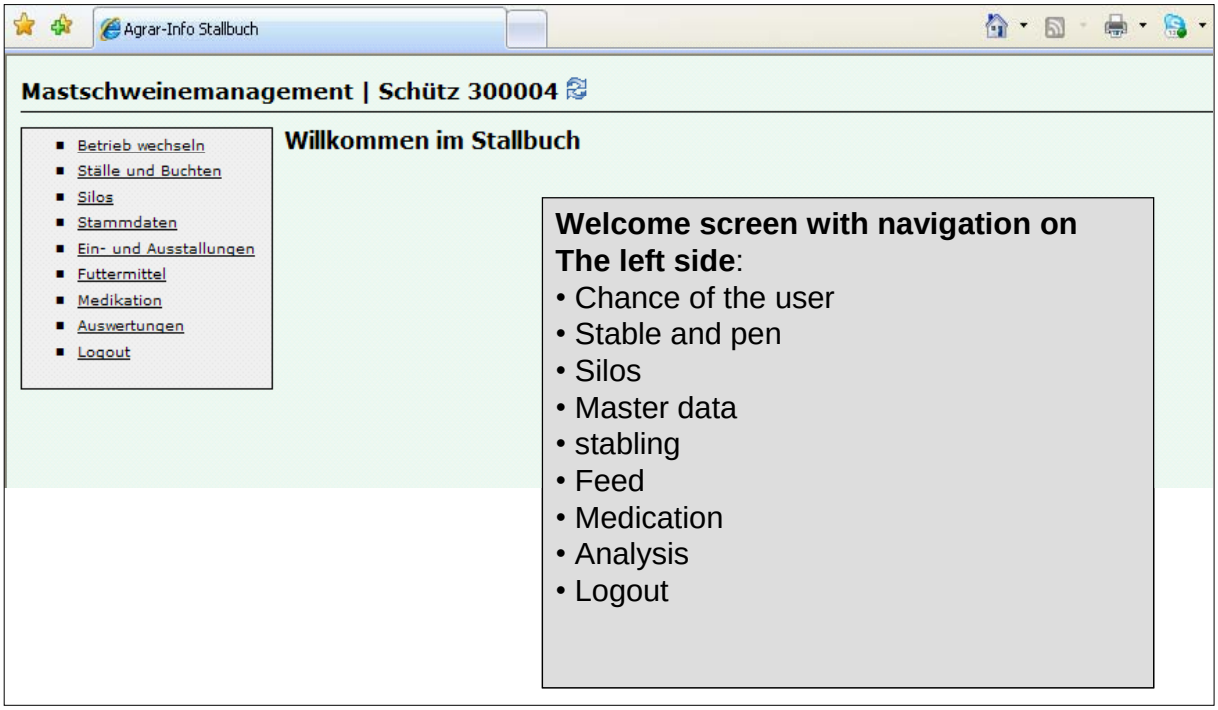

Figure 9: Documentation system for pig fattener – starting slight

Further slights attached at the annex I.

3.3 Technical and organisational innovations

The best practice demonstrator is an example how single operative data sources of different user groups can be integrated in one Data Warehouse Solution. In all regions an increasing demand of that kind of technical innovation can be seen. The experts on the research side agreed that besides the technical also the organisational innovation is essential to prepare a rapid implementation of inter-organisational information and communication systems.

During the implementation of inter-organisational information and communication systems network coordination take on an intermediary function between the first the administrative level and the third level (figure 10). The resulting legal and private standards lead to the creation of own control systems according to the HACCP guidelines. Furthermore in regards to the reorganisation of processes in the economy and administration as well as creation of alliances for independent information and service provider agencies. For the three mention aspects networking coordinators which are the link between the first and third, of the producing level represent a key function.

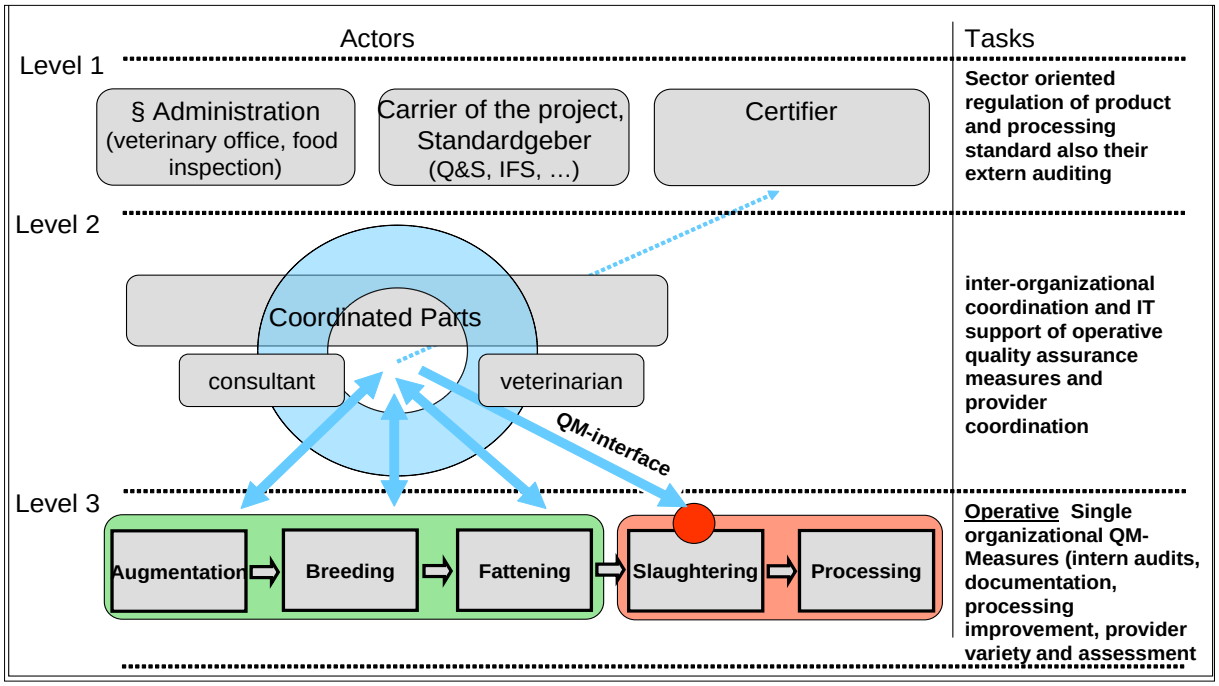

Figure 10: 3 Level Model of quality management in meat chains (PETERSEN et al, 2007)

For the fulfilment of the function as networking coordinator this means that the three areas of activity have to elaborated and rearranged through structural changes of organisational processes and technical systems.

- **For the area of strategic and operative planning**

  Strategic planning refers to the search of field of activities and forms of organisation which assure long-term success. The operative planning on the other hand functions as the implementation of strategic objectives through the fulfilment of concrete management tasks for instance in the area of logistics if it means undertake short and medium-term quantity control. For the networking coordinators this means that they have to optimize logistical processes and implement these onto a modern quality, health and risk management.

- **Documentation, audit and provisory management**

  For this area cross-functional processes for the back-up of services have to be defined. This means to transfer frequent reoccurring processes into standardised and routinely computer supported processes.

- **Maintenance of interfaces**

  The inter-organisational quality management aims to incorporate the entire company that is to say the supply chain of the primary production, with all its fields of functions, from the production over to administration till the management level. Objective is among other things to detect mistakes and initiate measurements for the elimination of errors. For the networking coordinators in food retail chains this means based on the production of division of labour to attend a number of interfaces.

Networking coordinators are not only to compile and implement selective solutions. In fact the extended task fields can only be fulfilled only through a combination of organisational and technical innovations. The research experts identify such as in figure 12 shown at a time four technical and organisational innovations. Challenge for the future is to connect and establish these in a master plan.

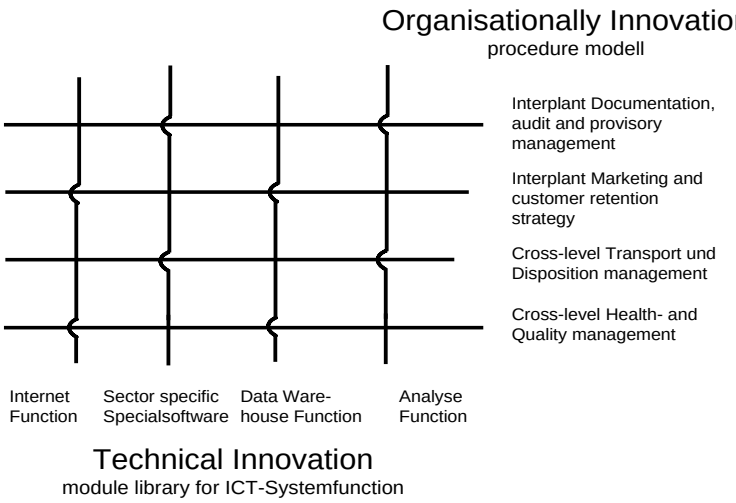

Figure 11: Combination of technical and organisational innovations

All in all the strengths and weaknesses as well as chances and risks of inter-organisational information systems were explained in detail in a SWOT-analysis. Results show that the chances of inter-organisational information and communication systems are of advantage compared the not insignificant risks (figure 8).

STRENGTH	**WEAKNESS**
• High penetration level of peripheric data processing • online presence • Self-checking systems • Awareness for using computerised technical support • interplant information demand for specific decision situations • Process orientation of configuration and development organisations	• Provision for a multitude of local solutions • Komplexity of individual interfaces • Taking long time for standard developmentr • High training needs for user groups • Reorganisation of used process flows
CHANCE	**RISK**
• data multiple shift usage • Provision of informations for time critical decision-making process • Individual data preparation • new and advanced services respectively for network coordinator	• absence of the disposition to coordinate the establisment • absence of financial and personal resources of development and implementation • unsolved data protection regulation arrangements

Figure 12: SWOT-analysis of interplant Information and communication systems

From these results as well as from the trends of the further development of classical service providers in the agri and food economy it is recognizable that the new challenges can only be cooped with in combination of technical and organisational innovations. Inter-organisational information and communication systems will take on a central role here for the allocation of information for the different decision making situations in the food production.

3.5 Impact of own control systems on the reorganisation of public food monitoring

Often the food safety and quality attributes consumers seek are difficult to verify, especially when those attributes are derived from the actions of numerous, spatially dispersed primary producers. Direct monitoring of farm production processes is prohibitively expensive in most cases. Annual costs of the 557 public and 414 semi private food safety inspectors in the Netherlands are substantial. The inherent riskiness of agricultural production further complicates the problem. Even if product quality can be assessed at a reasonable cost, it may be difficult to determine whether quality problems are due to lack of care and effort by the primary producer or to factors outside his control. This is the basis for the moral hazard and risk sharing issues that have been a central focus for the large, growing literature on contracts and the provision of incentives. A variety of incentive mechanisms for addressing these agency problems have been proposed, analysed and implemented. Quality premiums and discounts have long been used to provide incentives for key product attributes. STARBIRD (2005) analyzed situations where sampling inspection procedures are used to assess product quality, noting that the regulation of sampling inspection procedures is an effective tool for policy makers who wish to improve food safety. The more efficient incentive systems economise on testing costs by reducing the probability of testing in response to a favourable production history (KING et al., 2007).

It is important to note that food safety can also be promoted through market forces or through strict product liability laws (BUBZY et al., 2001). Regulation may be a good complement to reliance on market forces in this case, since the additional information potentially available to consumers as a result of the required testing may eventually induces stronger market incentives for improving food safety through shifts in demand patterns. On the other hand, strict product liability laws can be the basis for strong incentives to improve hygiene, food handling, and food preparation practices in retail shops and food service establishments.

A literature survey provided an overview of the relevant legislation and regulations and the national and international private systems applied in the Netherlands regarding food safety. The basis for these regulations is the Codex Alimentarius. The agreements laid down in the Codex are reflected in European Union legislation, where necessary translated into National regulations. The present basis for EU legislation relating to food safety is the General Food Law (Council Regulation (EC) No. 178/2002). This lays down the general principles and requirements regarding the responsibilities of food manufacturers, the introduction of the ‘precautionary principle’ and the obligation to introduce tracing and tracking systems. There are virtually no clear overviews of food safety legislation. It is impossible to find a clear overview of what legislation applies at sector or link level. Sometimes legislation does not yet seem to have been enforced or does not apply to all the links in the chain. Even if all the relevant legislation is known, it is difficult to assess whether the legislation is correctly incorporated in private systems. This is because the legislation often includes general target requirements (open norms), while private systems include concrete resource requirements (closed norms).

The supervision of control policy relates to new supervisory arrangements whereby the private sector is assigned more responsibility for compliance with statutory regulations; the authorities then operate at a greater distance but retain the ultimate responsibility. The Dutch Ministry of Agriculture, Nature Management and Food Quality expects that the supervision of inspections will result in more efficient and effective assurances for public interests. Within “Supervision of Control programs” Dutch food companies seek to qualify for less intensive public control for food related hazards by inspectors of the government. The reduced costs of less public inspection are assumed to outweigh the costs of implementing

and maintaining own control systems (BAKKER et al., 2007). The application of Audit Monitoring with the aid of private norm systems also offers opportunities to improve the level of food safety, because this further promotes quality thinking and risk management. Contrary to the situation with government inspections, in private systems it is clear what is being inspected, by whom and how often this takes place (BONDT, 2006).

4. Conclusion

The great variability of the stage of development of inter-organisational information and communication of agri and food economy was the cause for experts form research and economy of the region Gelderland (NL), North Rhine Westphalia (D), Rhône-Alpes (F) und Vidin (BG) within the scope of empirical inquiries, expert dialogues and group discussion intended to discuss seven questions. Based on the structure of different food retail chains the inquiries focus on state and prerequisites to construct and to further develop chain oriented inter-organisational information and quality management systems.

The division of labour with the production in the food retail chain results that a number of companies in terms of the own core and support are involved in the decision making process of a product. Actors of the chain take over at the same time the role of the customer and supplier. The production of secure and high-quality foods is the foreground. Companies try to achieve these objectives by establishing organisational own control systems according to HACCP guidelines. In addition to that these companies also see the necessity in the future to exchange even more between in front of and downstream levels within the scope of quality management.

Using this background information this is how producers and service providers define a high demand of decision relevant information. Besides the consolidation of data and information from different production stages as well as computer systems, the challenge is to make production convoying information for time-critical decision making available to the chain actors. In the taking over function of information forwarding and preparation traditional service providers of the food retail chains see new field of activities.

These fields are to be divided into two scopes of network coordinators. One field supports the exchange of food retail chains information, another is dedicated to the own control systems and animal epidemic prevention. Within Supervision of Control, food ccompanies can qualify for less intensive public food safety inspections within Supervision of Control. The reduced costs of less public inspection are assumed to outweigh the costs of own control systems. Networking coordinators in the future take over an intermediary function between level 3 and 1, which have in the recent years developed in the area of quality control. For these three levels an effective chain oriented quality management system computer system is to be developed further in order to adjust the organisation structure. How this is to be organized from the technical and organisational perspective depends mostly on the existing costumer and supplier relations and the ambitions regarding the responsibility and division of labour of actors within the supply chains. A great amount of cooperation and quality demands from the single production stages are always going to result in the networking coordinators offering a great amount of support to the chain actors. The best practice demonstrator functions as an exemplary system which functions across several levels and therefore with this an information and communication platform for pig fatteners has been created. The model behind this as well as the basic approach can be adapted for further food retail chains.

Experts agree that a new innovation culture can be created for small and medium-sized enterprises. For this innovative networking is very suitable as already shown in this project. Through international and interdisciplinary projects a creative idea exchange is enabled and this way similarly stored organisational and technical problems can be solved together.

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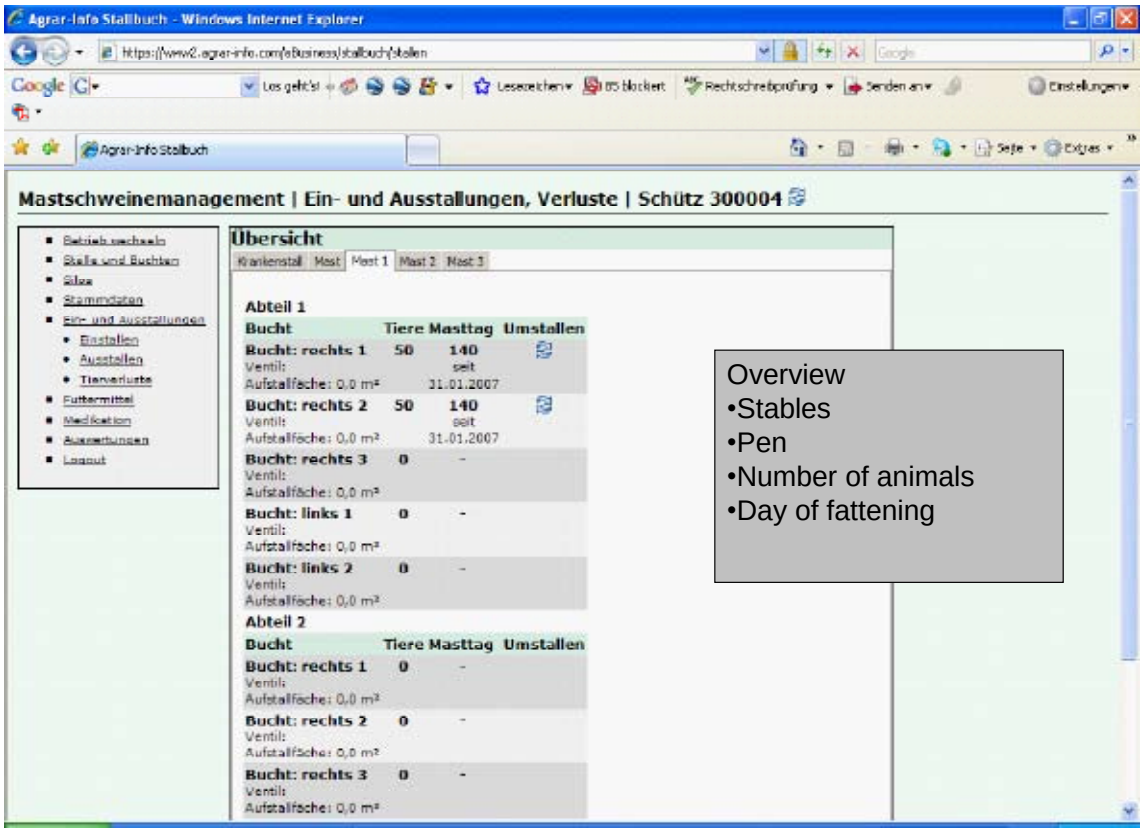
Annex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Bucht: rechts 2 50 140
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Bucht: links 1 0
Bucht: links 2 0
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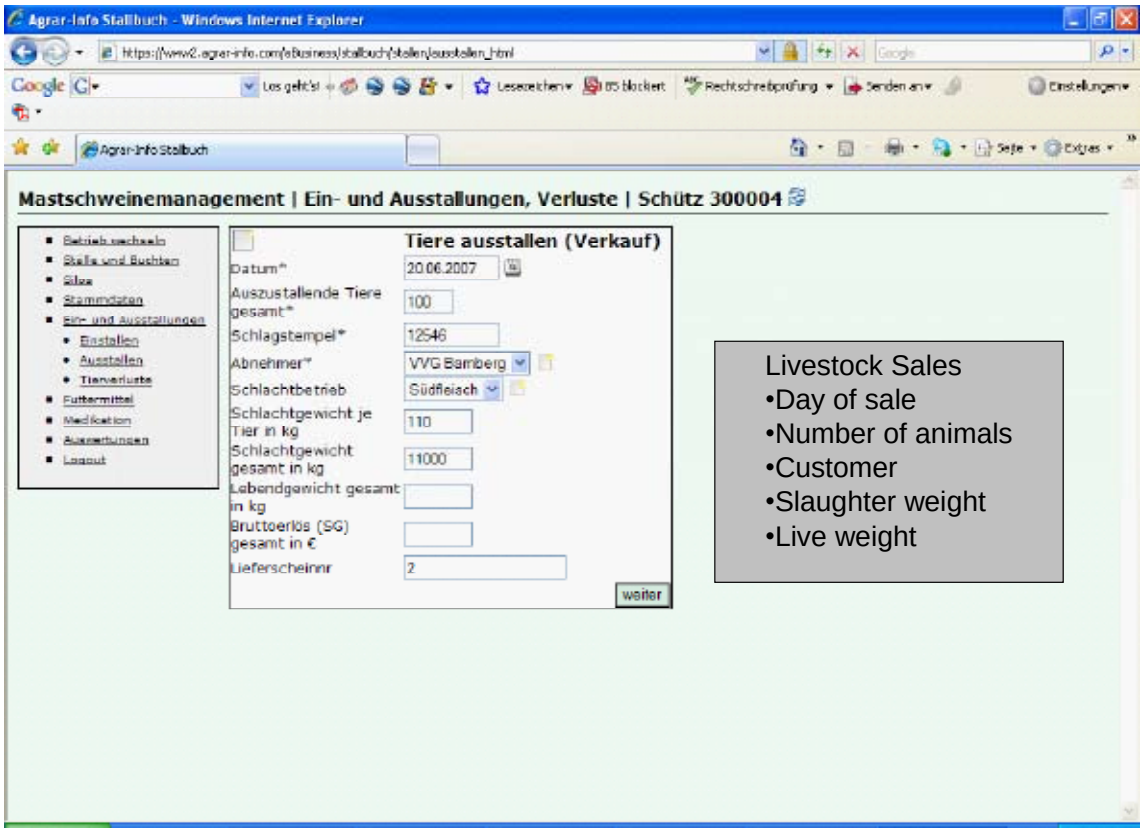
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Abnehmer* VVG Bamberg
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Lebendgewicht gesamt in kg
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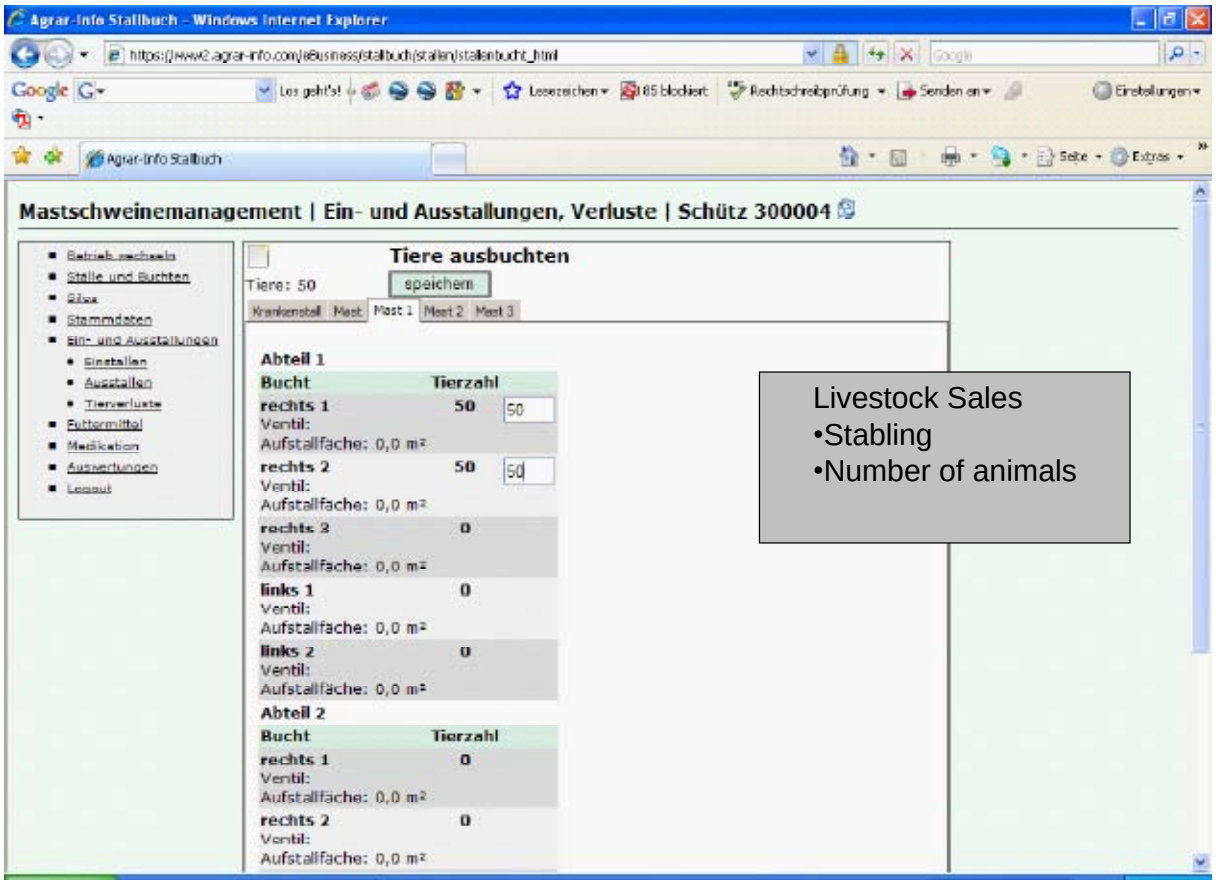
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Tierverluste
Futtermittel
Medikation
Auswertungen
Logout
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Aufstallfläche: 0,0 m²
rechts 3 0
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Ventil:
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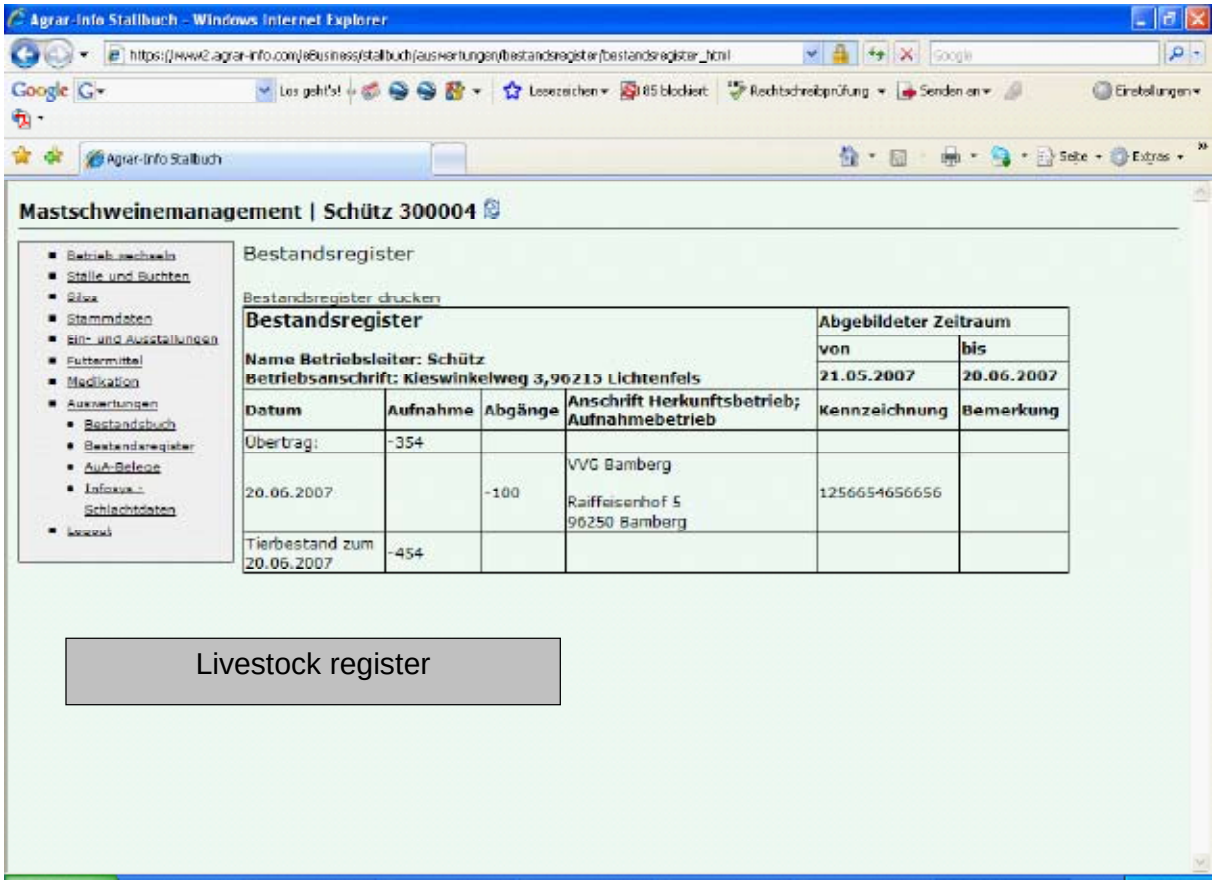
•Number of animals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AuA-Belege
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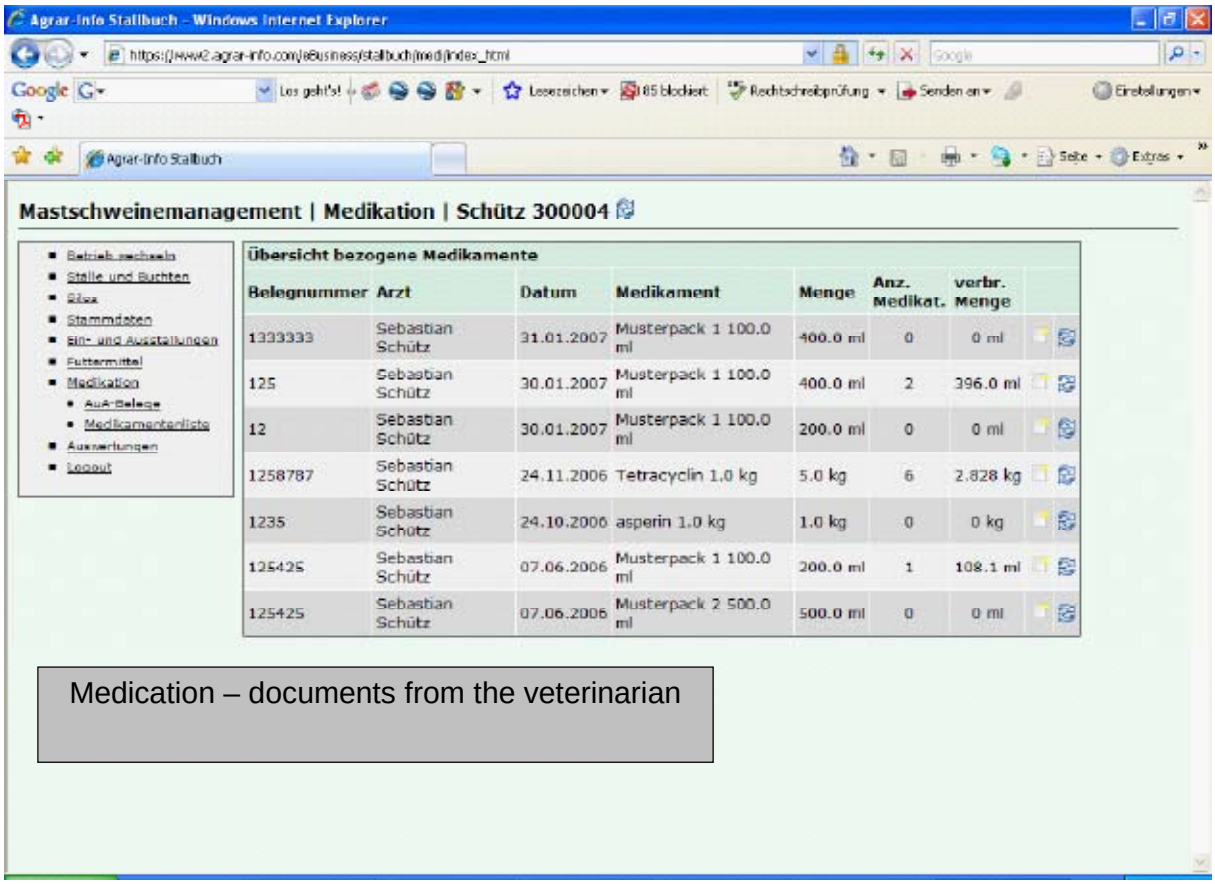
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125 Sebastian Schütz 30.01.2007 Musterpack 1 100.0 ml 400.0 ml 2 396.0 ml
12 Sebastian Schütz 30.01.2007 Musterpack 1 100.0 ml 200.0 ml 0 0 ml
1258787 Sebastian Schütz 24.11.2006 Tetracyclin 1.0 kg 5.0 kg 6 2.828 kg
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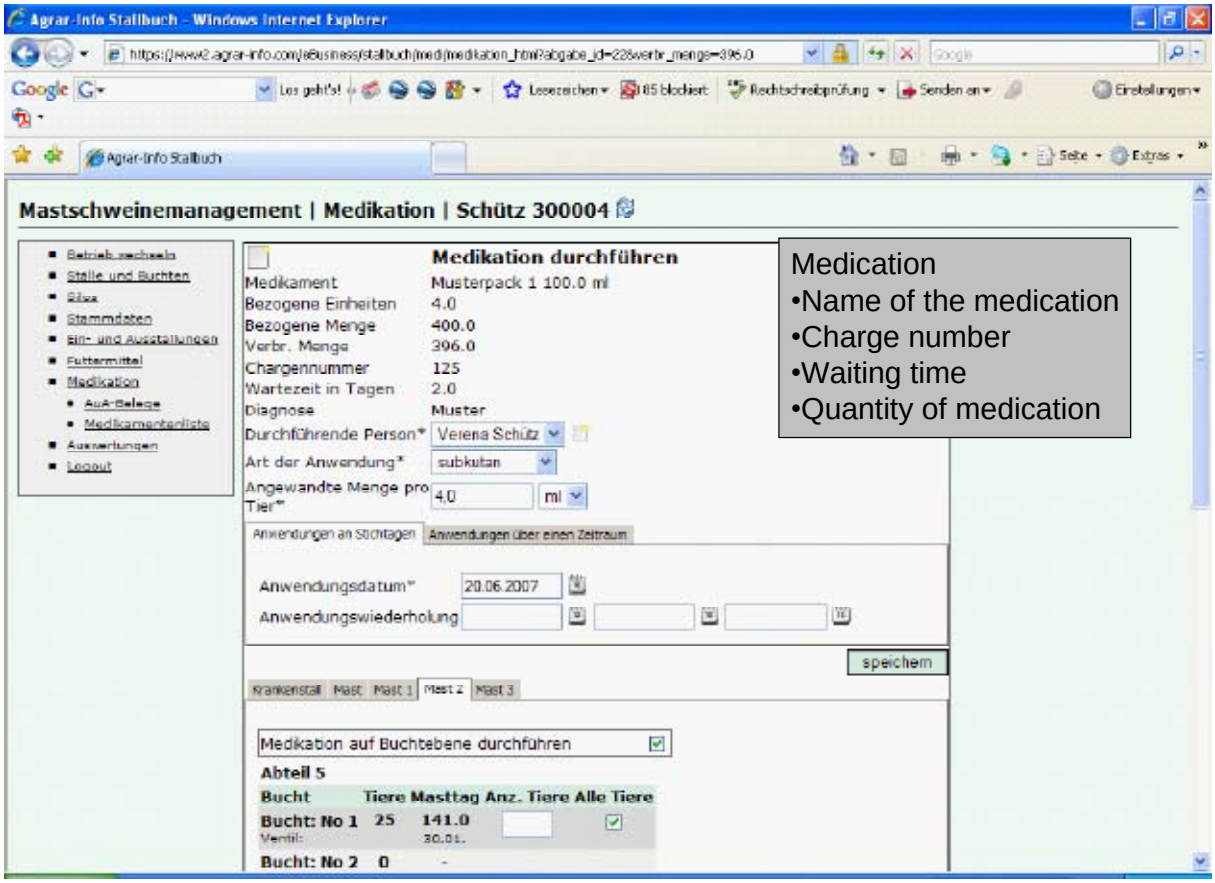
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Bezogene Einheiten 4.0
Bezogene Menge 400.0
Verbr. Menge 396.0
Chargennummer 125
Wartezeit in Tagen 2.0
Diagnose Muster
Durchführende Person* Verena Schütz
Art der Anwendung* subkutan
Angewandte Menge pro Tier* 4,0 ml
Anwendungsdatum* 20.06.2007
Anwendungswiederholung
speichern
Medikation auf Buchtebene durchführen
Abteil 5
Bucht Tiere Masttag Anz. Tiere Alle Tiere
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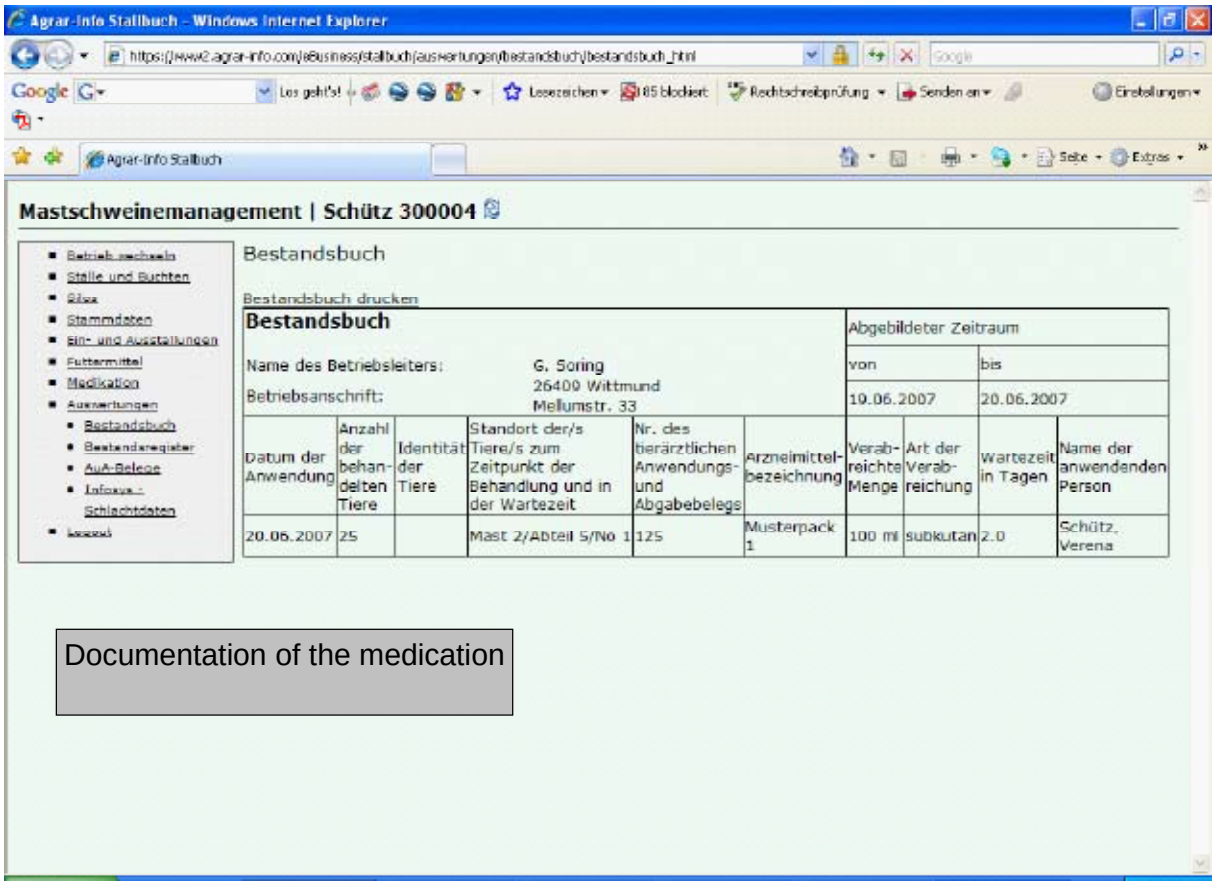
•Waiting time
•Quantity of medication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Abgebildeter Zeitraum
von 10.06.2007
bis 20.06.2007
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20.06.2007 | 25 | | Mast 2/Abteil 5/No 1 | 125 | Musterpack 1 | 100 ml | subkutan | 2.0 | Schütz, Verena
Documentation of the medication

Facilitating 'Supervision of Control'

Bondt, N., Oosterkamp, E. B., Backus, G. B. C.

LEI Agricultural Economics Research Institute, Animal Systems Division, P.O. Box 35, 6700 AA Wageningen, The Netherlands, E-mail: Nico.Bondt@wur.nl, Elsje.Oosterkamp@wur.nl, Ge.Backus@wur.nl

Keywords: food safety control, public-private cooperation, principal-agency theory, incentive structure, costs of inspections.

Abstract

General Food Law states that companies are responsible for food safety implying self-control by firms and the application of private quality control systems. Governments remain responsible for compliance with law and thus for maintaining a system of public control. Public control of the private quality control systems (supervision of control) is however still immature and the effort is needed to provide public authorities with efficient and meaningful control principles and strategies amidst a growing complexity of food supply chains.

This study is carried out within the Promstap Interreg IIIc project. The objective is to promote the establishment of professional food safety management systems in agribusiness by the exchange of knowledge on supervising of control systems in the regions of the Netherlands, Denmark, and North Rhine-Westphalia (NRW), by identifying strong and weak points of each system and formulating recommendations for improving the practices of supervision of control. A structured questionnaire was developed to allow project partners to collect basic data on food production, the institutional setting of public food control and policy, private food quality and assurance systems and public-private cooperation. Principal-agency theory is used as a framework. Preliminary results were presented in a "science meets policy" workshop with researchers, representatives from industry, and public authorities. Recommendations were formulated based on the discussions in the workshop. The focus of food safety policy differs among the studied regions, although self-control is a leading principle in all three countries. However this principle is not yet applied as a general starting point for public food supervision in Germany. First priority of NRW is the restructuring of the public food organization and increasing the number of food inspectors. In Denmark self-control has led to more private sampling, but at the same time public inspections remain the backbone of the public control system. In Denmark strategic policy focus is on efficiency in public sampling and testing procedures. In the Netherlands supervision of control is laid down as a policy framework (Ministry of ANFQ, 2005). The strategic policy focus is found to be on organizing public-private arrangements.

Experiences indicate that supervision of control requires an innovative way of public-private cooperation, which could provide substantial potential welfare gains. Possible gains are: lowering of inspections costs, lowering of sampling and testing costs and improved food safety. It is recommended that governments specify the requirements for food safety objectives and food quality systems. Industry, policy and science should develop a comprehensive vision on the role and responsibilities of parties involved, and give priority to build bridges based on common language and trust.

1. Introduction

Consumers have growing interest in food safety and quality. Concerns range from the health risks of consuming food, to the environmental implications of production processes. Often the food safety and quality attributes consumers seek are difficult to verify, especially when those attributes are derived from the actions of numerous, spatially dispersed primary producers. In most cases direct monitoring of farm production processes is prohibitively expensive, although recent advances in testing technologies will provide better information at lower cost and in a shorter time (Unnevehr et al., 2004). The inherent risk of agricultural production further complicates the problem. Even if product quality can be assessed

at a reasonable cost, it may be difficult to determine whether quality problems are due to lack of care and effort by the primary producer or to factors outside his control.

To protect the general public against food safety hazards governments introduce food safety legislation. Until recently this was mainly based on command and control interventions. Globalization, consolidation in food production and processing, and increasingly complex food supply chains make existing legislation insufficient to effectively and efficiently control food safety hazards. In 2000 the EU introduced new food safety legislation with the White Paper on food safety (Commission, 2000). With this paper the EU aims to ensure a high level of human health and consumer protection. This regulation is based on risk analysis using the precautionary principle in risk management decisions. The food safety system includes the whole chain from feed producers to consumers and lays primary food safety responsibility at producers. Governments keep their final public health responsibility. Since 2002 all food producing companies in the EU (the primary sector excluded) have to work according to the principles of Hazard Analysis and Critical Control Points (HACCP) (EU Decision 2001/471/EG) which was incorporated in the General Food Law in 2005 (General Food Law, 2002).

Market based incentives are economically preferable, because tighter regulation reduces producers' choice space (Cropper and Oates, 1992). A new HACCP-based food safety control system is likely to be a more economically efficient approach to food safety than command and control interventions (Unnevehr and Jensen, 1999). HACCP potentially reduces government costs as with HACCP-based regulation, the regulatory agency can view records (including verification of processes and the effectiveness of control) periodically to verify that a HACCP program is working and thereby indirectly control food safety. The new EU legislation for food safety thus opens possibilities to change towards a more effective and efficient control of food safety making use of voluntary approaches. The legally introduced private responsibility for food safety increases liability and thereby opens possibilities to efficient self-control within public conditions. The availability of product safety information increases the likelihood that firms would actually be held liable for damages resulting from a contamination (Segerson, 1999). Because food safety hazards can enter, regenerate, and cross contaminate in production processes throughout the entire supply chain, all companies in the supply chain are involved in a control system.

The principal-agent theory enables analyzing the economic motivations behind the private and public policy decisions regarding food safety control, including the supervision of control principle. To ensure that a food product is safe private companies in the supply chain have to implement control measures in the production process. This means that for a government to reach a public appropriate level of protection it has to rely on the private companies to appropriately implement and perform control measures. But a government cannot observe private companies taking these actions, although these are essential in controlling food safety: hidden actions lead to information asymmetry between the government and private companies. Delegation of the task to private companies can lead to moral hazard problems. Although a company has promised to take actions, it can shirk, or it can even take actions not in line with food safety, if this is more efficient for it. This becomes especially important when the interests of the private companies are not in line with public food safety interests and the agent does not experience the negative side-effects of his actions for the principal. Without sufficient observation the company cannot be confronted with the external effects of his actions for the government (or general public). When these external effects are high enough, social costs exceed the private benefits for the company, and thus the action leads to a decrease in social welfare. A government can control whether or not private companies indeed apply appropriate measures by setting targets for food safety results through product indicators, e.g. the maximum prevalence of hazards, or process indicators and checking whether or not private companies comply with these indicators (Cropper and Oates, 1992).

If the safety of a product cannot be observed directly, purchasers need to gather information about the safety. When information gathering is cheaper than the expected benefits from the transaction, purchasers will search the information and knowing, the actual safety choose, the optimal safety level and price. Suppliers can produce each quality level, as for each level a self-regulating market exists. Thus, the government can leave the product safety control to the market. When information gathering is more

costly for a purchaser than the expected benefits, the purchaser will not search for safety information. Thus, because purchasers are not able to assess the safety, they assume that safety is low and are only willing to pay the low safety price. Suppliers cannot sell high safety products for the high safety price, but only for the lower low safety price. So they are inclined to produce only products with a lower safety. This is known as adverse selection or the 'lemon' problem of Akerlof (1970). Government control is needed to guarantee a minimal safety, as the market does not lead to high safety.

The current public control apparatus is under vast reconstruction in many EU countries and regions, in order to handle the problems within the increasingly complex food supply chain. To update public control apparatus the assignment will be to develop best quality management instruments in public authorities to inspect the control activities of food chains. A further intention is to enable public authorities to guarantee the adaptation of 'supervision of control' (abbreviation: SoC) principles to the changing control activities in the future food economy. Supervision of control is important because the costs of unsafe food and the inspection and testing costs on the EU level are substantial. The total costs of Salmonellosis and Campylobacteriosis are in the range of billions of euros. To ensure the compliance with food laws in the EU tens of thousands of food safety inspectors are active. The EU-General Food Law states that companies are responsible for food safety implying self-control by firms and the application of private quality control systems. Governments remain responsible for compliance with law and thus for maintaining a system of public control. Public control of the private quality control systems ('supervision of control') is however still immature and the effort is needed to provide public authorities with efficient and meaningful control principles and strategies amidst a growing complexity of food supply chains. Adequate systems for monitoring and testing as well as incentive mechanisms need to be developed.

An essential change is the transition towards increased self-regulation, from 'government' to 'governance' (Reijnders, 2003), with private companies having the primary food quality responsibilities with own check schemes and monitoring systems. Supervision of control fits in the trend towards deregulation and privatising of the governmental policy. The basis for supervision of control is new: on the one hand it is a result of another political ideology ('civil society'), and a new control filosofy, in which self regulation plays a very important role. But in the Netherlands and Anglo-Saxon countries this is translated in a stepping back of the government to give more space for private initiatives and private responsibilities. The public control of private quality control systems is still immature and effort is needed to provide public authorities with meaningful control principles and strategies. In this, the exchange of information will play a major role. The challenge will be to change the food control system from the traditional structural end-of-pipe control including time consuming analyses, and incidental inspections, towards a pro-active system which aims at both a quality and a safety guarantee. The tools for this will be quick analyses, selective end-of-pipe control of processes rather than control of specific products, and targeted inspections aimed at the quality of both the system and the product.

The overall objective of the Promstap Interreg IIIc project is to promote the establishment of professional modern food safety management systems in agrifood-industry that are linked to the public food control. This has been done by comparing existing control of control systems in the different regions, identifying strong and weak points of each system, to learn from each other and to formulate recommendations for improving the practices of supervision of control-principles. In an evaluation study like this a number of aspects are relevant: the national legislative framework, the practical organization of supervision of control and the use of penalties and sanctions by certifying organization (incentives). Important aspects of this interregional project are the exchange of knowledge on supervising control systems and other best practices in the regions of the Netherlands, Denmark, and North Rhine-Westphalia. The project supports knowledge exchange on existing SoC-systems, extend the knowledge on cost-effective systems in the regions of Gelderland (NL), North Rhine Westphalia (DE) and Hovedstad (DK), and share the developed knowledge with Vidin (BG) and the other Promstap partner regions. The project was carried out by the following researchers: G. Backus, E. Oosterkamp, C. v. Wagenberg and N. Bondt (NL), B. Christensen, S. Aabo and T. Hansen (DK), S. Bruckner and A. Mack (DE).

2. Materials and Methods

After a kick off-meeting at first a structured questionnaire has been developed to allow the project partners to collect basic data on food production, the institutional setting of public food control and policy, private food quality and assurance systems and public-private cooperation. Principal-agency theory is used as a framework to evaluate incentives for private companies to join public-private cooperation and the impact on system-wide performance.

The principal-agency theory analyses the relation between principal (in case of supervision of control the principal can be the private organization of certified quality control systems) and agent (in case of supervision of control the individual food business operator). The certifying organization is in charge and sets the standards, the individual food producer only has to comply with the standards. The crucial problem in this relation between principal and agent is the information-assymetry (Bakker et al., 2007). The principal is in charge, but doesn't have all the information to evaluate the compliance with the rules. The principal-agency theory focuses on the (organization of the) cooperation between principal and agent, to optimize the results. Important are the proper incentives to stimulate the proper behaviour of the food company. If it is very difficult to measure the compliance of companies with the food safety standards, a free rider problem can arise. In that case individual companies could decide to take profit of the certificate, without really comply with the standards of the certification scheme. To avoid this situation an effective incentive structure, adequate audits and sanctions are very important.

Preliminary results of the study were presented in a "science meets policy" workshop, held in Hilversum (The Netherlands) in June 2007, with approximately fifty participants: researchers on risk assessment and food law, and representatives from industry and public authorities. Recommendations about food safety risk management and supervision of control were formulated based on plenary and group discussions during this workshop.

3. Results and Discussion

Supervision of control is a multi layered control system. It requires an essential change in policy, e.g. the transition towards increased self-regulation (from 'government' to 'governance') with private companies having the primary food quality responsibilities with own check schemes and monitoring systems as the first control layer. The public control of these systems, or the second control layer, is still immature and effort is needed to provide public authorities with meaningful control principles and strategies. In this the exchange of information plays a major role.

Possibilities to reduce the costs of food safety control are relevant, because the costs of inspection and testing food safety in the EU are substantial. Also ensuring a high level of food safety can result in substantial welfare gains. Estimation of health costs of human salmonellosis and compylobacteriosis in the Netherlands in 2000 are €16 to €50 million (Mangen et al, 2005), based on 46.000-54.000 Salmonellosis incidencies per year (www.rivm.nl, August 2006). The number of reported cases varies per country from 4.4 per 100.000 per year in Portugal to 322 in Czech republic, at an EU-average of 38 per 100.000 (180.000 cases in total). In reality the number of incidences may be at least 10 times higher and the variation in actual incidencies may be much lower (EFSA, 2005). Based on the Dutch incidencies the costs at EU level could be: €440 million to €1,380 billion, only for Salmonella and Campylobacter. The costs on EU level will be billions of euros, and there will be ten thousands of inspectors, based on the actual level in the Netherlands of 550 food safety inspectors per 16,3 million inhabitants.

3.1 Definition

Supervision of control is the use of (certified) private quality control systems (q.c.s.) which can qualify for less intensive public control by inspectors of the government, on the condition that these systems meet legal preconditions. Stated shortly: 'legally conditioned self-regulation' (Bakker et al. 2007).

In figure 1 'Supervision of control' is defined and possible developments towards increased self-regulation by private companies are illustrated. At a certain point in time (now) total food safety control from private companies and the government is illustrated by (A+B+C+D) in the figure. 'Control by companies' (A+B) and 'Control by government' (C+D) can consist of check schemes, sampling and analysis, monitoring systems, the auditing and accreditation of monitoring systems. Both private companies and the government can use similar kinds of check schemes, sampling and analysis, monitoring systems, and audits for the same hazard, indicating that in principle they both can make use of each other's control activities. In the figure the government is making use of a certain number of private companies control activities (B). 'Supervision of control' is defined as the governmental activities to verify/control audits and the control data provided to them by private companies (C). B is the part of the food quality and safety control data and audits by private companies, which is also used by the government for their supervision as part of public control. The extent to which 'supervision of control' is possible may differ between hazards and/or sectors. By using 'supervision of control' the government can decide to reduce its own number of control measures (D), thereby effectively reducing the total food safety control and reducing food safety control costs. Cost reduction is reflected by E.

The next example illustrates the figure. The Dutch feed sector collects 35.000 samples a year for Salmonella. So A consists of 35.000 samples and additional auditing schemes. Until 2006 the Dutch government collected 400 samples a year for Salmonella in the feed sector for public control, D consists of these 400 samples and additional audits; no data was shared (B=0). Last year the government gained access to the private salmonella and stopped taking the 400 public samples. So 'supervision of control' consists of government personnel analyzing and controlling these data (C), B consists of the 35.000 samples for salmonella and the relating auditing costs, and savings for the government (E) are the reduction of costs by D minus C. Savings for the companies consist of the costs of involvement in taking the 400 government samples and audits.

In the Netherlands the expected development is towards increasing 'supervision of control' in the future, thus the governments activities relating to control of control (C) are increasing and the government is using an increasing amount of information from control activities by private companies for the purpose of public control (B). Using these private data the government can reduce the number of public sampling and auditing (D) and reduce total food safety control (A+B+C+D) with an amount E. In the extreme case the government may only control the auditing of the private food safety systems and their accreditation and has access to the information from the companies, without any own governmental check schemes, sampling and analysis, monitoring systems. In that case D may become 0 in a hypothetical point in the future.

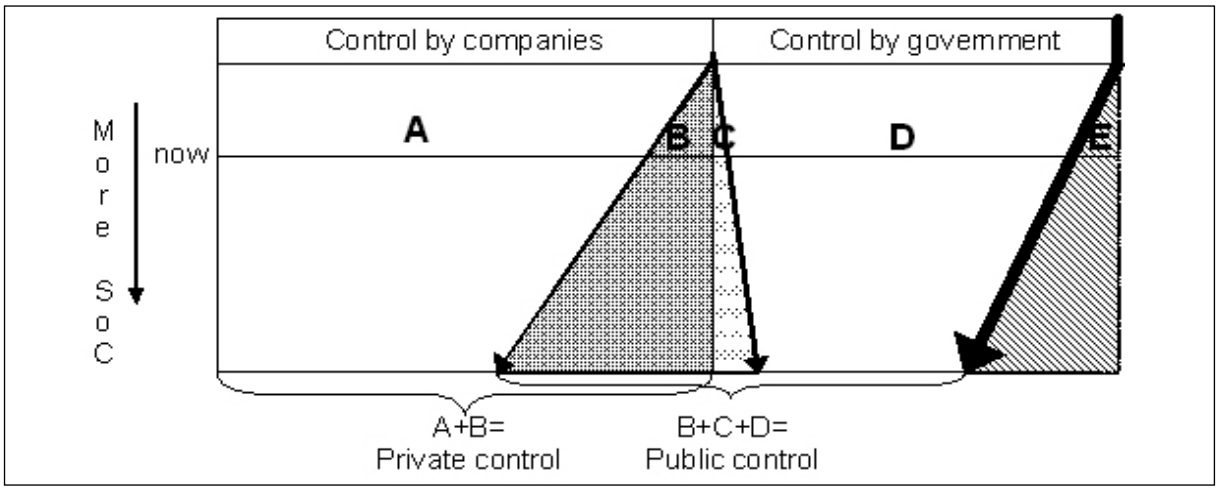

Figure 1: Definition and possible developments of Supervision of control. A = Control by companies for private use (data, audits), B = Control by companies for private and public use (data, audits), C = Supervision of control: Control by government of private control data available for public use, control of private audits and new activities (mainly manpower), D = Control by government for public use (data, audits), E = Savings through control of control.

A system of supervision of control is more efficient than public control systems when the reduction in sampling, testing, and procedure costs is larger than the increase in governmental control costs and private administrative costs, given that it ensures an ex-ante specified food safety level. It is important that a reduction of the number of public inspections is not a necessary element of supervision of control. For example in Denmark the total number of public inspections will certainly not be reduced, the public control activities will only be shifted from food business operators with high performance to operators with a lower performance.

3.2 Legislative framework

Supervision of control is made possible by EU-legislation. In this respect the General Food Law, harmonization of food regulations EC 882/2004 and the Hygiene package are the most relevant. General Food Law (GFL; EC 178/2002) states: 'Given that a food business operator (or feed operator) is the best place to device a safe system for supplying food/feed and ensuring that the food/feed it supplies are safe, it holds primary legal responsibility for ensuring compliance with food law and in particular food safety'. So the GFL links liability with self-control systems, but also states that liability is based in the national legal order and in the specific infringed legislation. Shortcoming of the EU-legislation is that food safety is not clearly defined, so the European Union should fix the objectives and define what is (un)safe (workshop presentation of Van der Meulen, 2007). Based on those definitions private companies (Food Business Operators) could ensure that food law requirements are met, and verify that by using an adequate self-control system.

The EU-Regulation on Official controls (EC; No 882/2004) focuses on official controls performed to ensure verification of compliance with feed and food law, animal health and welfare rules, and is to ensure a harmonised approach. Member States should ensure that official controls are carried out regularly, on a risk basis and with appropriate frequency. A risk based approach means that Member States have to take account of: a) feed or food business operators' past record as regards compliance with the law; b) the reliability of any own checks that have already been carried out, especially checks of HACCP based private quality assurances programmes. In the case of non compliance the past record of the company also should be taken into account in deciding which action to take. For the possibilities of Supervision of control it is important to see that the Competent Authority may delegate specific tasks to a 'control body'. A control body is a third party to which the competent authority delegates certain control tasks. Such a 'control body' should be an impartial third party, accredited and free from any conflict of interest. There has to be communication between the competent authority and the control body on a regular basis.

Supervision of control does not change the roles: public authorities remain responsible for setting legal requirements and maintaining a system of official control and enforcing taking action (workshop presentations of Mrs. Bergkamp, Mr. Heres and Mr. Van der Meulen). Supervision of control implies self control, so those elements are closely linked, but not all self control will be part of supervision of control. A limited definition of supervision of control is: auditing of self control systems. In the context of public control on food safety however the legal requirements for food safety or the control systems must be taken into account. According to the General Food Law food and feed business operators have product liability, limited to the legal requirements. Supervision of control can be related to product liability legislation, because companies are being held responsible for producing 'good' (and 'safe') products. One wouldn't expect that it should be a public responsibility whether a company would sell a 'safe' car or coffee machine. The same should be the case when it comes to food. In fact companies need quality management systems to control and prove the quality of their products. In the German "Produkthaftungsgesetz" (product liability law) it is stated that: "If due to the error of a product someone is killed, his body or his health is hurt or a thing is damaged, then the manufacturer of the product is committed to replace the damage". With a good working quality management system food companies a) can avoid unsafe products and b) also prove the quality of their products to the authorities, or to the court.

3.3 Current SoC-situation in the regions

Self-control is a leading principle in Denmark, Germany and The Netherlands, and these countries adhere to the principle of supervision of control. Public control activities are adjusted to q.c.s., based on risk assessment. However the implementation and focusses are different, and also the national legislative framework and organisational structure of food control are different in the regions.

Germany, North Rhine-Westphalia (NRW). First priority in Germany at the moment is the restructuring of the public food control as well as harmonisation and standardisation of the public control in the different federal states. The principle of risk-oriented control of food enterprises according to the new EU-Hygiene law has been integrated in the German food law in 2007. A project group (LAGV[1]) has developed a model for the risk evaluation of food enterprises. This model has been integrated in the revised version of the AVV RueB[2] (AVV Rahmenueberwachung), which is a general administrative regulation about principles concerning the execution of the official public food control. Evaluation of existing self-control systems in food enterprises and so their effectiveness is a component of the risk evaluation and now obligatory for the public food control in Germany (BMELV, 2007). Additionally to the AVV RueB, there is the AVV LmH[3] (AVV Lebensmittelhygiene) since September 2007. The AVV LmH is a general administrative regulation about the execution of the official food control concerning the compliance with hygienic regulations for food of animal origin and methods for the control of good manufacturing praxis guidelines. The aim of this regulation is particularly a standardisation of the public control in the federal states in Germany.

Since January 2007 there is also a new State Office in NRW, the State Office for nature, environment and consumer protection (Landesamt fuer Natur, Umwelt und Verbraucherschutz, LANUV). It combines three former regional authorities and includes also former responsibilities of the departments 'veterinary concerns/food control' of the five district governments of NRW. By the foundation of the LANUV expert knowledge should be bundled and the prevention as well as abatement of food scandals should be facilitated. Additionally a cooperation of local chemical investigation offices and offices for food investigation and national offices for veterinarian investigation is planned. Thereby the number of investigation offices should be reduced from approximately twenty at about six. From 1999 to 2005 the number of controlled enterprises in Germany decreased as well as the number of control visits in Germany. Now, after a lot of food scandals (especially the meat scandal in 2006 and 2007) things are going in another direction (BVL 2007). Therefore another point for optimisation of the public food control is increasing the number of food inspectors in Germany. For example there are plans for doubling the number of food inspectors in NRW from approx. 300 today to 600 until the year 2010 (Uhlenberg, 2006). At the moment no control data by companies are used by the government. The public food control is also not allowed to look at audit reports of private accredited certifying bodies. Supervision of control is only implemented in Germany as part of the risk evaluation of food enterprises done by the public food control. This information is based on written answers by the project partners on questions in the framework and additional questionnaire.

Denmark, Hovedstad. In Denmark self-control has led to more private sampling, but at the same time public inspections remain the backbone of the public control system. Wubben and Hubeek (2005) conclude that Denmark is ahead in imposing self control systems. These self control systems need to be approved by the regional food agency. All privately collected data are accessible for the government. In Denmark the data from private systems are considered very useful to improve the quality of the public control system. Inspection results are partly made public by using a smiley system for restaurants. Governmental sampling and testing are more frequent compared to the Netherlands and Germany. In Denmark strategic policy focus is on efficiency in public sampling and testing procedures. For example in the project slaughterhouses have been sampled with carcass swabs and analysed quantitatively for

1 Länderarbeitsgemeinschaft gesundheitlicher Verbraucherschutz

2 Allgemeine Verwaltungsvorschrift über Grundsätze zur Durchführung der amtlichen Überwachung der Einhaltung lebensmittelrechtlicher, weinrechtliche,- und tabakrechtlicher Vorschriften

3 Allgemeine Verwaltungsvorschrift über die Durchführung der amtlichen Überwachung der Einhaltung von Hygienevorschriften fuer Lebensmittel tierischen Ursprungs und zum Verfahren zur Pruefung von Leitlinien für eine gute Verfahrenspraxis

Salmonella and E. coli. Project data have been compared with slaughterhouse own control data. This information is based on written answers by the project partners on questions in the framework and additional questionnaire.

The Netherlands, Gelderland. In general the Dutch system is still a mix. On the one hand the government is still inspecting animals in slaughterhouses, on the other hand there is a policy focusing at possibilities for 'supervision of control', tested in several experiments (Wubben, personal communication). In the Netherlands the strategic policy focus is found to be on organizing public-private arrangements. Supervision of control is laid down as a policy framework, submitted to the Parliament in 2005. The Dutch government wants to emphasize the sector's own responsibility, as laid down in the GFL. NGO's and politicians are still sceptical. The public inspection hopes to withdraw from companies which participate in private quality systems, in order to intensify the inspections for non-participants. Supervision of control will be laid down in agreements between the government and the owner of the certification system (third party). Main elements of SoC in the Netherlands are that the government remains responsible for supervision of compliance, there is an independent private third party (preferably accredited) auditing the participating food business operators. The private certification system has to contain the legal requirements, and the owner of the system reports to the government on audits. Basis of sanctions is the certification system, in which the auditor imposes measures, but in the case of very serious breaches the government will also imply sanctions (presentation by Bergkamp, workshop). Six pilot projects started on public-private arrangements in which an independent auditor is an important condition. In those pilots independent organizations take over public tasks or, in the case of poultry slaughterhouses, the inspection is carried out by employees of the company itself, under public supervision. Transparent, independent control and sanctions imposed by the government are important for internationally operating food and fees industry, it gives a license to deliver (presentations by Bergkamp, Heres and Hessing, workshop). Reducing cost is a major driver for the Dutch government, but for companies pilot improving food safety is. Reputation of companies is an important factor, being a source of trust. In the Netherlands public inspection results will be published sectorwise, not yet by names of the company, and recalls are published on the internet.

In Germany and Denmark there are no public policy papers in favour of the implementation of 'supervision of control' like there is in the Netherlands. But at the same time there is growing support for the principle of self-control by companies and the application of risk-orientation of food control in Germany and Denmark. In Denmark the level of public control is still high, which is also reflected in a relatively high number of public inspectors. In Germany and Denmark there are no pilot projects of SoC. However, increased self-control and risk orientation of food control opens the possibilities for supervision of control. Table 1 gives an overview of the institutional setting in the three countries.

Table 1: Institutional setting in the regions. See also Wubben and Hubeek, 2006.

	GER	DK	NL
Organizational			
Responsability	Restricted autonomy	Agency structure	Agency structure
General policy	Getting more centralized	Central	Central
Implementation policy	Decentralized, shift from District to Länder	Decentralized	Central
Consultation industry	Yes?	Yes	Yes
Implementation			
Procedures	Substantial diversity, close cooperation with industry	Standardized	Standardized
Self-control and Control of Control	Not yet, pilot project on HACCP started	Yes, but public inspections remain backbone	Depends on sector / in progress several pilot projects
Involvement private organisations	No	No	High

For example Germany has a decentralized implementation. The official food control is under the responsibility of the federal states in Germany. Public food control is coordinated by the responsible regional ministry of the federal states (for example the Ministry of the Environment and Conservation, Agriculture and Consumer Protection of the State of North Rhine-Westphalia (MUNLV) in NRW) or the responsible senate administration in the city states. Smaller countries (Denmark, The Netherlands) tend to have standardized procedures and greater distance to the industry. Greater distance and more responsibility for the industry seem to go together (Wubben en Hubeek, 2006).

Table 2 gives an overview of agricultural production, number of food manufacturers and number of public food inspectors in the three regions or countries.

Table 2: Number of public food inspectors and production capacity in the regions; Numbers in second and third row based on EU statistics. Numbers in fourth row based on information from project partners (NRW, DK) and oral information by VWA (Dutch Food Safety Authority)

	NRW (GER)	DK	NL
Chicken (1000 ton) Pork (1000 ton)	34 1075	181 1793	551 1297
Manufacturing units (food & beverages) Employees/unit	1037 89	2209 34	6560 19
Public food inspectors	338 -> 600	Slaughter 750 Retail, wholesale a.o. 300	557 public + 414 semi private

This table shows that the number of public food inspectors is relatively low in NRW, but will be increased in coming years. In Denmark and The Netherlands the number of inspectors are more or less at the same level. It is difficult however, or even impossible to judge whether or not these numbers of inspectors are sufficient. This evaluation has to be 'risk based', and so the number of inspectors that is needed mainly depends on the quality, regarding the control of food safety, of the companies that have to be inspected.

Table 3: Number of samples and audits in the three regions. Information in second and third column is based on information by project partners; Information in the fourth column is based on oral information by VWA (Dutch Food Safety Authority)

	NRW (GER)	DK	NL
Annual public *Salmonella* tests	GER: all micro organisms in animal feed: 3000 (NRW??)	3000	400 in feed recently quitted as consequence of CoC 4200 in zoonosis
Annual private *Salmonella* tests	??	480.000	35.000 in animal feed 60.000 in poultry
Public feed audits feed (per company per year)	1/2 - 4	4-6	2 for GMP + certified feed (was 4)
Private feed audits (per company per year)	2 (??)	2 (??)	2 on average for GMP+

Table 3 shows the intensity of sampling and auditing in the different regions. Interesting is the fact that in the Netherlands the number of public inspections on feed companies has been recently reduced from four to two a year, but only for those companies with a certified GMP-q.c.s. These GMP-certified companies are also regularly audited by private certifying bodies.

The most important aim of food safety controls, and also of supervision of control, is to ensure and improve the safety of food (and feed). Table 4 shows a rough indication of the current situation in the three regions, concerning Salmonellosis. The estimated incidences of Salmonellosis vary from approximately 300 cases per 100.000 inhabitants per year in the Netherlands to more than 500 cases in NRW. An adequate system of monitoring this food safety situation is important to get good insight and have possibilities to evaluate the effects of changes in the organization of public and private food safety control.

Table 4: Incidences of Salmonellosis in the three regions; Information from NRW: www.rki.de and oral information C.Frank; Information DK provided by projectpartners; Information NL from www.rivm.nl.

	NRW	DK	NL
Population (x million)	18.0	5.4	16.3
Reported cases Per 100.000 inhabitants	9,792 54.4	1,798 33.0	1,388 8.5
Estimated incidences/year Per 100.000 inhabitants	10 x reported 544	20,000 370	48-54,000 313

3.4 Evaluation of Supervision of Control

The implementation of supervision of control has several advantages. It stresses the company ownership and primary responsibility for food safety. Furthermore it helps public control to become more efficient and effective, by shifting the focus towards companies without certification or with less developed self control systems, based on risk assessment and based on the results of checks of private q.c.s. Also supervision of control gives the competent authorities a certain access to underlying data of private q.c.s. For private companies with well functioning own control systems supervision of control can possibly result in a reduced administrative burden due to public inspections. It is expected that a system of supervision of control will result in more transparency of procedures, and in a better image of companies as a result of increased legitimacy (licence to produce). A higher level of compliance to legal standards can be expected, because in most cases the private audits are more frequent en more stringent than the regular inspections by the government. Ultimately supervision of control aims at an improved level of food safety, by stimulating the awareness of food safety in companies, and more frequent and adequate use of q.c.s. by food business operators.

Supervision of control can also have some disadvantages, and difficulties for implementation. De Bakker et al. (2007) states that in practice the policy framework is often far from compatible with the sector's needs for more practical regulations. There is a risk of an excessively static and insufficiently dialogic use of the available policy framework. This can in part be explained by the absence of a generally-shared policy viewpoint on supervision of inspections and the lack of knowledge about the opportunities offered by the various private certification and inspection systems. One of the other problems is that for small enterprises and retail it is difficult to implement q.c.s. Another disadvantage is the possibility of moral hazard, which means that certain companies could be able to profit from a SoC-system without realizing an adequate level of food safety within the own company ('free riders'). But, if the certifying organizations are functioning properly this should be a limited risk. However, there remains a certain risk of illegal behaviour, due to (financial) dependences between food companies and their certifying bodies, and between certifying bodies and the national accreditation council. It is a serious problem that many, especially smaller firms (SME's) lack the knowledge, availability of personnel and financial resources to adequately operate a HACCP-based quality management system. Right now these systems are not implemented in enough companies, especially at retail level. To operate a system of supervision of control a completely new cooperation between inspectors of the authority and private quality systems needs to be developed. Public inspectors need specific experience and training in the field of supervision. The basic knowledge of quality management tools is missing, both in authorities and in food companies. Important prerequisite for the implementation of supervision of control is international acceptance, especially for exporting countries like Denmark and the Netherlands. Finally it is possible that supervision of control may lead to less quality of public supervision caused by lack of experience in the governmental organization. Also there is a risk of erodation of the capacity of the public food safety authority, which has to be available in case of "emergencies".

4. Conclusion and recommendations

The focus of food safety policy differs among the studied regions. Experiences indicate that supervision of control requires an innovative way of public-private cooperation, which could provide substantial potential welfare gains. Possible gains are: lowering of inspections costs, lowering of sampling and testing costs, more efficient and more effective public control, and improved food safety. It can be concluded that supervision of control is possible, under certain conditions. The main conditions are: a) that the private q.c.s. are audited by an impartial third party, preferrably accredited and free from any conflict of interest, b) that results of private control, in some way, must be known to the government.

In the project it proved to be possible to find the crucial differences in strategic policy focus between the three regions. In the beginning 'supervision of control' seemed to be implemented in the regions in a comparable way, but later on important differences were found, through cooperation with experts from the regions. In all three countries audited self-control systems are the starting point, but with substantial variation in the reduction of public inspections of food companies with certified q.c.s. In Denmark public inspections will not be reduced and remain the backbone of public control. In the Netherlands the focus is on public savings and reducing administrative burden of companies. In Germany (NRW) the first priority is restructuring the public food organization. Reduction of the number of public inspectors is absolutely no option, on the contrary: the number of food inspectors is planned to be doubled in the next three years.

Several 'Best Practices' were found in the three regions. In Denmark a best practice is that public inspectors have full access to private data. Germany has a lot of experience with advisory and controlling tasks of the government. In the Netherlands there is concrete experience with the implementation of supervision of control by downsizing public inspection capacity in certain situations, and delegation of public control to independent, private organizations.

The cooperation between the regions turned out to be profitable, especially in the organization of the international workshop in June 2007. By combining the international networks of the three regions it was possible to compile a very interesting program with first-class speakers, and thus attracting more than fifty participants from Denmark, Germany, Bulgaria and The Netherlands.

Before implementing a system of supervision of control it is recommended that governments specify the requirements for food safety objectives and food quality systems. Another important factor is the adequate training of public and private inspectors, so they will be able to perform their part of the SoC-tasks well. It is recommended to start education and campaigns towards companies. Industry, policy and science should develop a comprehensive vision on the role and responsibilities of parties involved, and give priority to build bridges based on common language and trust. It is important to pay more attention to social-economic and political aspects, and to look carefully at other 'drivers' than cost effectiveness. It is recommended that scientists compare policy frameworks thoroughly to understand the environment of supervision of control. Also the development of a stakeholder dialogue can be helpful. In addition, attention is needed for the development of social cost-benefit analyses in the inspection and enforcement areas, and to social cost-benefit analysis studies of the effects of incentive systems for food safety and food quality in the chain. A specific recommendation for the industry is to share information and data on public food safety, with other companies and also with the government. Government should invest in the international acceptance of supervision of control. In drawing up agreements about supervision of control, trust plays an important role. Therefore communication and cooperation between government and industry are crucial. Supervision of control is new, both for the government and for industry. It is therefore sensible to choose a pragmatic approach, with sufficient flexibility (Bondt et al, 2006).

The participants in Hilversum in June 2007 have recommended:

- to give priority to making bridges between industry, policy and science built on trust and common language;
- to develop a comprehensive vision on the role and responsibilities of the parties involved, also to avoid future setbacks in case of food scandals;
- not to wait upon the Rolls-Royce model of science and focus on a practical level of understanding and formulate practical targets;
- industry and policy to set the research agenda through exchange meetings;
- consumers to organize themselves and make sure that control will be independent;
- governments to act when rules are not complied with, to support self-control trainer programs for organizations of SME, to support data exchange on specific food hazards, and to set food safety targets to be reached;
- science to make more use of case based approaches ("we need more examples from practical solutions"); to specify and develop more 'simple' and user friendly risk based systems; to look into existing quality assurance systems: to advice industry on how to improve these systems and give it a sound scientific basis;
- industry to share information and data in the field of public food safety, and give science a view in their kitchen of how things really work; small and medium enterprises (SMEs) to cooperate in improving self-control, and to improve their skills on self-control;
- to upgrade the qualifications of public and private inspectors;
- to broaden the base of involved countries, as well as institutions, including the FVO and the Commission;
- the establishment of targets or objectives, preferably at EU level, in order to communicate official acceptable levels with which the industry has to comply;
- that targets or objectives need not necessarily to be in accordance with Codex legislation;
- food safety risk managers to act according the real life fact that zero risk is an utopia;
- to establish more baseline studies at the EU level;
- continue ongoing technological research, and to pay more attention for social-economic and political aspects; look also carefully at other "drivers" than cost effectiveness, i.e. development of stakeholder dialogue; compare policy frameworks thoroughly to understand the environment of control of control - very different in each country also effects idea of performance in the field of food safety.

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Oral information: Mrs. Christina Frank, RKI (Germany); Mrs. Lisette Poldervaart, VWA (Dutch Food Safety Authority); Mr. Emiel Wubben, Wageningen UR.

Information exchange and integration of documentation and information systems in meat chains

Ellebrecht, A.[1*], Zandbergen, J.[1*], Schütz, V.[2], Schwaer, P.[3], Erke, R.[4], Chiche, D.[5]

[1] Chainfood, IJsselburcht 3, 6825 BS Arnhem, The Netherlands, E-mail: a.ellebrecht@chainfood.com

[2] University of Bonn, Institute of Animal Science, Katzenburgweg 7-9, 53115 Bonn, Germany, E-mail: verena.schuetz@web.de

[3] Infosys, Nevinghoff 40, 48471 Münster, Germany

[4] Land24, Robert-Bosch-Strasse 19, 58155 Münster, Germany

[5] Agri'Oeuf, La Marine Route de Villars les Dombes, 01320 Chalamont, France

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Abstract

New regulations of the European Union include site specific rules for product and process documentation and information sharing between meat chain actors as well as a better traceability. Implementing these new requirements assume communication and information exchange in food chains. Organisational and technical improvements have to take place in order to be efficient and effective. Different internet based information systems are already used, especially to solve problems of documentation, information transfer or analysis. The integration of data from these different IT systems of the chain actors will reduce time consuming, costly documentation and support decision making. Especially the actors in the meat sector with their objectives to continually improve themselves require a particular support for chain information management from stable to table.

The subproject Infex Meat is the only business to business project within Promstap. In this project, two focuses and therefore two working groups were defined. One group focused on chain aspects and deeper analysis regarding fields of cooperation of IT companies with the maximal added value. The other group focused on aspects of feasibility and implementation of computer-assisted traceability and production management systems with the chain aspect to fulfil e.g. EU regulation 178/2002 requirements. The project was divided into four steps:

- Development
- Implementation
- Validation
- Knowledge exchange

In the IT-integration group the results show that there is a demand for data integration throughout chains. But there is a need of establishing an organisational unit bringing chain actors in the position to fulfill legal requirements and to optimise quality management throughout food chains. For aspects like data integrity, a netchain coordinator is needed.

In the user group the results show that through the implementation, an adaptation of an integrated information model between internal management systems will allow a better transmission of quality information in hen eggs chains. The requirements regarding traceability and food safety of customers can be fulfilled in a more effective and efficient way. As one important result of the project, further developments take place in feed and food industry within other international R&D- projects.

1. Introduction

Food safety and consumerism are invigorated through the European Union. Especially the commencement of the EU General Food Law (Regulation (EC) 178/2002) and the "hygiene package" with its several regulations demand a good traceability, transparency and a stable to table approach throughout

the agricultural production. The new requirements include on the one hand site specific rules for product and process documentation and information sharing between meat chain actors (Regulations (EC) 853/2004, 854/2004 and 183/2005). On the other hand there would be added personal responsibility of both, food and feed producers.

The implementation of the new requirements and adaption of the cooperation processes throughout the chain assume both: A better communication and information exchange in feed and food chains.

There are some recent developments in hardware and software technologies that enable internet based information systems. As to new developments, coordinative organisations use them to solve especially problems for documentation, information transfer or analysis; for users, this involves the need for different software modules. Therefore conditionally a double data input is essential, increased error margin and high personal consumption of time.

Improvement of inter enterprise data warehouse technology enables newly available information. Integration of different data sources from one or more coordinative organisations with their information, documentation and advisor services will reduce time-consuming documentation and support decision making. It is structured to enable a variety of analyses, including the elaboration of queries on large amounts of data that can require extensive searching. Through its long term availability the data warehouse enables better comparisons and prognostic views on the available information in the agro food sector (SCHULZE ALTHOFF et al., 2005).

Especially the meat sector with its recurring affairs and anonymous products requires a particular support for chain information management from stable to table. Therefore it is essential not only to document separate and vertically information regulated by law but also to realise chain wide information transfer. Positive as well as negative feedback in form of so far as necessarily compressed and easy to read information will encourage the personal responsibility, food safety and consumerism (PETERSEN et al., 2007).

One important objective of this sub project is to consolidate the different individual documentation and information systems (Land.24 module for pig fatteners, Infosys slaughter information system, Chainfood (inter-) enterprise data warehouse module). This will result in a more integrated chain documentation, information and management system. Different chain actors will be supported by the integration of the systems. The availability of data will be optimised through this collaboration.

Clearly structured food chains like egg and poultry production with close relationships between the production stages have other requirements compared to pork and beef chains. Coordinative organisations are mostly integrated in major enterprises. However they are liable to implement ICT for process controlling, quality management and traceability in order to accomplish the legal requirements. This means that for example packaging companies for hen eggs have to adapt all the functions of the process in order to ensure the smooth running of their software solution. Challenge of the analysis is to check that effect: How to integrate ICT solutions from major enterprises and systems used by the coordinative organisations to fulfil user specific requirements.

Beyond the acquisition of an adequate software at Agri'Oeuf, all the functions of the (inter-) enterprise process will be influenced and adapted in order to ensure the smooth running of the ICT solution. The whole of the products and information flows, from the reception of eggs to grading and to expedition will be inspected. The enterprise will analyse expenses considering further investments in software and the time spent by the managerial staff to analyse the process.

Moreover, another objective of the project is to share the experience and knowledge in different sectors of food industries. Beyond this the results of the private partnership project should be transferred to other PromSTAP partner regions within workshops, exhibitions, visits of companies and presentations. Through the involvement of 'control of control' aspects which are required by the EC hygiene package that the PromSTAP focus has taken into account.

2. Materials and Methods

2.1 Project partner description

Private information and communication technology (ICT) organisations in the Regions North Rhine Westphalia (Land.24 and Infosys) and Gelderland (Chainfood) developed specific applications for particular demands in pork chains. Land.24 has developed different internet platforms for communication and information transfer in agro and food sector. One aspect is to provide effective systems for rural documentation needs for pig and plant production. Infosys has developed systems for online feedback of slaughter data from slaughterhouse backwards to fatteners. The systems can also be used to organise information transfer for breeding objectives. Chainfood is a software company that develops and implements solutions to enable quality management for food and agriculture related businesses. Therefore the Chain Collaboration Framework was developed. The Framework covers the collection and storage as well as the processing of data and the distribution of information between organisations. Thus efficient collaboration features are offered, e.g. regarding quality assurance, supply chain management and risk control.

Beside the German and Netherlands partners, Agri'Oeuf as a non ICT organisation decided to participate in the project. Agri'Oeuf is a centre conditioning shell eggs; it belongs to the Glon Sanders group. Knowledge exchange between the private ICT partners and Agri'Oeuf should help each other in realisation aspects of EU regulations in more (e.g. egg and poultry chains) and less integrated (e.g. pork) chains.

The project consisted of two different focuses. The regional IT partners decided to focus more on chain aspects and deeper analysis regarding fields of cooperation with the maximal added value. The user group focused more on aspects of the feasibility and implementation of computer-assisted traceability and production management system with the chain aspect to fulfil e.g. EU regulation 178/2002 requirements. Because of that it was decided to work parallel on the first three of the defined four main project steps and to communicate over the results. The different steps were:

- Development
- Implementation
- Validation
- Knowledge exchange

2.2 Approach of the IT system group

Development:

First project activity in group 1 was the description of current activities. The future planning and the tasks of the German and Netherlands partners in the project were discussed. Therefore the status quo situation was analysed in order to define more in detail where cooperation is possible. It was discussed how different users could benefit from the integration of data and user specific analysis. As one of the most interesting fields, the exchange of food chain information between abattoirs, fatteners en official veterinarians in pork chains was defined. The development phase shows that for the integration of the different systems a netchain integrator is needed like an abattoir, a feed mill or an advisory service. So it was decided to present results to companies active in pork chains during the project.

Phase of Implementation:

In the phase of implementation interfaces were defined on how to exchange data from the solutions of Land24 and Infosys to Chainfood and from Infosys to Land24. Infosys suggested to realise the data export of slaughter data by the ADED data dictionary and to transfer the data by mail. This was tested between Infosys and Land24. Land24 suggested the export of farm data about e.g. medication, feed in XML-format to the data warehouse solution of Chainfood.

Interface descriptions has been made regarding important aspects like user rights, logging, workflow, frequency of data exchange and description of data integrity and security. The content of the data ex-

change was set up in a flexible way so that depending on the needs of a netchain coordinator and the users of the different systems, an adaption of the data content is possible. After definition of a list of possible contents for data exchange, Chainfood and Land24 developed first demonstrations of how to present the added information in their systems.

Validation:

In the validation phase the developed systems were presented to slaughterhouses and feed advisory services. The feedback was used as an input for further developments of the cooperation of the software companies. Farmers and feed advisors gave their feedback on the common use of Infosys, Agrar-Info and the data warehouse system and gave their suggestions for a further optimisation.

2.3 Approach of the user group

Development phase

Agri'Oeuf decided to implement a computer-assisted traceability and production management system in order to answer different challenges:

- To comply with the EU regulation 178/2002 by implementing a system to trace the products
- To meet the IFS (International Food Standard) requirements regarding the traceability
- To optimise internal production management

In the development phase a detailed analysis on the different challenges and furthermore a review of the production and its organisation took place. It was decided to choose for the software supplied by INFOLOGIC. This software has already been adapted to AGRI'OEUF company's specificities.

Phase of Implementation

The software of the company Infologic had to be adapted to Agri'Oeuf specific software. In the implementation phase, the software of Infologic was parameterised and integrated into the different existing specific software applications. Further activities were training of the employees in charge of collecting the traceability information, quality assessment of the producer, traceability and search of cross-traceability.

Validation

In the validation phase an adaption of test results took place and the advantages/feasibility of further steps were analysed.

Phase of knowledge exchange

It was decided by all project partners to communicate the project activities continuously at exhibitions, meetings with potential netchain coordinators and other companies interested in Promstap. Furthermore, the knowledge exchange between Infex Meat and the other Promstap partners was established through the common workshops and the website.

3. Results and Discussion

3.1 Focus group results IT-system group:

The first result of the development phase is an overview of the different types of target groups and fields of activities:

Primary target groups for Land24 in meat chains are pig farmers, but also consultants and slaughterhouses can use the system. The business model is focused on Business to Consumers via local farm cooperatives with focus on feed trade. The software is focused on the support of farmers in the docu-

mentation of product and process data required by legal rules. Infosys' primary target groups are pig farmers in meat chains, but also consultants and slaughterhouses that can use the system. The business model is focused more on Business to Business so e.g. a farmer can get access to his slaughter data by registration via a slaughterhouse. The focus of the system is to make fixed standard reports on all relevant slaughter data. Chainfood sees its primary target group in netchain coordinators in agro and food chains. The business model is focused on Business to Business activities. The software is generic and exists of data capture and management functionalities as well as data warehouse-functionality, as used in this project. This software enables an effective communication along food chains. The main user groups of the Chainfood data warehouse system are advisors, veterinarians as active users and farmers as 'push users' which means that they get e.g. reports by mail or fax. Further developments of Chainfood are e.g. the support of better mobile communication within food chains.

The analysis shows that on the one hand Chainfood and on the other hand Infosys and Land24 have different main user groups of their existing software. Chainfood focuses in chains more on advisors, veterinarians and Infosys or Land24 see their main target group more on farm level. The integration of the systems by data exchange via interfaces will deliver more integrated chain documentation, information and management system for pork chain actors.

As the most interesting example, the partners focused on the requirements of different actors in pork chains regarding food chain information (Regulation (EC) 853/2004 and 854/2004). Official veterinarians have to check and analyse relevant information from the records of the fattening period of animals intended for slaughtering and to take account of the documented results of this check and analysis when carrying out ante- and post-mortem inspection. A risk based (visual) meat inspection is possible for animals where the food chain information shows the official veterinarian that the animals have e.g. a good health status and that the farm the pigs are coming from fulfils all requirements.

The food chain information contains information about the health status at the farm as well as post mortem slaughter information. This data are already documented in the systems of Land24 and Infosys. So the content of the interfaces between Land24, Infosys and the data warehouse system focused on all relevant data for food chain information. The concept was presented to two slaughterhouses in Germany. A practical test during the project was not possible because of political discussions on how to accept the data exchange supported by ICT which is intended in the EC regulations

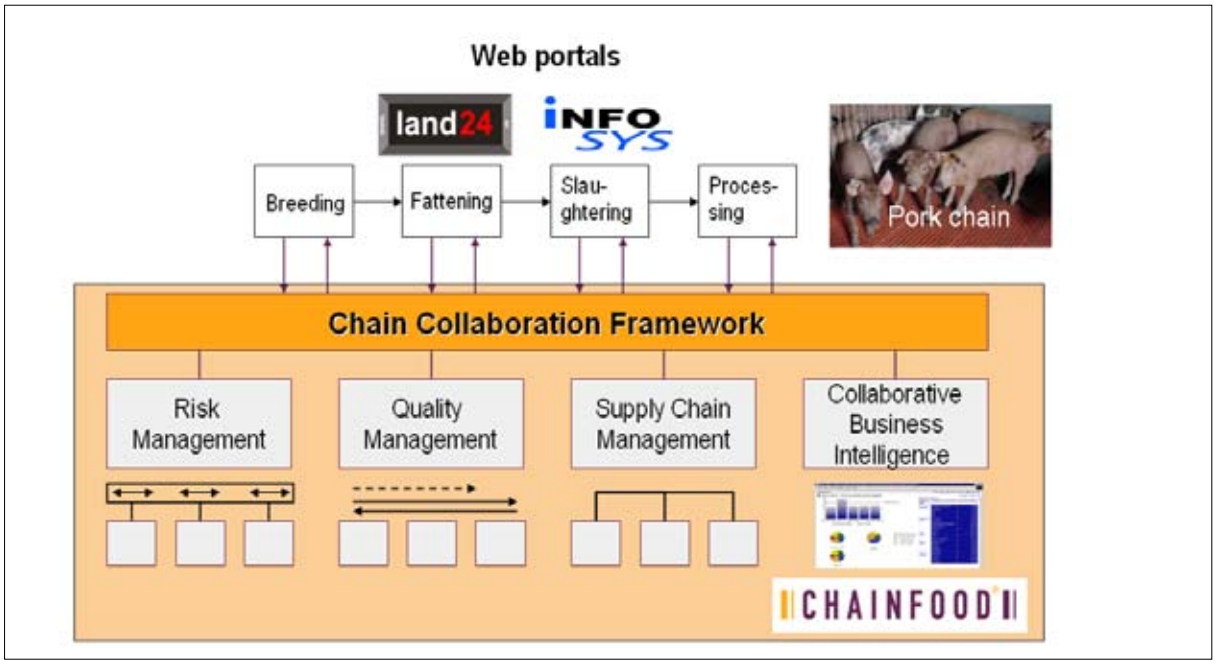

Figure 1: Integration approach of software solutions in pork chains

Beside the fulfilment of EC regulations, Chainfood works on possibilities on how to present slaughter and farm data for advisors and veterinarians in one analysis tool. As a result, an analysis cube is customised and presented at feed cooperatives advisors. The system delivers flexible analysis functionalities. The screenshot “Example of analysis cube based on data warehouse information with slaughter and farm data” shows an analysis based on test data.

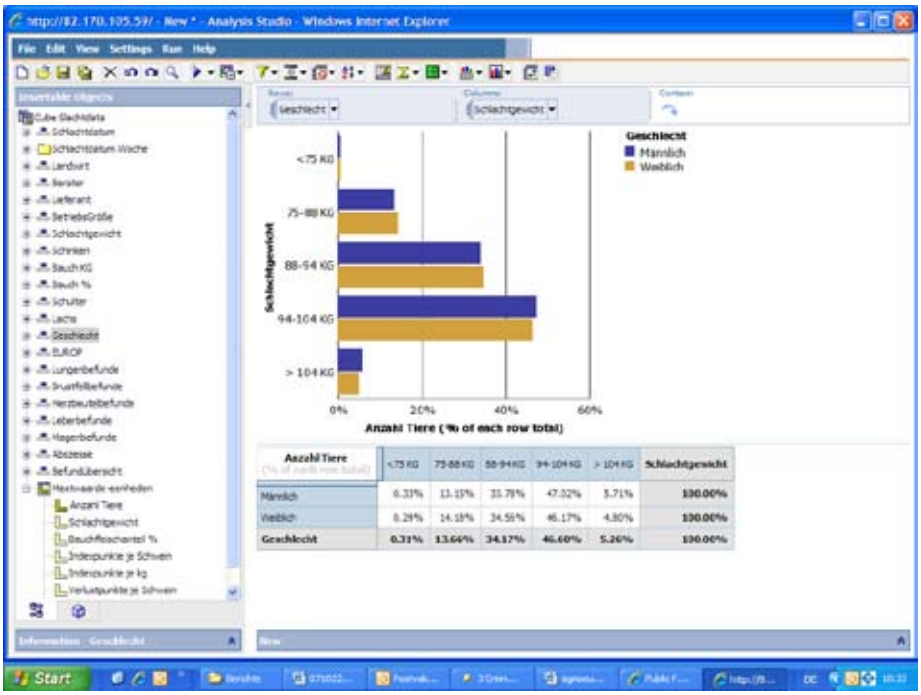

Figure 2: Example of analysis cube based on data warehouse system with slaughter and farm data

The validation of the different activities shows that there is a need for a netchain coordinator which manages the information management between the different systems. Questions like the definition of user rights but also financial aspects have to be managed.

3.2 Results of the user group

The review of the existing processes describes elements of each step of the process like recorded data, traceability and information media, technological equipment and user profile. The defined areas Agri’Oeuf worked on, are the reception of raw material and optimisation of order and production management.

Reception of raw material:

The review shows that data like date of delivery which is necessary for the supplier to fix his/her invoice and for the time being, cannot be directly forwarded via Infologic software and need to be recaptured. The objective would be to forward these data coming from Infologic software to the marketing management software which deals with purchase and sale.

Orders and production management:

Several development axes have been defined:

- The management of SSCC (Serial Shipping Container Code) ranges and parcels
- The optimisation of the traceability of bulk products
- The minimisation of orders’ preparation post
- The connection between the traceability system and the ink-jet printer in the grading machine
- The integration of traceability data from the supplier of trade products

These activities led to following further fields of improvements:

The implementation of an interface between Infologic traceability system and marketing management system will allow the transfer of data from the one to the other, and then the transmission of these traceability data to the Agri'Oeuf customers, via EDI. The validation phase shows further added value in the development of an interface between the marketing management software and the production management software. Actually, there is no link between the traceability/production management software and the marketing management software. The customer orders are either captured manually or directly put into the marketing management system. These customer orders are captured again in the traceability system, since there is no exchange between the two systems. Besides, the traceability elements are captured again manually into the marketing management system.

Main dissemination activities within Infex Meat

Beside the discussion and information exchange between the regional partners, the project results were presented during exhibitions, an excursion to the Netherlands and additional visits of different companies. The following table shows an overview of the main dissemination activities.

Table 1: Overview of main dissemination activities

Public activities	External participants
Promstap workshops	More than 100 Promstap partners in Genua and Vidin
Training of the employees in charge of collecting the traceability information at the end of the calibre machine	Employees of AgriOeuf packing stations in France
Validation of the information system	Partner companies of Agri'Oeuf in processing of alternative eggs (organic, farm-egg...)
Presentation of the project activities	Employees of slaughterhouses with a slaughter capacity of more than 50% of total capacity in Germany
Present cooperation possibilities to integrate further data pools by interfaces to optimise enterprises analyses especial for farmers in the cross boarder region Denmark and Germany.	Denmark: Dansk Landbrugs Grovvareselskab a.m.b.a., four feed cooperatives in Germany
Excursion to different companies from the Netherlands with the main aim to exchange knowledge and to inform about the project idea	Main feed cooperatives and software companies in Netherlands
Infex Meat brochure	-
Participation at the exhibition Eurotier	>1500 exhibitors and 111.000 visitors (26.000 international visitors)
Workshop in order to introduce the different solutions	Farmers, Advisor services from Germany
Workshop testing of project results	Farmers, Feed advisors from Germany

4. Conclusion

The analysis of requirements in the region NRW determined enterprise information needs of different actors in pork chains. Two different approaches were focused. On the one hand the actors in meat chains, under which pig producers, feed advisor services and slaughterhouses have demands on information to support their decision making, secure the traceability and improvement of their quality management. On the other side feed producers have additional demands for chain wide information management systems. Especially the fulfilment of demands issued from slaughterhouses, food processors and food trade organisations lead to reduction of consumer risks. The knowledge and information exchange between the partners identify enhanced development possibilities with added value for all participants of food chains. By integrating essential data from the farm process and the slaughtering

process, the partners in the chain will be able to comply with legal requirements and at the same time improve their quality and health management and reduce their risks. Further more the first results of the networking activities show adjusted usage of existing data sets in the pork chain for the actors pig fatteners, slaughterhouses and advisor services. The collaboration of independent organisations with similar solutions for meat chains facilitates the development of new approaches. Depending on detailed requirements of the industry, a further cooperation within the software companies could be established rapidly.

Feed producers in Germany are not able to assure many risks because they can not quantify the risk potential from deliveries of raw materials. Through the information and knowledge exchange of Chainfood and Land24 during new project solutions for the German market will be worked out. This cooperation is a result of the common activities within the Infex Meat project. Potential net chain coordinators are available. Within the Inspire and Innovate program a further cooperation was established in a new project. Through this project e.g. German feed producers can benefit from the experiences of Dutch feed companies regarding a better supplier assessment.

Agri'Oeuf activities are a good example of the positive aspects a better communication between existing software solutions delivers for innovative companies, like better data integration and the minimisation of double data capture. The further objective for Agri'Oeuf is to develop the system in such a way that the data exchanges (customer orders and traceability) between the marketing management software and the production management software can operate computer-assisted without any double data capture. In this field of interest, the information exchange with the German and Dutch partners had additional value for all partners.

The developments show also that there is a need for netchain coordinators which support all organisational aspects with respect to the cooperation and data exchange of chain actors. The demand for better integration of data is similar in all regions. One example besides Promstap is the AIDA project in Germany, where farm cooperatives in the pork sector work together in the fields of quality, health and risk management.

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Moving food chains towards a demand-driven world

Verdouw, C. N.

LEI Wageningen UR, Postbus 35; 6700 AA Wageningen; The Netherlands, E-mail: Cor.Verdouw@wur.nl

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Abstract

It is widely recognized that food companies more and more have to participate in agile chains that are driven by market intelligence information. However, especially for SMEs this is not easy to realize. The FOOD-Dynamo project has been conducted to support them in this challenge. The project has focused on promotion of the 'innovation, implementation and internationalisation' of demand-driven food chains by jointly elaborating best practices that enable SMEs to participate in agile, demand-driven food chains. Therefore, first generic best-practices about demand-driven food chains have been developed, resulting in generic chain control models. These models can be used as a frame of reference for chain redesign and implementation of demand-driven chain business systems. The models depict how processes are driven by market intelligence information in different arrangements of planning- versus order-driven control.

Next applications are made to case studies in two different food industries: pork and olive oil chains. In pork chains it was found that there is particularly a strong need for quality alignment between retail, slaughterhouses and farmers. Therefore, the focus has been on modeling and implementation of a new quality classification system, based on measurements of the processed parts in stead of measurements of the entire pig. This has resulted in better alignment of pig quality with demand requirements of end customers. Further, the improvement of the quality attribute 'stress tolerance' has been analyzed in order to minimize drip loss in pre-packed meat. In olive oil chains it was found that production orientation is a dominant approach for many companies. There emerged to be a strong need for more in-depth assessment of demand-orientation and high-level design of new chain/production systems that help olive companies to be more demand-driven and thus strengthen the competitiveness olive industry in the region. Therefore the focus of the olive oil case study has been twofold: detailed assessment of market orientation in existing olive oil chains and defining different variants for more demand-driven olive oil production.

1. Introduction

The business environment in food industries is changing rapidly. Important driving forces include: increasing consumer concerns about food safety and effects of bio-industrial production; fast changing food safety legislation; growing unpredictability of consumer demand, globalization and liberalization of markets; intensification of competition; fast advances in (information) technology; and ever-shorter product life cycles. Together, these developments result in increasing volatility and diversity of demand.

In order to sustain competitive advantage in this turbulent business environment, it is widely recognized that food companies have to participate more and more in demand driven chains that are able to deliver customized products and to adapt flexibly to changes in the market place. Participation in demand-driven chains requires agile business systems that sense and react dynamically to changes in the marketplace.

However, this is not easy to realize, especially for Small and Medium Enterprises (SMEs) in food chains. Traditionally, the primary focus of food SMEs is not on the market but on optimal production in order to assure safe food supply. Further responsiveness of food chains is hampered by long production lead

times among others because of seasonable production, short required delivery time due to product freshness, and lengthy processes to adapt products. Even the largest food companies with significant resources of money, technical expertise and management skills find it difficult to develop and implement the required advanced and integrated business systems for more agile supply chain management and customization. However many small companies have remained outside these developments and thus can not benefit from potential performance improvements.

The FOOD-Dynamo project was conducted to support food SMEs of different European regions in the challenge of moving towards more demand-driven chains. The name is an acronym of 'Food On Demand by Dynamic modeling' and reflects the mission for dynamic chains that are continuously tuning to the market, within the food-specific possibilities.

The overall objective of the FOOD-Dynamo subproject is to promote the 'innovation, implementation and internationalization' of demand-driven food chains by jointly elaborating best practices that enable SMEs to participate in agile, demand-driven food chains. This by transfer of knowledge on demand-driven food chains from research organizations to SMEs, and cross-industry learning between SMEs in the participating regions. To support optimal knowledge exchange, a reference model approach was chosen. Reference models represent best practice knowledge in practical designs, which can be used as vehicles to make knowledge of researchers, industry experts and implementation experiences accessible for SMEs.

All participating regions have a substantial part of their economy based on food production and food trade activities by SMEs. These companies are challenged to sustain meeting the fast-changing consumer and environmental requirements in a more and more international competition. The project contributes them in this challenge by stimulating demand orientation and enhancing the ability to adapt to changes in the food market place. It helps SMEs in the participating regions to achieve this challenge by increasing the ability to adapt business systems dynamically to the changing requirements.

This paper reports the results of the FOOD-Dynamo project. Therefore, first the overall project approach and used materials and method are described. Next sections highlight of most important project results. The paper ends with some concluding remarks and some suggestions for future activities.

2. Materials and methods

The research approach is primarily design-oriented. It starts with theoretical construction of generic best practices about demand-driven chains, followed by case studies in two different food industries: pork chains in North Rhine-Westphalia and olive oil chains in Liguria pork and olives. The unit of analysis in both case studies is the supply chain of cooperating companies, starting with the farmer. Both case studies follows the cycle of:

- Investigating sector- and region-specific characteristics and requirements, regarding to the subject of demand-driven chains with special attention to the issue of food quality and the role of SMEs;
- Designing new, demand-driven chain configurations for demand-driven pork and olive oil chains, by application of the generic model in accordance with the determined requirements;
- Validation of developed chain configurations by the participating SMEs.

Main involved project participants are:

- Development of generic best practices about demand-driven chains: LEI Wageningen UR and Wageningen University (The Netherlands), Politecnio di Milano (Italy);
- Application to pork chains in North Rhine-Westphalia: Erzeugergemeinschaft Rheinland w.V. (EGR, Germany), Chainfood and LEI Wageningen UR (The Netherlands);
- Application to olive oil chains in Liguria: Regione Liguria - Servizio alle Imprese Agricole and Politecnio di Milano (Italy), LEI Wageningen UR (The Netherlands).

The main activities of developing of generic best-practices were:

- Definition study of demand-driven chains: literature review of Supply Chain Management and marketing literature about demand-driven chains;
- Investigation of relevant existing reference models based on desk research;
- Design of a generic process model for demand-driven food chains: combining insights from literature and existing reference models into high-level control models for demand-driven chains.

The main activities in developing pork-specific best practices were:

- Investigating case-specific characteristics and requirements in workshops with the involved partners;
- Designing new, demand-driven chain configurations: combining developed generic practices and investigated characteristics/requirements in workshops with the involved partners;
- Reviewing and dissemination: validation in Proof of Principle implementation in a case study (1 slaughterhouse, 1 intermediate and 10 farmers) and dissemination in 3 workshops with 180 farmers in total.

The main activities in developing olive-specific best practices were:

- Investigating case-specific characteristics and requirements in workshops with the involved partners;
- Designing new, demand-driven chain configurations:
  - Assessment of the current situation by successively analyzing chain structure, the distribution channels and the market (interviews with industry experts, 104 questionnaires of consumers, survey of 1085 product records in different distribution channels);
  - Designing new chain configurations combining developed generic practices and investigated characteristics/requirements in workshops with the involved partners;
- Reviewing and dissemination: validation in a Delphi analysis with 30 industry experts (olive growers, olive pressers, associations, etc.) and 3 dissemination events with olive industry.

3. Results

The main results can be subdivided according to the project phasing into:

- Generic best-practices about demand-driven food chains;
- Pork-specific best-practices and dissemination;
- Olive-specific best-practices and dissemination.

Below a summarized overview of the project outcome is given. For more detailed information we refer to (Verdouw et al. 2006; Brun et al. 2007; Tatge and Ellebrecht 2007; Verdouw et al. 2007).

3.1 Generic best-practices about demand-driven food chains

The development of generic best-practices about demand-driven food chains was threefold:

- Definition of demand-driven chains from literature;
- Investigation of relevant existing reference models;
- Design of a generic process model for demand-driven food chains.

What are demand-driven chains?

Since the 1980s, Supply Chain Management has emerged from the concepts of logistics management. The focus was shifted from individual firms to chains of organisations that together supply products to consumers. Supply Chain Management initially was focussing on improving efficiency by streamlining material flows, reducing waste and minimizing inventories. However, as (Vollmann et al. 2000) argued, the 'chain focus should start with the customer and work backwards, instead of starting with supplier/manufacturer and working forward'. The term demand-driven chain was introduced in order to stress the fundamental difference between supply-push oriented chains and chains that are focused on the

market by responsive and customized fulfilment of consumer demand. In this project we defined such demand-driven chains as (adapted from (Vollmann et al. 2000; Cecere et al. 2004; Qiao and Wilding 2005):

> A **Demand-driven Chain** is a supply chain of cooperating companies that senses and reacts to real-time demand information of the ultimate consumer and meets those varied and variable demands in a timely and cost-effective manner.

Main challenge of creating demand-driven chains is to realize rapid and customized response to customer demand. This requires a combination of efficiency to fulfil demand with minimal use of time and money, and flexibility to deal with the ever-changing amount and variety of the demand. In order to find a balance between efficiency and flexibility, the positioning of Customer Order Decoupling Points (CODPs) plays a central role (Naylor et al. 1999). The CODP separates that part of the supply chain geared towards directly satisfying customers' orders from that part of the supply chain based on planning (Hoekstra and Romme 1992). Upstream the focus can be on efficient production of standardized products, while downstream the focus is on flexible strategies to deliver customized products. In figure 1 the CODP concept is visualized.

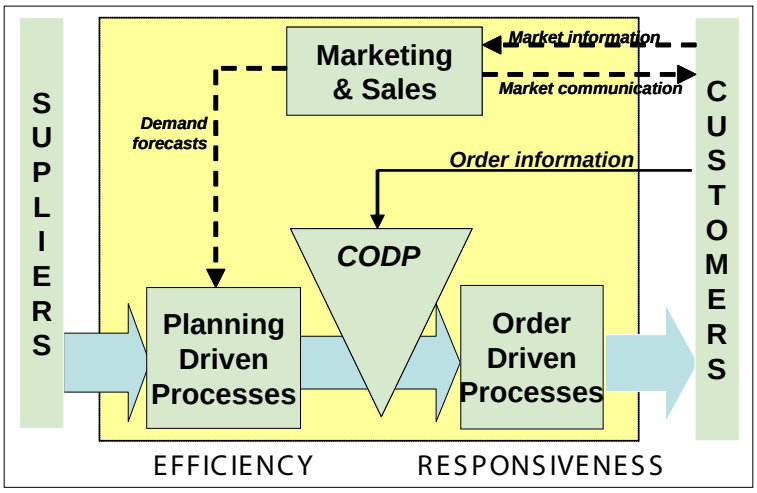

Figure 1: The Customer Order Decoupling Point (CODP)

In this figure all business processes are based on demand information. The planning-driven processes are based on forecasts that are derived from market information about consumer preferences, trends in buying behaviour and more general underlying factors. The order-driven processes are driven by the actual demand, i.e. specific customer orders. If we apply this figure to chains of cooperating firms, there is a CODP for each collaboration interface in the chain network (Trienekens 1999), starting with the consumer order and working backward to business-to-business orders. There are many possible positions of these CODPs. Consequently, there are many possible configurations for demand-driven chains.

Existing reference models

In this research a reference model approach is chosen to deal with the problems of food SMEs in realizing demand-driven chains. Reference models are generic and reusable models that generalize recommended practices of a certain domain (Fettke and Loos 2003). They are used as a frame of reference for business process redesign and implementation of demand-driven business systems. Reference models can improve the quality, lead time and costs significantly. Furthermore, while reference models represent best practice knowledge in practical models, they can be used as vehicles to make knowledge of researchers, consultants and others, accessible for companies.

In the investigation many existing reference models were found. Some well-known existing enterprise models are CIMOSA (Kosanke 1995), GERAM (Bernus and Nemes 1996), ERP reference models of among others SAP (Curran and Ladd 1999) and Baan Company, nowadays Infor (Jendry 2000), ISA-95

(ISA 2006). Some well-known existing inter-enterprise models are VERA (Tølle and Bernus 2003), CPFR (VICS 2004) and SCOR (SCC 2006).

For this project, the Supply Chain Operations Reference-model (SCOR) was evaluated to fit best. It provides a high-level model repository that is appropriate to depict demand-driven chain networks, and it is broadly accepted. SCOR has been developed and endorsed by the Supply-Chain Council (SCC) as the cross-industry standard for supply-chain management (SCC 2006). At the moment over 1000 companies are member of SCC and the model is international broadly acknowledged. The SCOR-model focuses on the processes plan, source, make, deliver and return. It provides process models on three aggregation levels, standard process descriptions, performance metrics (in the categories Delivery Reliability, Responsiveness, Flexibility, Costs and Asset Management Efficiency), and descriptions of redesign strategies. SCOR depicts basic chain process variants with different CODP positions.

Design of a generic process model for demand-driven food chains

Based on a combination of insights from literature and existing reference models, a generic reference model for food chains is developed. This model concentrates at high-level chain control models for multiple demand-driven configuration. These control models visualizes the core business processes of the different chain actors, the position of multiple CODPs and the exchange of market information of food chain configurations. In figure 2 one example of such control model for a demand-driven food chain is visualized.

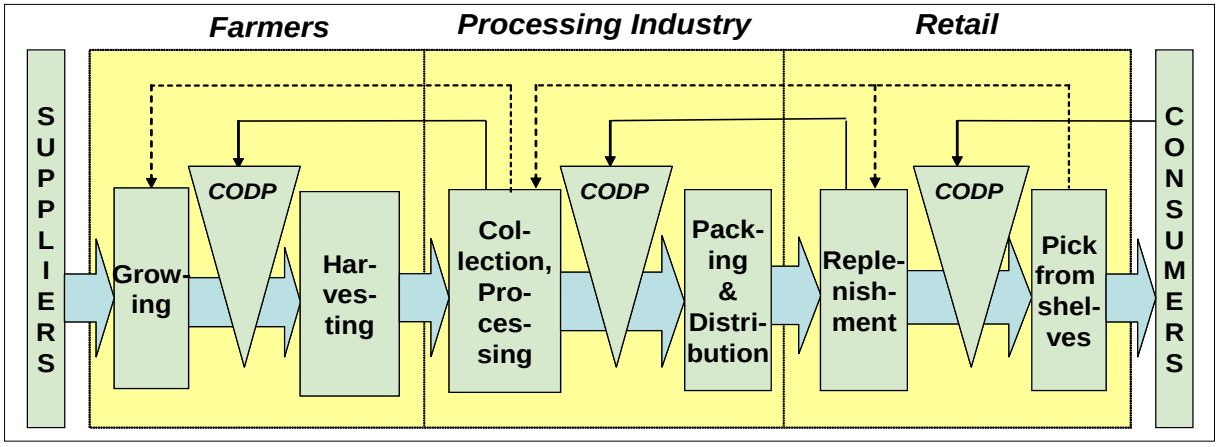

Figure 2: Example of a demand-driven food chain configuration

In this example a retailer sells food products to consumers in a supermarket. If the shop inventory is below the ordering level, the retailer sends a replenishment order to the processing industry. This factory fulfils the replenishment order by packing the already produced food products and distributing it directly to the retailer. The processing industry produces the food products on stock based on forecasts that are derived from sales information of the retailer. Based on his production planning, the processor demands the farmers to harvest the required crop and make it available for collection. The farmers set up there nurseries based on the long-term planning of the processing industry.

3.2 Pork-specific best practices and dissemination

According to the project phasing as described earlier, the pork-specific results can be subdivided into:

- Investigating case-specific characteristics and requirements;
- Designing new, demand-driven chain configurations;
- Reviewing and dissemination.

Pork-specific characteristics and requirements

The pork-specific requirements are discussed in workshops with the involved partners in North Rhine-Westphalia and Gelderland (EGR, Chainfood and LEI Wageningen UR). Main investigated characteristics include:

- Meat belongs to the basic assortment of retailers. Therefore availability is a key issue, while especially in the German market there is a strong emphasis on low prices and high quality.
- Divergent processes: pigs are processed into a broad range of consumer products. The flows of these products are highly interdependent. For example: if demand for pork ham increases, also the other parts of the pig must be processed and sold.
- Meat is a fresh product, due to decay shelf life is limited.
- In Germany there are quiet a lot different slaughterhouses with specific quality requirements.
- Utilization of slaughterhouse capacity is an important issue.
- There are many relatively small farmers.

Based on this investigation, it was found that in pork chains there is particularly a strong need for quality alignment between retail, slaughterhouses and farmers. Thus the pork case study has focused on two of these issues:

- Implementation of the AutoFOM classification system: implies payments on basis of quality measurements of the different parts of the pig in stead of measurements of the entire pig. This enables more sophisticated alignment of pig quality with demand requirements.
- Improvement of the quality attribute 'stress tolerance' in order to minimize drip loss in pre-packed meat, and thus to deliver products that better meet the needs of discounters.

Designing new, demand-driven chain configurations

In workshops with the involved partners, the processes in pork chains were analyzed. Pork chains involve the whole of processes from 'farmer's stable to consumer's table'. Main stages are breeding, multiplying, finishing, transportation from farmers to slaughterhouses, lairage, slaughtering, processing meat into consumer products (e.g. ham, sausage, and minced meat), transportation to wholesale/retail, replenishment and selling to consumers.

Next the developed generic best-practices have been discussed and applied to two defined focal issues: improvement of the quality attribute 'stress tolerance' and implementation of AutoFOM. The chain control model of last mentioned variant is visualized in figure below.

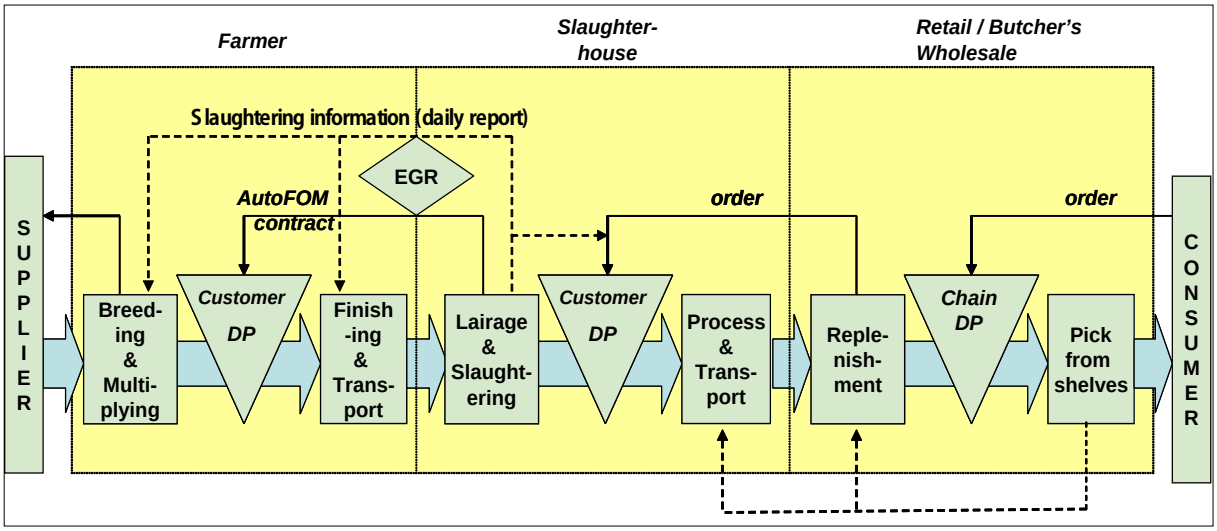

Figure 3: Alignment of demanded and supplied quality based on AutoFOM: example of a demand-driven pork chain configuration

In this example the quality requirements of slaughterhouse customers (i.e. retailers, butcheries, wholesalers) are matched with the quality of the supplied pigs. This is done based on AutoFOM, which is a fully automatic carcass classification system based on ultrasound technology. Furthermore, AutoFOM is a new pricing system in which payments are based on quality measurements of the different parts of the pig (i.e. loin, leg, shoulder, belly) in stead of measurements of the entire pig. The new agreements are made between the slaughterhouse and the farmers via an intermediate (EGR). The quality measurements are done at the slaughterhouse and communicated via EGR with the farmers. They use this information to optimize their business processes. The slaughterhouse uses the measurement information to allocate the specific lots of pigs to different types of customers (each having different quality requirements).

Reviewing and dissemination

Last the developed chain configurations for AutoFOM and stress tolerance were validated by doing a Proof of Principle implementation at EGR, in cooperation with one of their customers: slaughterhouse Manten. For the implementation of AutoFOM, the existing EGR Backbone software system is extended (by Chainfood), an XML-based interface with the slaughterhouse is set up and a daily report for the farmers is made. The system was first tested with 10 farmers and than discussed in three workshops with approximately 180 farmers in total. For the implementation of 'stress tolerance' improvement, ten farmers with stress solid pigs were selected through a survey. To exam the quality of the meat, the drip loss of this pigs should have been measured after 48 to 72 hours post mortem. However, it turned out that it was not possible to differentiate between standard and stress tolerant pigs during the slaughtering and storing processes.

3.3 Olive-specific best practices and dissemination

According to the project phasing as described earlier, the olive-specific results can be subdivided into:

- Investigating case-specific characteristics and requirements;
- Designing new, demand-driven chain configurations;
- Reviewing and dissemination.

Investigating case-specific characteristics and requirements

The olive-specific requirements are discussed in workshops with the involved partners in Italy and Gelderland (Regione Liguria, Politecnio di Milano and LEI Wageningen UR). Main investigated characteristics include:

- Olive yields are fluctuating very much by nature of olive tree production. After every good production year, there is a decline in yields.
- The production circumstances in the Liguria region are very difficult because of the steep mountains ($25^0/30^0$). Therefore, modern production mechanization cannot be applied.
- Olive oil chains are often short: many farmers are also processing and selling their products to the market, although there are differences within the region.
- Production is highly fragmented. There are many small olive farmers, partly organized in co-operatives.
- Low volume flexibility due to long production lead time (yearly seasons).
- Olive oil of the Liguria region is marketed as a high quality product.
- Production orientation is a dominant approach for many companies.

Based on this investigation, it was found that there is a strong need for more in-depth assessment of demand-orientation and high-level design of new chain/production systems that help olive companies to be more demand-driven and thus strengthen the competitiveness olive industry in the region. Therefore the focus of the olive case study has been twofold: detailed assessment of market orientation in existing olive oil chains and defining different variants for more demand-driven olive oil production.

Designing new, demand-driven chain configurations

The assessment of the current situation was focused on successively analyzing the chain structure, the distribution channels and the market. Olive oil chains involve the whole of processes from 'farmer's oliveyard to consumer's culinary art'. Main stages are growing, harvesting, collection from farmers, processing into oil, packing, distribution to wholesale/retail, replenishment and selling to consumers. Most important steps of processing olives into oil are: breaking down the olives in pieces, mixing, and separating oil, water and pomace.The distributions channels for olive oils are diverse. Distinction is made between physical channels (wine shops, gastronomies, supermarkets, mini markets and discount stores) and online channels.

In the market analysis it was found that the prices are characterized by a great variance due to the type of shop providing oil, in particular the price for oil in a wine shop and a gastronomy is respectively over two and three time the price of an oil sold in a supermarket. It was found that DOP certification is able to create premium price for olive oil in physical channels. However, in on-line channels this certification does not result in higher prices. Further, it was found that the price of organic oil is very close to non-organic oil. However, organic oil is sold more in on-line channels. The average price in online channels is about 60% higher than in physical channels. After having analyzed existing olive oil chains, in work-shops with the involved partners, the developed generic best-practices were discussed and different variants for more demand-driven olive oil production were developed, including:

- Establishing an association that is able to manage the whole chain. Farmers can decide which part of they want to outsource to this association, dependent among others on size and strategy. This can vary from farmers that rent their land to the association and outsource all processes, to farmers that only outsource distribution and marketing.
- Direct sales to consumers via a web shop managed by an cooperative of farmers.
- Category and shop inventory management by a cooperative of farmers for specialty shops.

The control model of last mentioned variant is visualized in figure below.

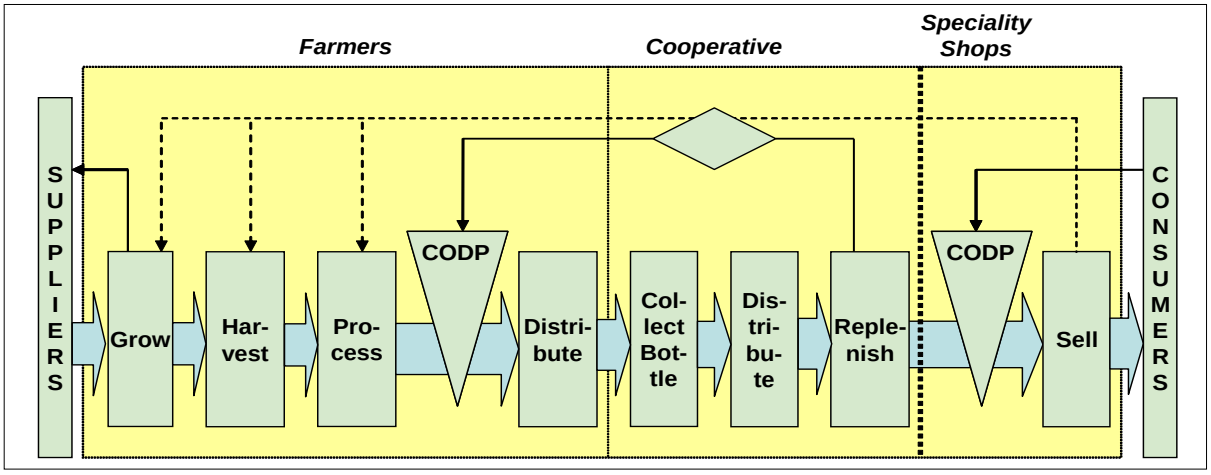

Figure 4: Category management by a cooperative of farmers for specialty shops: illustrative configuration of a demand-driven olive oil chain

In this example, a cooperative of farmers completely manages the inventory of olive oils in speciality shops. It has taken over the replenishment in the shops and has the lead in determining the assortment of oils. Further, the cooperative collects the oil from the farmers, checks the quality, bottles it and distribute it to the speciality shops. The farmers use sales information of the shops to decide on growing olives, harvesting and processing them into oil.

Reviewing and dissemination

The project results are reviewed in a Delphi analysis, in which the assessment results and the developed chain configuration were confirmed. Furthermore, the analysis resulted in three causal maps: an overall

map about causes and effects of not being demand-driven, and two maps zooming in on DOP certification (effects on consumers, and on olive supply chains). The overall causal map can be summarized by a SWOT analysis of the sector:

Strengths	**Weaknesses**
- Excellent potential quality for the product - Regional touristic attitude can help the local store in the selling - In the territory exists sales channels for typical foods - In the Ligurian region there are cases of firms producing oil with consistent mark-up - It can be possible to redefine the methodologies to distribute the regional economic incentives to improve the territory competitiveness	- Focus primary on local market - Insufficient access to the most profitable distribution channels - Small firms (often sideline activity) implying: • a lack of economies of scale • variable and small volumes • scarce attitude toward the most evolved production techniques - poor adoption of the modern parameters to achieve a top quality for the product - olive grove abandonment
Opportunities	**Threats**
- The market is willing to pay more for product characterized by traditional processing, healthy effects and organic products - The market is willing to pay a premium price for a Ligurian product - The E-commerce can expand the market to global level - Potential market greater than the production	- A poor revenue disincentives the new generations of producers to enter in the market - The competition (oil from another regions) can quickly becomes the leader in the high value market segment

4. Conclusions and future challenges

In this paper the results of the FOOD-Dynamo project are summarized. The project has focused on promotion of the 'innovation, implementation and internationalisation' of demand-driven food chains by jointly elaborating best practices that enable SMEs to participate in agile, demand-driven food chains.

Therefore, first generic best-practices about demand-driven food chains have been developed, resulting in generic chain control models. These can be used as a frame of reference for chain redesign and implementation of demand-driven chain business systems. The models depict how processes are driven by market intelligence information in different arrangements of planning- versus order-driven control.

Next applications are made to case studies in two different food industries: pork and olive oil chains.

In the pork case study it was found that there is particularly a strong need for quality alignment between retail, slaughterhouses and farmers. Therefore, the focus has been on modeling and implementation of a new quality classification system, based on measurements of the processed parts in stead of measurements of the entire pig. This has resulted in better alignment of pig quality with demand requirements of end customers. Further, the improvement of the quality attribute 'stress tolerance' has been analyzed in order to minimize drip loss in pre-packed meat, and thus to deliver products that better meet the needs of discounters. However, it turned out that in the case study it was not possible to differentiate between standard and stress tolerant pigs during the slaughtering and storing processes.

In the olive oil case study it was found that production orientation is a dominant approach for many companies. There emerged to be a strong need for more in-depth assessment of demand-orientation and high-level design of new chain/production systems that help olive companies to be more demand-driven and thus strengthen the competitiveness olive industry in the region. Therefore the focus of the

olive oil case study has been twofold: detailed assessment of market orientation in existing olive oil chains and defining different variants for more demand-driven olive oil production. Developed chain configurations include:

- Establishing an association that is able to manage the whole chain. Farmers can decide which part of they want to outsource to this association, dependent among others on size and strategy. This can vary from farmers that rent their land to the association and outsource all processes, to farmers that only outsource distribution and marketing.
- Direct sales to consumers via a web shop managed by an cooperative of farmers.
- Category and shop inventory management by a cooperative of farmers for specialty shops.

The project results are reviewed in a Delphi analysis, in which the assessment results and the developed chain configuration were confirmed. Furthermore, several dissemination events with olive industry have been organized.

Overall, the project has shown that production orientation is still a dominant approach for many SMEs in food industry. Consequently, the position of food SMEs is put under pressure. This impacts regional economy, while food SMEs are an important source of income and employment in the participating regions. FOOD-Dynamo has helped food SMEs in the participating regions to start moving ahead from production-push towards flexible demand-driven chains. This in the first place by creating awareness of the importance of demand orientation. Next valuable insight is gained in best practices of how to implement demand-driven food chains. Therefore, reference models has shown to be valuable, both in developing best practices about demand-driven food chains and as a vehicle of knowledge transfer.

It can be concluded that the project has contributed considerably to the 'innovation, implementation and internationalization' of demand-driven food chains. However, moving towards market-driven chains a fundamental transition. The FOOD-Dynamo project has been a good start which demands for follow-up. Important future challenges include:

- Further exploration of demand-driven chain configurations in pork and olive industry;
- Elaboration the developed high-level reference model into more detailed process, control and information models;
- Further validation of the developed best-practice chain designs in Proof of Principle implementations;
- Extending the project scope to other food sectors and other European regions.

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The Exploitation of Traditional Quality Products: rural environment, local marketing, food safety

Lercari G.[1] , Gardere E.[2], Borgogno S.[1]

[1] Regional Institute for Floricolture, Via Carducci 12, 18038 Sanremo (IM), Italy, E-mail: irf@regflor.it

[2] PEACRITT, European Pole in Agrofood for Communication, Research, Innovation, and Transfer of Technology, 100, Route de Paris, 69260 Charbonnières-les-bains, France, E-mail: gardere@peacritt.fr

Abstract

EXTRAPRO partners have developed and specified the following project objectives:

- to define an exploitation strategy dedicated to traditional products, dealing with the local integrated development of rural areas;
- to identify some new proposal to face the traditional products in connection with the food safety question, with particular reference to the Hygiene Pack laws application;
- to create a training module specifically addressed to agents in charge of local economic development.

The aforesaid goals have been attained thanks to the realisation of some activities, including: the study visits in Liguria and Rhône-Alpes, the surveys upon a representative sample of traditional enterprises, the bibliographic research, the various workshops and meetings organized to face each other about the differences and possible confluence among partners' requirements.

At the end of this work, it has been possible to achieve the following results, according to the starting goals:

- a proposal for the exploitation of local traditional products, suited to their distinguishing features;
- the example of a derogation request for traditional food processing, expressly created for single enterprises but easily modifying into a derogation concerning a specific food production process (for example a special dairy process shared by some enterprises locally operating);
- a training module explaining to local development agents the different tools to characterize and exploit the traditional products. This module should contain also some indications to help little local enterprises to conform to the Hygiene Pack law application.

1. Introduction

The actual EU Regulation doesn't provide the necessary legislation tools for a suitable exploitation of traditional products. The Regulation n. 509/2006, on agricultural products and foodstuffs as Traditional Specialities Guaranteed (TSG) deals with traditional products, rural economy and the necessity of retaining the rural population in less – favoured or remote areas (whereas, n. 2). However, the registration of agricultural products or foodstuffs is not permitted when "the specific character is due to its provenance or geographic origin" (Article n. 4, point n. 1). For this reason, the regulation is not a suitable tool in order to exploit all those traditional agricultural products and foodstuffs, that we all know are frequently and deeply linked to a well defined geographical area.

Such a regulation should be necessary also because many of the products we know as traditional don't reach a market value high enough to justify the registration procedure necessary to obtain the geographic protection mark (PDO). This distinction implies the necessity to clearly separate the geographic origin protection marks from other similar exploitation models. But this doesn't change the essential point of the question: how can we help all those little and very precious traditional products (it means also rural economy and cultural heritage) to survive?

We need a new legislation tool, or a derogation to the existing regulations, aimed at avoiding the disappearing of traditional agricultural products and foodstuffs closely linked to a well defined geographic area.

The analysis, we did, ran on two key words: definition of traditional products and safety criteria. The link between a product and its geographic area is not the only requirement needed to characterize it as traditional. Other elements have to be fulfilled to complete the definition of traditional products. These characteristics should be able to identify a product as traditional one, without considering of the production process or the product itself. To reach this goal we can draw on existing definitions or characterization attempts, trying to improve or complete these definitions in order to give an answer to the partners' needs and the project goals.

The other very important question deals with the food safety criteria introduced by the "Hygiene Pack", a collection of about ten regulations that has been definitely introduced since January the 1st 2006. Traditional products have usually great difficulties to conform to hygiene procedures and authorizations. This represents a very important issue whose complexity Partners are well aware. With the new rules, the responsibility for food safety deals with the food business operators. They are responsible and they must manage the activities of prevention and control of hygiene procedures. Food safety criteria must be assured throughout the food chain, and extended to the primary production.

By the other side, HP laws states that food safety criteria should be flexible enough to apply to all situations, including small enterprises, operating locally and/or in peculiar geographical constraints. The regulations permit specific derogations in the following cases:

- of direct supply from producers to final consumers;
- every time it's possible to demonstrate the existence of traditional food and products or processes. Derogations may concern sanitary authorizations about production places and the use of traditional instruments and equipment.

It's possible to recognise in this new food safety system the attempt to be gradual and soft introduction of the regulations, even though it must be said that the application of this set of rules in each Member State appears at present to be quite chaotic. Considering both the importance to promote traditional products for the economy of rural areas and the risk that the HP can be for traditional products, all subproject activity propose a general view of actual HP application in the partners Region and give some recommendation to the Public Control Services (exploitation model and food safety recommendations). The dissemination of the exploitation model and food safety recommendations should be proposed through a short training module, to reach the enterprises and *other target (reference) stakeholders* of the subproject.

2. Materials and methods

The first step of the work was to find a clear and shared definition of traditional products and their production processes.

This aim has been pursued with different tools:

- study visits in the partner Regions;
- enterprises' survey;
- bibliographic research on traditional foodstuffs products;
- comparable analysis among different definition and characterisation of traditional products.

2.1 Study visits

The study visits showed the main traditional productions in the different Region. Each of them give the opportunity to have a direct contact with enterprises, who has been asked to talk about their experien-

ces and answer to questions. An important aspect of the visit was about the tasting of products and the practical demonstration of manufacturing process. During the visits has been possible to see and to compare different geographical situations, specific premises and equipments, the enterprise organization.

2.2 Survey in Liguria: methodology

One of the most important elements in the definition process of the characteristic of traditional products was to know and to understand the producer's opinion. So it has been prepared a questionnaire and it has been selected a small sample of enterprises to be interviewed. The questions asked in the survey have been mainly addressed to farmers. Nonetheless they were submitted to local sector operators and citizens having experiences with typical and traditional products. The questionnaire was specifically aimed at collecting information and technical data about farms and productions.

The more difficult task was to understand as precisely as possible the interviewees' perception of the word 'traditional' and the way this word is related to local farms productions. This approach was necessary because, before the beginning of the survey, it was realised that was very difficult to find a word in the local dialects which would correspond to the meaning of the word 'traditional'. Could this be due to the fact that the dialect is 'traditional' itself having its roots in past centuries and generations and has therefore no need to define what 'traditional' is? To put it in other terms, are the words 'tradition' and 'traditional' a modern need? This and other aspects were taken into consideration when the questionnaire was drawing.

2.3 The sample

In order to select a representative sample of farmers, experts and operators we considered the following elements:

- the knowledge and experience level about traditional products and processes;
- the different geographical areas of each department interested by the survey;
- the various holdings dimensions;
- the various and most important traditional products and processes existing in each Region.

In Liguria Region the farms working in the field of fresh fruits and vegetables cultivation are over 2500, but most of them have lost the ancient knowledge deeply tied to tradition. The kind of information we are looking for is more easily achievable talking with very little and familiar holdings, whose primary goals are not the economic interest. Obviously we don't have to forget the importance to help traditional farms introducing new technologies and improving their production process or economic management. But most of all, as regard to this survey, we needed an answer to a precise question: characterize the traditional farms and production processes, but our aim was to collect answer about what characterize the traditional products and production processes.

So we selected our sample looking for in little rural villages, talking with little farms, local experts and simple inhabitants or old farmers. By the other side, to have a global picture of opinions about traditional, we have also asked to the local cooperatives, starting from those which are very little ones and more tied to tradition, until the greatest ones. We have finally selected 20 farms and some more operator/ local expert. A brief synthesis of results will be furnished in the next chapters.

2.4 Survey in Rhône-Alpes: methodology

We have surveyed 20 enterprises situated in the 8 Départements of Rhône-Alpes, through semi-directive face-to-face interviews, in their premises. They are enterprises from different food sectors, such as: sausages, processed fruit-products, dairy products, bread and pastries, alcoholic beverage. We chose to interview enterprises whose communication and marketing rely on the image and tradition. In other

words, the sample is composed of enterprises whose products are sold with a packaging that reminds of tradition and its ethics. Most of the time, we interviewed the general manager of the enterprise or the marketing manager.

The interviewer could rely on a guideline. In each interview, questions were asked regarding

- the definition of traditional food according to the interviewers
- the way the enterprise valorizes its products
- the way the traditional products behave on the markets (local, national and/or international)
- the way the enterprises integrated the new EU regulations (Hygiene Pack)

The interviews have been reported and written. They have been analyzed and synthesized, and displayed to 18 enterprises on the occasion of a training session in July 2007.

With the **bibliographic research** we have tried to collect a great number of publications dealing with tradition and traditional agricultural products. The most interesting indications have come from the different characterisation attempt that have been at present carried out, especially in France and Italy. These indications have been compared with the experience and observations collected during the study visits, to outline an our own characterisation of traditional products.

3. Discussion

3.1 The state of art

3.1.1 Identification of existing valorization strategies

a. A partnership between farmers, a museum and a municipality (Rhône-Alpes)

We organized a 3-days study visit in Haute-Savoie for the Bulgarian and Italian partners, including an important meeting with public sanitary authority (regional DGAL). The visit of the cooperative dairy was particularly interesting because the cooperative relies on a quite innovative partnership between different kinds of stakeholders. This cooperative was created by a group of farmers who wanted to be competitive in front of the setting up of big dairy industries in Haute-Savoie. The farmers own the place. They bring their milk in the cooperative and the employees make cheese out of it. They produce 3 different kinds of cheese that they sell directly in the cooperative or in small markets in the area.

Study visits' agenda

Visit of Paysalp – Ecomuseum
Projection of a movie and speech on traditional products

Visit of "Gourmands d'Ayze"
Vineyard cultivation and wine tasting

Visit of a cooperative dairy
Projection, discussion and cheese tasting

Visit of Pinaud enterprise
Traditional sausages process

Visit of a small goat's cheese mountain farm
The holding, the breeding, the cheese

Visit of a milk workshop in ENILV
A school for future agrofood process technicians

The farmers are partners with the Ecomusuem whose name is *Paysalp. Paysalp* is an NGO managed by volunteered people and financially supported by the surrounding municipalities. Professional lecturing guide works for the organization. The aim is to valorize the economic and cultural identity of the region, including food identity. For example, a permanent exhibition shows the story of food in this area: how and what people use to eat, cook and grow, what are the know-how and the process developed in the territory. Among their actions, together with the cooperative's farmers, Paysalp organizes guided visits of the cooperative and the lecturing guides have implemented a didactic path in the factory specially targeted at children. In exchange of the visits (that bring visitors and potential buyers) the Ecomuseum receive 10% of the sale of the cooperative products.

The cooperative is partner also with the surrounding municipality, whose important activity is tourism related to skiing. Indeed, the cooperative's farmers still bring their flock to the high mountain pastures. Thanks to the preservation of this traditional know-how, the ski runs are easily prepared: as a matter of facts, the flocks browse on the herbs, which makes the preparation of the ski runs far easier. Therefore,

the preservation of this traditional know-how (pasturing) helps the municipality to maintain an environment favourable to skiing activities. In counterpart, the municipality gives the cooperative's farmers a percentage of the profits gained thanks to the ski-lift pass. As a conclusion, we can say that the cooperative, thanks to a relevant win-win partnership, has succeeded in maintaining traditional know-how, granted, but also economic activities in the region that allow the farmers to earn a living without denaturing their job.

b. The study visit in Liguria

During the last twenty five years, in Liguria we don't have developed a lot of exploitation models to show as good examples. The highest exploitation models we can show concern the wines, the extra virgin olive oil, and the basil PDOs. Other little and local experiences tied with traditional products could be mentioned, but it is very hard to find experiences that are based upon local integration systems (agriculture and tourism, restaurants and little trade channels).

In order to identify the traditional products to deal with in the project, the Ligurian main cooperatives were contacted along with some single enterprises which set an example as far as traditional ways of production and are representative of the sector. A first proposal, which came out as a result of this information exchange, focused its attention on some Horticulture species, the only regularly present on the local market and from time to time on extra regional markets, too;

In the study visit we have tried to select some of the best existing exploitation models, especially near Sanremo and Imperia countryside. The main attempt was to show the real situation of our traditional agricultural products, to make French and Bulgarian partners understand our territories and their problems, but also their opportunities. We thought that the best way to reach our goal was to meet the enterprises and talk with them, tasting the products and discussing about problems. A very simple organization model, but also very direct and clear.

In this attempt, we have selected three exploitation experiences dealing with as many traditional products. In particular we have chosen two very important vegetable cultivars: **Vessalico garlic** and **Pigna white bean.**

Study visit in Western Liguria

3-days study visit in Liguria Region for the Bulgarian and French partners, including a meeting with the participation of Genoa University.

The program of visits and experience exchange included:

Visit to the wine producer Lorenzo Ramò's Farm and Cellar.

State of the art and problems in traditional vinification;

Visit to the cooperative "A Resta"

Harvesting and manufacturing of traditional Vessalico garlic;

Visit to the wine producer Cane Giobatta's Cellar.

Traditional vinification in east Liguria;

Visit to Holiday mountain farm "Il Rifugio"

A traditional cheese factory: analysis and discussion about traditional cheese production in mountain farms;

Protection Body of the Pigna White Bean

visit to a traditional "white" bean cultivation and discussion about market strategies.

Vessalico is a tiny village in western Liguria, where can be found a very ancient garlic cultivar. The cultivation dates back to XVIII° Century and this tradition is connected to the annual Fiera dell'aglio (garlic Fair). Another very important aspect is the traditional art of the reste, bundles of interwoven garlic, practiced by local farmers. Cultivation is entirely manual and the final product is intensely flavored, with a slight spiciness and a delicate aroma.

In the hinterland of the Imperia department, the village of Pigna is famous not only for its landscape and works of art, but also for a traditional product: a white bean cultivar.

The Pigna white bean is smooth, candid white with an intense, characteristic flavour. They can be found both in domestic households and the most exclusive restaurants of the extreme west of Liguria. In the last decade this product was object of a serious exploitation activity, with a participative model that should be example for other traditionsl specialities and territories.

Another traditional enterprise we chose is a little dairy farm, that is trying to survive between the great love for tradition and the attempt to respect the sanitary rules. Cheese production is not a very representative product of Imperia territory, but the problems posed by this enterprise are very important and representative for the project.

Last but not least, we chose to visit two different cases of traditional viticolture farm with a little familiar cellar.

3.1.2 To identify how the different stakeholders define traditional products

a. tradition seen by the enterprises in Rhône-Alpes

According to the enterprises, tradition implies **anteriority** and a **historical anchorage**. They mentioned anteriority with regards to:

- **the know-how**
  - **in the process** *('we don't even communicate of the fact that we do the moulding with the hands, but all our customers know it. We work in the old traditional way')*
  - or **in the production of the raw materials** *('the producers do as it was before to get new varieties [...] The maintenance of the plantations is done with the pick-axe, like beforehand.')*
- **the recipe** *('we are an industrial enterprise but we have a recipe that respects what have been done for a century')*
- **a population and the consumption of the product** *('it is a traditional Lyon foodstuff. It is eaten by Lyon inhabitants from very very long on')*
- **a population and the making of the product** *('each family has its own plantation next to one's house. It was cultural')*

Some of the interviewees also mention the origin of the raw materials *('for the nuts bread we have DOP nuts. This is a traditional ingredient')* that can give a traditional dimension to the product.

We can underline that according to the enterprises, tradition is linked to **a local community**, since they refer to a population's production and consumption. Now, we will see that the enterprises' definition meets somehow the ethnological definition of traditional products (see c.)

b. Tradition seen by the farmers and cooperatives in Liguria

The results of the survey in Liguria Region have shown that "tradition" is still important (100% of interviewees) and is mostly perceived as a strong link with past generations (50% of answers). A large part of the enterprises interviewed (more than 50%) don't know a local word (or a phrase) that can define or substitute the term "tradition" or "traditional". There is a large agreement (over 90%) about the existence and the individuation of products and events linked to tradition, even if someone points out that all these events are quickly disappearing.

As it regards the second part of the survey, especially dedicated to enterprises (often very little ones, mostly producing just for a familiar consumption) we have found a good knowledge about traditional products (over 77% of interviewees). Most of these products are still cultivated and, when we asked "*what characteristics make your production `traditional´",* the most frequent answer is the products strong link with the territory (31,8%), followed by the "historical anchorage", by the taste value and the absence from great distribution trade chain. We have asked the difference between traditional homemade cultivars and the nursery material (seeds and seedlings) coming from ordinary trade channels. The most frequent answer (over 40%) is related to the scarce reliability of traditional products. By the other side, the interviewees think that the most important advantages of traditional products lie in their organoleptic (over 36%), genetic and cultural value (over 45%).

Most of enterprises (over 63%) don't believe that the average costumer knows enough and/or well the traditional products qualities. Nonetheless they admit the costumers' good disposition to buy this kind of products. The enterprises (81,8%) think that Public Institutions should have a strong role in the exploitation of traditional products. They should also be well-intentioned (over 86%) to take part in exploitation projects.

c. The social sciences' point of view[1]

Local food products cover a high diversity. They regard all the food sectors, from vegetal to animal to processed products, such as delicatessen, cheeses, pastries, oil and fermented drinks. How thinking such a diversity? Here is the ethnological and sociological answer.

The word *tradition* comes from the Latin verb *tradere* that means to *pass* on.

Therefore, according to the etymology, tradition is **dynamic**: it is not something ossified. To go deeper into the reflection, we can state that tradition is an interpretation of the past, based on criteria that are really **contemporary**. Put differently, the past does not produce the present, and the present shapes the past. In this way, tradition is **a selective reading of the past.** Moreover, as tradition is a selective reading of the past, **patrimony** is a selective reading of tradition itself. In other words, a traditional product is not necessarily a patrimonial product, i.e. a product that is famous and whose fame is linked to a place. Tradition is in relation with the past as well as **culture**. Indeed, a traditional product has a history and relies on know-how shared by a group of individuals. It is also in connection to local food habits.

So we come to a definition of traditional products that is able to include all the products whose specificities are linked to a place. A traditional product means

- **a historical anchorage**: today, we consider as a historically anchored production, a production that has taken place from at least 50 years (around the world war two).
- **a sharing of know-how among a local community.** This very criteria is the most efficient one to state the traditional characteristic of a food product.

3.1.3 To identify the needs and expectations of the enterprises

a. Survey in Rhône-Alpes with the enterprises

The main need of the enterprises is to know better the market potential regarding the traditional products. Some of them do not want to sell their products via mass marketing (hypermarket) for two reasons: 1) they are afraid of denaturing their products in the eyes of the consumers 2) they do not know how to behave with mass marketing stakeholders. Now, mass marketing is not the only market today, but yet, it represents the first breeding-ground of consumers. The enterprises need to have some elements to be able to answer their questions regarding mass marketing.

Possible actions targeted at the different stakeholders were identified thanks to the enterprises' feedback via the survey:

- at the enterprises :
  - To encourage the participation of the consumers and customers to the enterprise's activity by reinforcing the link between each other. In some enterprises, visit of the workshop open to the general public is a good way to get the consumers involved in the valorization of products.
  - To encourage the cooperation between the enterprises to reach a critical number of consumers. For example, to collectively manage a direct sale shop or propose a 'basket of traditional products'.

1 On the basis of the publications of BERARD Laurence and MARCHENAY Philippe, Antenne 'Ressources des terroirs' de Bourg-en-Bresse, CNRS, France.

- at the public authorities
  - To give the enterprises a free access to some data regarding the consumers and customers' expectations and the market tendency.
  - To enhance the part of traditional products in the public collective catering (school cafeteria) by bringing some changes to the invitation to tender.
  - To finance collective programs gathering the different stakeholders (agrofood enterprises, experts, catering, schools…) to create sustainable partnerships.

b. Survey in Ligurie with farmers and cooperative

In the Ligurian survey, the last three questions concern "*what are the actions that principal actors should make in order to avoid the extinction of traditional products"*. The concerned actors are the enterprises, the costumers and the Public Institutions.

The answers can be synthesized as follows.

Most of the interviewees said that:

- the enterprises should make an effort to cultivate and keep traditional cultivars in their farm (over 59% of interviewees);
- the costumers should buy more traditional products (over 68% of interviewees);
- the Public Institutions should promote, protect and give more funds to develop and increase the traditional products cultivation (over 72% of interviewees).

3.2 Supporting the enterprises

3.2.1 Training the enterprises

In Rhône-Alpes, we have organized a whole day training session targeted at regional agrofood enterprises. 18 enterprises attended the training: they were from different sectors, but all of them were SMEs. The training program and module have been formalized by a complementary partnership, involving different kinds of expertise: ethnology and sociology expertise, marketing expertise and regulation expertise. The training module can be divided up into 3 parts:

- one part dealing with the definition of tradition. The aim was to give the participants elements to understand what is behind a traditional foodstuff. A lot of photos illustrated the speech of the trainer.
- the second part was about the different marketing strategies to valorise traditional products. The official signs, based on EU regulations, were displayed and discussed, as well as the private brands, and the collective initiatives gathering a group of enterprises.
- the last part covered the Hygiene Pack regulation and the procedures to follow when asking a derogation for a specific production.

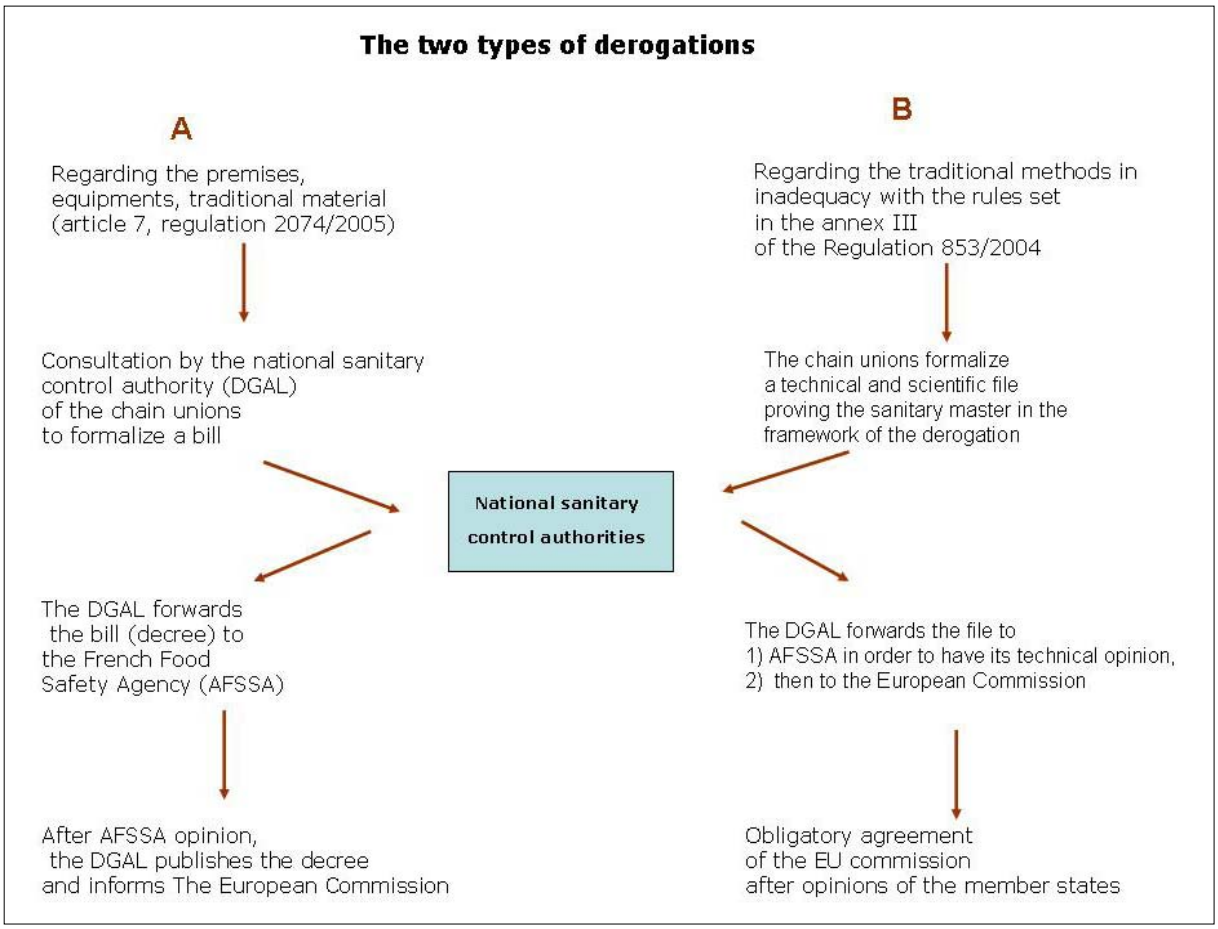
We asked the participants to assess the training. Their feed-back is globally positive. It is worth it to mention that the ethnological and sociological part was found particularly interesting: most of the participants needed to better understand the various dimensions behind the tradition, which is a necessary step before communicating in a genuine and relevant way on their products.

3.2.2 Raising awareness about the necessary derogations to the Hygiene Pack

From January 2005 on, a legislative framework sets the rules to comply with, regarding food hygiene and safety. This framework, composed of different regulations, is called Hygiene Pack. From primary production to distribution, the Hygiene Pack gives the operators the food safety and hygiene responsibility. All the food products are covered, including of course products made with a traditional way of production. Now, some of these products are in inadequacy with some points of the regulations, in par-

ticular the annex II of the regulation 852/2004 related to the general hygiene rules, and the annex III of the regulation 853/2004 related to the description of the way of processing animal foodstuff.

Let us have an example: the regulation 853/2004, annex III, section 2 "poultry meat" establishes that "*during the cutting, the boning… and the packaging, the meat temperature must be under 4°C…*" Now, traditionally the fat poultry (foie-gras palmided) is processed with a temperature that can go higher than 10°C. The committee for foie-gras palmided (gathering the enterprises and farmers) had to formalize a series of documents proving that it is possible to process fat poultry meat at 10°C without jeopardizing the consumers' health. This document will go through a specific procedure that is explained below.



We have explained this procedure in one page document and sent it to regional enterprises in order to get them mobilized and ask for derogation if necessary, with the support of their chain union.

3.2.3 Proposal for an exploitation strategy

Each phase and the various outputs that have been carried on during the subproject has finally contributed to define an exploitation model especially suited for little traditional products. This model has been constructed taking care of all the experiences and many problems discussed with the enterprises during the study visits, as well as of the survey results and the bibliographic research.

All along the project, according to the IRF specific competence and experience, a particular care has been dedicated to monitor fungal or bacteria diseases most frequently founded in FFV (fresh fruits and vegetables) cultivated in Liguria. This activity has been very important on account of the exploitation model proposed. One of the most important phases inside the exploitation chain lies on the conservation of natural resources (local and traditional cultivars) and their propagation in controlled and authorized nurseries. This model practical working is based upon the reliability of seeds and seedlings or other plant parts.

This should be done with:

- nuclear stock, committed to Public Institutions, to maintain basic material free from pathogens and genetic purity;
- nurseries of plants and seedlings for commercial production using propagation material originated from the nuclear stock;
- the traceability of plants coming from previous phases and are cultivated and bought by farmers and costumers.

The sanitary and phytopathological quality of traditional products must be controlled in every phase of propagation and seedlings production chain. If we think that traditional FFV include *cultivars sexually and vegetatively multiplied* , that often are conserved without any prevention technical care from plant diseases, we can understand the importance of this experience, also because the FFV chain is a very less organized one than the livestock productions.

This activity has been carried on in the IRF laboratories, with employed personnel especially trained in phytopathological research. The various steps identified could actually be performed in Liguria and Rhône-Alpes Region, to evaluate their real effect upon the development and economic increase of traditional products on local markets.

As for the products exploitation, the identified strategy is aimed to minimize the production and administration costs to be paid by enterprises. At the same time it has been necessary to maintain the guarantees for consumer protection. The strategy involves public institutions and private enterprises linked by a traceability system. The control system is based upon the producers and costumers' participation. It is aimed to discourage food adulteration and to assign the public supervision to a very important task. The private bodies are not suitable for this kind of valorization process, because of the high costs normally consequent on the inspection activities.

Exploitation procedure

The model identified is divided into three sub-models, according to some marked differences due to raw materials source and nature or to the production process.

Crop productions

Step 1: Identification of a species or cultivar clearly linked to a well defined geographic area. The surface of the area should not be defined or restricted by law but should be connected to a well known popular/ cultural identity.

The species/cultivar must be assigned to a public institution or a producers' organization, whose task is to take care of the genetic, morphologic and sanitary entirety of the plant.

The Institution/Organisation must assure the availability of mother plants for propagation (nurseries, seedsman) or selected seeds or seedlings for farmers interested in the cultivation. All the actors involved must be consulted and should agree on the market price of the propagation material.

The species / cultivar must be registered on a public regional / national list, with a description of the peculiar characteristics (area, history, cultivation, cultural heritage…).

Livestock productions

Step 1: Identification of a traditional breed clearly linked to a well defined geographic area. The surface of the area should not be defined or restricted by law, but should be connected to a well known popular / cultural identity.

A special section of pedigree – book (hard – book, flock – book…) and specific identification badge to make the breed identification easier.

The creation of a regional / national list of traditional breeding livestock farms.

The breeds must be registered on a public regional / national list, with a description of the peculiar characteristics (area, history, breeding, cultural heritage...).

Control system

The control system is always a most delicate question, because it must grant every actor of the production chain from food and commercial frauds. Particular attention must be paid to the purchase and sale of raw materials or final foodstuffs coming from outside the geographic area. On the other hand, the control system must not turn out to be a burden for the very little farms and productions which are normally out of the main commercial channels.

A proposal for the control system is synthesized in the following points, directly related to the above-mentioned exploitation procedure.

- the control must be founded upon a simple traceability system;
- all the actors involved in the chain must keep all the necessary papers (codes or certificates);
- the code or certificate must point out the role and/or operations carried out in the exploitation system, the production obtained, bought or sold and the stocks.
- Every single actor of the chain must keep this traceability certification and assure the best visibility and transparency of data;
- In the same way, the lists of actors involved and production obtained must be public and visible.

Other qualifying requirements should be:

- to enable the consumers to exercise control over the products by establishing a panel group self-financed inside the chain;
- complaints must be seen like a further positive step along the exploitation process and a way to protect the authenticity and fairness of traditional products;
- the public institutions must keep a supervision role on the whole exploitation system;
- complaints must be examined by an apposite evaluation Committee.

Every actor of the chain must be easily able to show the authenticity of his products and the fairness of his work.

Every effort should be made not to give any chance to dishonest actors to operate in the traditional products exploitation system.

4. Conclusion

This exploitation model surely can introduce a sharper costumers' role into the traditional products local agrofood chain, because of the introduction of a local committee dealing with control. This model can also be useful to increase the little enterprises competitiveness, because of it is aimed to be completely free, but valid enough to adequately protect the smallest enterprises from fraud attempts.

The application and realization of practical projects could represent a very important step for the traditional products survival, as well as a good reason to survive (that is to say economic and productive development) also for the very small enterprises and the less-favoured rural areas now existing not only in France and Italy but in many other European Countries. The traditional products survival is a great and really essential question for France and Italy, where thousands of little products or specialities or recipes can be founded, and each of them is strongly linked to culture and heritage, to the history and to the local/rural future development too. But this is true also for many other European Countries, so this subproject results should be useful to stimulate new ideas and solutions for the traditional products survival.

About the sanitary question, in this subproject we have tried first of to propose some derogation request and suggestions targeted at Public Sanitary to focus the actual and real state of application of “Hygiene Pack” laws, with a particular regard to their influence on traditional production processes.

This question it is not less important than the exploitation model: both of them are fundamental aspects for the traditional products survival and their increase in production.

The intense work we did during (meetings and workshops, suggestions and derogation request) have surely increased the mutual knowledge and carried out a new kind of relations between producers and Public Sanitary Authorities. This approach should be pursued in the future because of the necessity to assure the costumers’ health and traditional producers’ survival. Moreover we can say that the suggestions and derogation proposed can be very useful for every local development agent, at least as a work indication to improve in relation to his own local situation.

Flexibility of Small and Medium Enterprises

- 6 Regions
- 5 Sub-Projects
- 16 Project-Partners

Priorities

Promoting innovations and flexibility of SMEs in food chains in fast changing markets and legal environment

Sub-themes

- Survey on the regional potentials of traditional and future markets
- Technology and knowledge transfer from research organisations to SMEs
- Interregional promotion and marketing of „stable to table approach“

Sub-Projects

- Best Practice Quality Systems
- Chain Innovation Benchmark
- QMKnow-ledge System
- Val‘mountain
- MYCOMON

Best Practices Quality Management Systems; Improvement and optimization of quality management in agri-food firms

Van Plaggenhoef, W.[1], Trienekens, J.[1], Gardere, E.[2], Molegnana, F.[2], Krieger, S.[3], Schiefer, G.[3], Pini, S.[4], Burlando, R.[4]

[1] Wageningen University, Management Studies Group, Hollandseweg 1, 6706 KN Wageningen, The Netherlands, E-mail: Jacques.Trienekens@wur.nl

[2] PEACRITT, 23 rue Jean Baldassini, 69 364 LYON Cedex 07, France

[3] University of Bonn, Department of food and resource economics, Chair for Business Management, Organization and Information Management, Meckenheimer Allee 174, D-53115 Bonn, Germany

[4] Regione Liguria, Settore Servizi alle Imprese Agricole, Laboratorio Regionale Analisi Terreni e Produzioni Vegetali, Loc. Pallodola c/o Mercato, 19038 - SARZANA (SP), Italy

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Abstract

Concerns about food quality and safety have been raised among consumers, especially due sector-wide crises, such as the BSE crisis and the dioxin crisis. The EU and the national governments have reacted on the above mentioned crises by setting up regulations for quality and safety of agri-food products. Furthermore, retailers have introduced quality management standards. However, concerns have been raised about the (administrative) burdens being placed on firms. European governments want to assign the private sector more responsibility for compliance with statutory regulations. This project comes up with recommendations for managers and policy makers for establishing self regulated and integrated agri-food supply chains. Four regions were involved in this sub-project of PromSTAP Gelderland, Nordrhein-Westfalen, Rhône-Alpes and Liguria. In order to formulate recommendations, a large scale survey (400 respondents) and a large number of in-depth interviews were held and workshops were conducted. Examples of recommendations from this project are that *Managers* should note that firms with higher levels of integration of quality management achieve higher levels of performance. However, it is necessary to find committed parties that share the firm's objectives with regard to quality management. *Policy makers* should note that self regulation may be more effective in preventing fraud. Certifiers have already experiences with firms and develop relationships with them which are aimed at the improvement of quality management systems. Self regulation also increases the effectiveness of the remaining governmental inspections, because bad performing firms on quality are inspected more frequently. Finally, policy makers should not focus exclusively on prescriptive legislative, but on innovative approaches.

1. Introduction

During the last decade, concerns about quality and safety in agri-food supply chains have been raised among consumers. Several sector-wide crises, such as the BSE crisis, the dioxin crisis, classical swine fever and foot-and-mouth disease and Aviaire Influenza have fuelled these concerns and indeed, when quality assurance fails, the adverse consequences can be large. For example, it is estimated that in the United States alone, contaminated food causes up to 76 million illnesses, 325,000 hospitalisations and 5000 deaths each year (Smith-DeWaal, 2003). Through media coverage consumers in industrialized countries have become more aware of the potential hazards (Jouve, 1998; Opara and Mazaud, 2001; Unnevehr and Roberts, 2002). Mass media and specialized publications propagate transparency about agri-food firms' quality assurance to the public(Frombrun and Shanley, 1990).

The crises have also increased consumer awareness of (other) side effects of bio-industrial production. As a result, the concerns of consumers may not only be limited to safety and quality issues, but also important ethical concerns are raised, for example, concerning the destruction of animals associated with the BSE crises (Van Kleef et al., 2006). Due to all this attention, consumers have become more critical regarding the food products they buy. Nowadays, they demand more information about the origin and the safety of their food, including the means of production, hygiene, genetic modification, application of pesticides and other environmental issues.

Chain-wide integration of quality management systems is regarded as the best strategy to deal with these complex quality demands because no individual firm is able to handle quality on its own (Omta et al., 2002). This vision is strengthened by a study of Cap Gemini and Ernst & Young (2002) in which a vast majority of the managers of European food processors (86%) and retailers (87%) indicate that food quality is basically a task of the agri-food supply chain as a whole. If food problems arise and recalls are necessary all parties in the chain will be affected, therefore, all supply chain partners should take their responsibility to assure the quality of food (Grievink et al., 2003). As a result quality has become an integral element of most farmers', wholesalers' and retailers' business strategy (Antle, 1999).

Firms increasingly respond to their tasks of quality assurance by adapting (private) quality management labels in which firms ask their suppliers to comply with certain regulations (Freriks, 2006). Big retailers in particular have developed initiatives to commit their suppliers to strict food safety regulations. These quality management systems rely on documentation of production processes, combined with third party auditing and certification placing strong requirements on gathering, storing, processing and transfer of quality information between the firms in the chain (Jahn et al., 2004). These private initiatives to regulate and to improve food safety and quality could be regarded as forms of self regulation, also known in literature as self enforcing', 'self governance' and 'self organising' (King and Lenox, 2005; Havinga, 2006).

(Inter) national governmental agencies have also reacted to the above mentioned crises by setting up regulations for quality and safety of agri-food products. For example, the European Union has issued the General Food Law in which the primary quality responsibility of firms in agri-food supply chains is emphasized. In agri-food supply chains, many firms go beyond compliance with legal regulations, because they have to meet the expectations of their buyers and avoid reputational disasters (Bondt et al., 2006; Freriks, 2006; Havinga, 2006). However, concerns have been raised about the burdens (especially administrative) being placed on the firms, because at the moment for many issues firms have to comply with (inter) national quality regulations and with private quality regulations. For example, for firms in fruit and vegetable chains the monitoring of pesticides residuals on products is an important issue in the Pesticide Law, but also in the private quality system Eurep-GAP.

In order to reduce the compliance burdens, the Dutch Ministry of Agriculture, Nature and Food Quality strives for a new inspection policy, called '*control-on-control*',. *'Control-on-control'* fits within the changing policy of the Dutch government in which the role of the government shifts from one-sided practices in which government was solely responsible for strategic planning (*'command-and-control'* approach) towards improving governance and creating transparency in policy processes. One outcome of this process was a rearrangement of the balance between public and private responsibilities, also with regard to quality assurance. This has led to Public Private Partnerships, as well as to a more performance-oriented government. At the same time, agri-food firms changed their strategic focus from cost to adding value for the buyer. These developments have far-reaching consequences for the way quality assurance in agri-food supply chain processes is structured and managed, as well as for the roles and responsibilities of the different actors involved. For example, the Dutch Ministry of Agriculture, Nature and Food Quality strives for a new inspection policy, called *'control-on-control'*, where the private sector is assigned more responsibility for compliance with statutory quality and safety regulations. *'Control-on-control'* fits within the changing policy of the Dutch government in which firms receive the objectives and the conditions to fulfil a certain policy. In practice this means that firms that perform well on quality management will receive lower inspection frequencies than bad performing firms (LNV, 2004). In this new situation the

Ministry operates at a greater distance but retains the ultimate responsibility, because even if the vast majority of firms do the right thing, there is always the chance that a firm will produce serious harm. The Dutch Ministry expects that *'control-on-control'* will result in a more efficient and effective assurance of the firms' interests (De Bakker et al., 2007).

One of the projects in the PromSTAP framework is the project 'Best Practice Quality Systems' which has the objective to come up with examples of 'best practices' from different EU regions such as Gelderland (The Netherlands), Rhône-Alpes (France) Nordrhein-Westfalen (Germany) and Regione Liguria (Italy) about the way quality management and self regulation systems can could be organized and to provide recommendations for managers and policy makers based on these 'best practices'.

This project was carried out in the poultry meat chain and the fruit and vegetable chain for the following reasons (Deneux et al., 2005; Berkhout and Van Bruchem, 2006):

1. These chains are valid representations of the agri-food sector, they are characterized by a large diversity of marketing channels and products.
2. All these chains are of great interest for the economies of the selected regions.
3. All the three chains pay a lot of attention to quality management.
4. All these chains are highly cross border oriented, but sell their products mainly in the other EU countries.

However, the scope varies somewhat across the regions involved. Regione Liguria has especially focused on olive chain, a specific fruit and vegetable chain. Furthermore, the breadth of the studies in the regions was also different. In the Rhône-Alpes region the project focused on a certain part of the chain, in this case the processors of foods, while in the region Gelderland has focused on multiple kinds of firms in the chain such as primary producers and traders and/or processors. Although these differences in approaches it was possible to come up with relevant recommendations for managers and policy makers due to the excellent co-operation.

2. Methodology

In the project two constructive phases were used to conduct the research. Some regions have used mainly survey questionnaires, while other have used in-depth face-to-face interviews or have combined both approaches, a so called ' mixed methodology'. 'Mixed methodology' designs incorporate techniques from both the quantitative and qualitative research traditions, yet combine them in unique ways to answer research questions that can not be answered by one methodology alone. A mixed methodology approach has been proved to increase the 'goodness' of the answers (Currall and Towler, 2003). '

The survey was used for quantitative research. This methodology allows researchers to gain an overall picture of a phenomenon. The survey answered questions such as: '*How, and to what extent do factors influence the integration of quality management? 'How does integration of quality management influence the dimensions of compliance behaviour?', and 'How do integration and self regulation of quality management influence performance of firms in agri-food supply chains'?* In quantitative research the problems of reliability and generalisability are easier to address than in a qualitative study. A survey is characterised by large numbers of research units, labour intensive data generation, breadth rather than depth and quantitative data analysis (Verschuren and Doorewaard, 1999). However, a major drawback of this research strategy is that it offers little contextual information.

In-depth interviews with experts in the chains were used in order to gain practical insights in how firms perform there quality management practice, counteracting the major drawback of a survey offering little contextual insights. Statistical findings from the survey were combined with statements from these case interviews and tried to answer the question: '*How can 'best practices' quality management systems including self regulation be designed?'* By answering this question, the present study provides recommendations for both managers and policy makers. Primary producers and traders and or processors

from the chain being involved were interviewed. In further improving the generalisability representatives from certification organizations and interest organizations were included because their experience with 'best practice' quality management enabled them to make appropriate comparisons between firms. Finally, experts from governmental agencies such as the Ministries of Agriculture and the Food Safety Authorities were involved.

Futhermore some regions, for example Rhone Alpes and Regione Liguria have organized a number of workshops in which firm experts. During these workshops the professional practices based on the individual experience with quality management are exchanged and analyzed. It is expected that the experiences of the participants could result in a cross fertilisation of the practices across the firms. Due to the emphasis on the exchange of professional practices the focus of this part of the project has focused exchanges between the same kinds of firms (i.e. between primary producers or between traders).

3. Results and Discussion

3.1 The questionnaire

First of all, the most important elements of quality management in a supply chain perspective were defined. The integration of quality management with suppliers and buyers is expected to have a positive impact on commitment and enforcement, which can be regarded as the two main dimensions of compliance behaviour, based on the 'Table of Eleven' a tool used for evaluating compliance behaviour (Ruimschotel, 1994). Futhermore, due to intensive collaboration on quality management, higher performance for the individual firms in the chain would be expected. However, literature on buyer-supplier relationships frequently states that increased performance is likely to be best achieved by means of committed suppliers and buyers. For measuring performance of a firm buyer satisfaction and revenue growth of the firm were used. In addition, information exchange by means of ICT can be regarded as a catalyst for successful integration of supply chain processes. Also specific investments (TSIs) are needed for the integration of quality management. Due to strong collaboration in chains supported by these investments, opportunistic behaviour of the chain partners is to a large extent prevented. Furthermore, external drivers *(media attention, legislative demands, changing consumer demands* and *societal demands for corporate social responsibility)* put pressure on firms to integrate their quality management systems.

In total 399 firms reacted to the survey. Table 1 shows the distribution of the respondents across the chains involved.

Table 1: Number of firms per chain

Firm	Number of firms		Total
	Poultry meat	Fruit and vegetables	
Primary producers	116	151	267
Trader/processors	34	98	132
Total	150	249	399

The factors that are expected to have an impact on the integration of quality management are depicted in Figure 1. It has empirically shown that if firms perceive stronger external pressures, their quality management systems will be more integrated with suppliers and buyers. Many of the pressures are not aimed at specific firms, but often influence all firms in a supply chain. However, incorrect actions of only one firm in the supply chain may result in increasing external pressures on all firms in the chain. By integrating quality management systems in agri-food supply chains, managers try to prevent this. Interestingly, *legislative demands* have hardly any impact on the integration of quality management systems with buyers and suppliers, while *media attention, societal demands for corporate social responsibility and changing consumer demands* have a great impact.

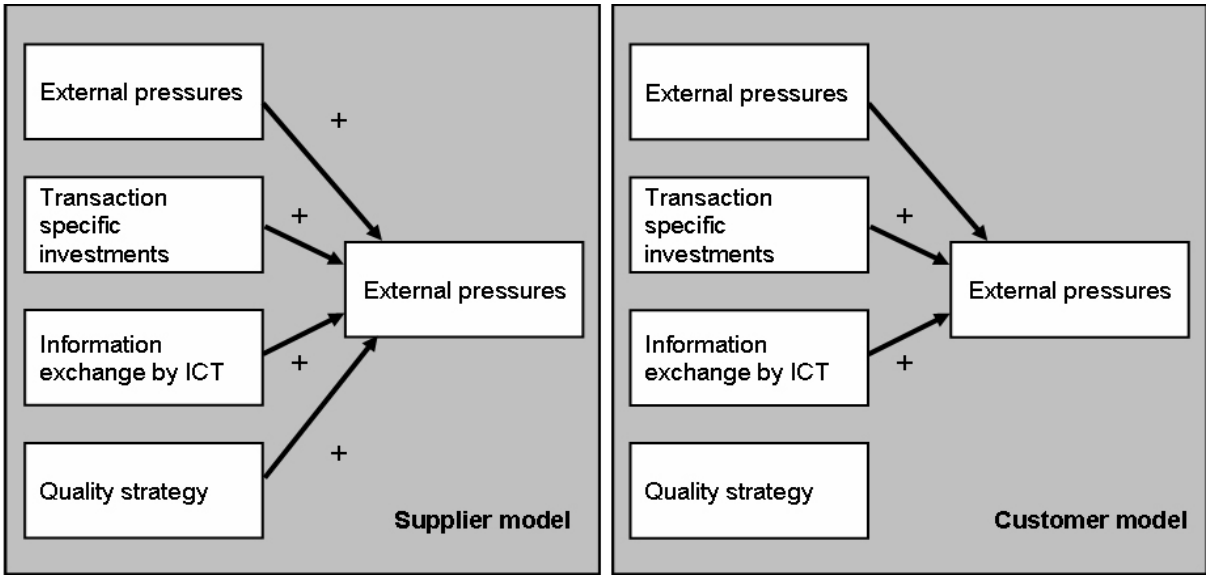

Figure 1: Factors influencing integration of quality management with the supplier (left) and buyer (right); no line means no significant relationship.

TSIs and integrated ICT systems (for example 'tracking and tracing systems') also contribute to the successful integration of quality management systems. Integration and collaboration on quality lowers the risks for opportunistic behaviour. Firms send an important signal to other parties in the chain that the relationship is highly valued by TSIs and integration of quality management systems. Interestingly, the quality strategy of the focal firm has an impact on the integration of quality management with the suppliers, but not with the buyers. The most likely explanation is that firms are able to impose their quality requirements upstream, but not downstream in the chain. When selecting suppliers, the firm is able to let its interest for quality management play an important role, whereas this is much more difficult in the choice of its buyers.

The project study showed empirical evidence that integrated quality management systems are strongly positively related to self regulation, see Figure 2. Due to the integration of quality management systems a platform is established for open communication about specifications and chain process improvements which results in a mutual understanding and commitment for each other's quality requirements. Moreover, the exchanges of outcomes of quality test and – inspections, results in more possiblities for enforcement of quality requirements. This project also shows that integration of quality management leads to higher performance. Firms that have integrated their quality management systems with their suppliers and buyers achieve higher levels of performance (both for buyer satisfaction and revenue growth). This effect is achieved by commitment of the parties in the chain and not by means of enforcement. A policy that is focused too much on enforcement and sanctions has no effect in the supplier model and works even detrimentally in the buyer model. Enforcement has the potential to result in conflicts with suppliers, especially if sanctions are imposed that are perceived to be unjust or unreasonable. However, although a large majority of firms will comply with quality requirements as well as possible and too strong enforcement is de-motivating for them, a certain level of enforcement is needed for firms that will behave opportunistically.

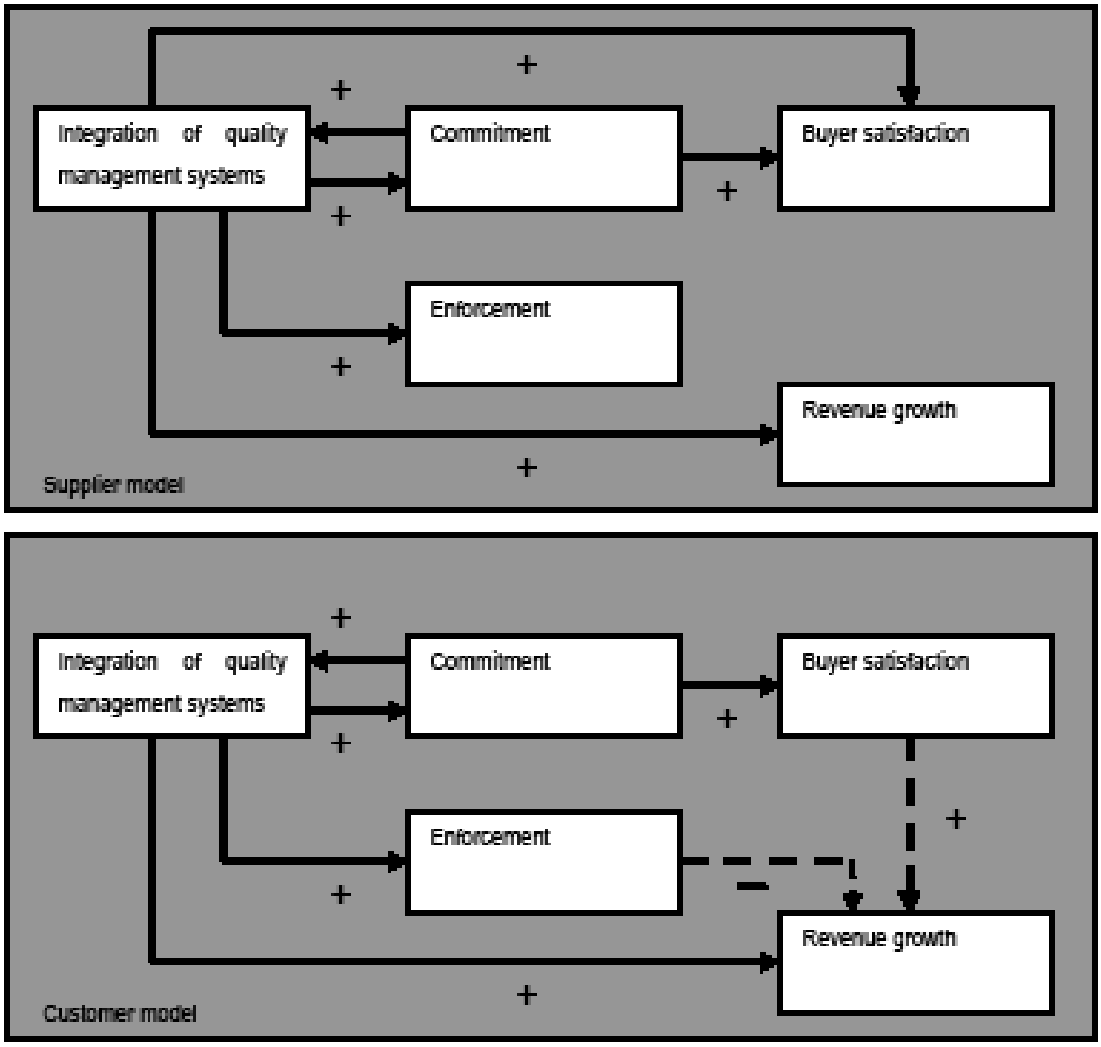

Figure 2: Impact of integration of quality management on self regulation and performance of firms in agri-food supply chains. (dashed arrow means weak significant relationship).

3.2 The in-depth interviews

The in-depth interviews paid paramount attention to self regulation and its dimensions, *commitment* and *enforcement.* In order to make an estimate about compliance behaviour of firms, the 'Table of Eleven' can be used (see Table 3.5). The 'Table of Eleven' has already been extensively used by many Dutch policy makers and researchers in agri-food chains (VWA, 2004a, b). The 'Table of Eleven' includes eleven dimensions for compliance grouped according to two main dimensions of compliance behaviour and is based on the work of Ruimschotel (1994).

3.2.1 Commitment

For many traders and/or processors it is a challenge to tie the best performing suppliers on quality to their firm. Three traders and two primary producers emphasized the presence of supplier panels. These panels serve as communication channels between suppliers and buyers and are very useful for increasing commitment as an expert from a big slaughterhouse stated:

Every six weeks, we have a meeting with a panel of poultry farmers to discuss topics of quality management ranging from new marketing concepts on quality to the reduction of Salmonella and Campylobacter contamination. We also organise excursions for them to our slaughterhouse. This makes them aware of the consequences of their quality management practices for our quality management.

Quality manager of a poultry slaughterhouse/processor

Among suppliers in such panels there are vivid discussions of all kind of topics aimed at improving quality performance. For example, a grower that delivers to Tesco organises a monthly meeting with other growers in which novelties, feedback from consumers, information about actions and demanded quantities of products are discussed. Furthermore, a newsletter is published every month. Suppliers participating in such panels often come up with improvements and suggestions themselves. PEACRITT in the Rhone-Alpes region has also recognised the importance of such panels and has established platforms in which information is exchanged, see Box 1.

Box 1: Peacritt's workshops with entrepreneurs

The PEACRITT organized 6 workshops gathering 6 firms. The exchange and analysis of professional practices were the central topics, valorized in a collective working context. Participants were active in the different hierarchical level of the management of agri-food firms This modality answers different types of objectives:

- to innovate: to valorize the experience in order to propose new solutions
- to investigate: to anticipate a change
- to create solidarity: to create social link, to struggle against individualism
- to capitalize: to valorize efficient practices for their generalization and to rely on a collective capital

In the 'Table of Eleven', *commitment* consists of the individual dimensions 'knowledge and clarity of regulations', 'the (im) material (dis) advantages of regulations', 'the degree to which regulations are accepted', the willingness to comply with regulations' and 'the chance of discovery and sanctions by third parties'. These are discussed in detail below.

The knowledge and clarity of regulations

Four experts mentioned that most private quality systems in agri-food chains are accredited systems, which means that the regulations and procedures are clearly described and are supervised by an independent Council of Accreditation. According to them, in this way, it is completely clear to firms what the requirements of private quality management systems are. Five experts mentioned that, however, the public regulations from the government were sometimes difficult to understand.

The (im) material (dis) advantages of non-compliance

Firm experts thought they would not gain financially by non-compliance with quality systems, because it could be easily detected by their buyers. Experts like the idea and the emerging practice in which good performing firms on quality are inspected less frequently than bad performing firms. If the costs of these controls are charged to firms, this introduces a bonus-malus principle for compliance with quality requirements. This approach could increase the motivation of firms to adopt quality regulations, because they know that compliance with quality management systems will result in lower inspections. This will remove annoyance, for example three experts from good performing firms held the opinion that they were inspected too often, although they had an outstanding quality management system.

Three experts mentioned that legislative demands on quality management may result in (logistic) problems in production processes. An expert from a big poultry processor said that legislative demands on inspections constrained his production process. For example, in The Netherlands a maximum of 9,000 chickens per hour is allowed to be slaughtered, because otherwise controlling agents are not able to control the total flow. This is quite low compared to Belgium and Germany, where 11,000 and 12,000 chickens per hour are slaughtered. It is recommended that governments implement quality control systems that are competitive with those of countries abroad. In case of more self regulation such problems may not exist.

The degree to which regulations are accepted

According to six experts self regulation might increase the acceptance of quality regulations. Governmental inspectors often works according to the inspection principle, in which each detail is controlled

extensively. This way of working of governmental agencies can be frustrating for firms with good performing quality management systems as an expert complained:

These kinds of inspections are disruptive in character, they remove initiatives and are e-motivating. If you trust someone, you do not check everything with a checklist and you do not want to see every detail.

A poultry farmer

Private audits make quality requirements in general more acceptable to firms. If a firm has a certified quality system, the audit is a learning process, in which auditors take the total structure of the firm into account. For example, how processes are organized and how information is communicated within the firm. A private auditor is not regarded as a police officer, but as an improver of the firms' processes. Experts would like governmental agencies to work like auditors, because the added value of an auditor is that he helps the entrepreneur to find the balance between quality requirements and how these requirements should be met within the firm. This difference might partly explain the lack of trust of experts of the VWA in the current quality management systems. An example of how inspections of the government could be replaced by other control activities is provided by PEACRITT and is called 'cross audit' and is described in Box 2.

Box 2: 'Cross compliance'

During the workshops explained above, a practice has been identified by the participants as a good way to optimize quality management: it is the so-called 'cross audit.' Now this practice is by definition a practice based on inter-enterprise exchange. In a nutshell: an enterprise makes its system audited by the quality manager of another enterprise and its own quality manager will audit the other enterprise.

An enterprise that wants to implement a quality management system needs to assess it through an internal audit. In the new 4th version of the International Food Standard in particular, the internal audit is considered as a Knock Out item (very important requirement (certificate will be suspended in case of non-compliance).

Now cross audit between enterprises is a possible and relevant answer to this requirement.

Therefore, the PEACRITT has investigated in Rhône-Alpes to see if such a modality has already been implemented. A similar experience indeed has taken place towards cooperative farms, launched by Coop de France Rhône-Alpes Auvergne, the Union of the regional farming cooperatives. PEACRITT met Coop de France and together it tried to define a device aimed particularly at agrofood enterprises, which is the target of PEACRITT. The inter-enterprise cross audit club as expected in Rhône-Alpes is organized in the following way

- a club of participating firms in the cross compliance coordinated by Coop de France RAA
- precautions formalized through procedures
- a monitoring board nominated by the member enterprises, for three years, which validates the formal procedures and develops and retain measures to tackle dispute and object of contention
- a coordinator and a substitute coordinator, nominated by Coop de France RAA who runs the club, organizes the audits, encourages the exchange and the evaluation of the auditors' qualifications and ensures the accounting of the club.
- auditors qualified according determined criteria

The willingness to comply with regulations

Three experts mentioned that for the introduction of self regulation an extensive network of industry organizations, Product Boards and other kinds of associations which represent many firms is advantageous. These organizations are often active in translating new or changed legislation to their members or introducing initiatives for compliance with quality regulations, preventing many troubles for firms. This results in a higher willingness to comply with quality regulations.

The chance of discovery and sanctioning by third parties

An expert from the Dutch Food and Consumer Product Safety Authority (VWA) reported that based on Regulation EU 882/2004 it is necessary to be transparent about the outcomes of inspections of controlling agencies. In fact this regulation introduces among others a kind of societal control by the public. In The Netherlands, the Ministry of Agriculture, Nature and Food Quality and the Ministry of Health, Welfare and Sport have decided that the fruit and vegetable sector will be a pilot sector to work out this EU regulation. The VWA has launched a web site in which all the results of the residual controls are published with the names of the traders and retailers *('blame-and-shame' approach)*. If the products fail, it is mentioned on which aspects and whether these aspects are harmful to human health. This approach may increase the efforts of firms to comply with quality management regulations, because they do not want to damage their quality reputation. However, this approach could also have some drawbacks as one of the experts stated:

This information is also accessible for Non-Governmental Organisations (NGO) which may use this information in order to put retailers under pressure to come with even more stringent requirements to their suppliers.

Representative from an interest organization in the fruit and vegetable chain

The expert further warns that when the government introduces more frequent inspections for bad performing firms and less frequent inspections for good performing firms, the possibility of finding an offence will become much higher. When these outcomes are published it might seem that the number of non-compliances in a country with such a policy is high.

3.2.2 Enforcement

Regarding enforcement, experts pointed out that almost all big market parties, especially retailers, have summarized their quality requirements for suppliers in certified systems (see Chapter 2). Independent auditors take care of the compliance with such systems and in case of repetitive non-compliance firms will lose their certificate. However, experts warn against using very stringent enforcement principles, because firms that are performing well are hampered by stringent enforcement, which might disillusion and demotivate them. As one of the experts stated:

Would it be necessary to develop a very stringent sanctioning system with many controls and inspections for a very small number of firms performing badly and hampering all firms that are performing well? Or would it be better to visit the less good performing firms and to look where the problems occur and to discuss with them how to solve these problems?

Quality manager of a poultry slaughterhouse/processor

Moreover, in case of very stringent quality regulations firms might fake compliance with regulations by manipulating measurements. When faking compliance, it might seem that these stringent regulations have some effect, but in practice they do not. If the sanctions are not very severe, it will stimulate timely notification of problems. The dimensions of enforcement of the 'Table of Eleven' are combined in two dimension 'creditability' and 'sanctioning'.

Creditability (chance of control, chance of detection and chance of selection)

The expert from the VWA stated that for the introduction of reliable self regulation it is necessary for certifiers to employ highly qualified independent auditors. Auditors should have the time, knowledge and experience to judge the system on its contents. This enables them to make a judgement on whether all hazards are clearly identified, whether these hazards are really hazards, and whether corrective and preventive actions are needed. According to the expert of the VWA some quality systems deal with the transfer of responsibility to the suppliers and not really with the assurance of quality itself. Another point of attention with regard to the creditability according to this expert was that the government takes

care of exact compliance with requirements, whereas in many private quality management systems the certificate is obtained if a firm complies with a certain percentage of the requirements. Therefore, it should be investigated whether partial compliance assures the same level of quality assurance as exact compliance. Three experts from business further stated that the government should realize that fraud is always possible, also with governmental control. For each control organization, whether it is private or public, it is impossible to check a total firm on its behaviour, as a expert summarized:

If people want to do things wrong you can hardly prevent it. If a person wants to use a kind of forbidden pesticide, will not be in the storage of the firm, but in the cabinet at home, or at the neighbours. Inspection agencies will not look in those places.

Lead auditor of a certification firm

These experts further argued that certifiers know firms and develop relationships with them in which improvement of quality management is very important. As a result they have more insight in the problems and can help to resolve problems. Therefore, they know best whether or not a firm complies well with the quality requirements. Therefore, they may be more effective in preventing fraud because certifiers know firms and develop relationships with them in which improvement of quality management is very important. Experts from business were also aware that introduction of self regulation would not lead to a decrease of the level of quality requirements, but it may even increase the level of the quality regulations, as one expert stated:

An important problem with self regulation is that governmental agencies will develop very stringent requirements for self regulation, because they are afraid that something will go wrong if they partly transfer their responsibilities to the market.

Senior consultant of interest organisation in the flower and potted plant chain

Sanctions (chance and type of sanction)

According to the expert from the VWA the introduction of a Council of Accreditation is a critical success factor for the introduction of self regulation. The commercial relationship between firms and certifiers could hamper certifiers in their sanction possibilities. If a certifier states that a certain firm does not deserve the certificate, the firm might go to another certifier. According to an expert from the VWA this could be quite simple for firms, because there is a strong competition between certifiers. However, two experts explicitly mentioned that the common sanction for repeated non-compliance is withdrawal of the certificate or exclusion from delivery, which is much more effective for a firm than a fine as one expert stated:

Loosing the certificate is often a more rigorous and effective 'shame-and-blame' sanction for a firm than a fine, because a firm is than loosing its market and excluded from the chain, whereas in case of a fine, it can still deliver to the buyer, because the buyer does not know this.

Lead auditor of a certification firm

According to a firm expert the VWA should not worry about the strictness of sanctions in certified quality management systems. However, firm experts warn that the government should take care of firms that operate at the bottom of the market where certificates have no value at all and are only seen as a burden.

4. Conclusions

In order to answer one of the most important questions posed in the introduction: *'What is the best way to create self regulated quality management systems in agri-food supply chains?'*, a number of important recommendations are formulated for managers and policy makers.

4.1 Implications for managers

The recommendations for managers are focused on establishing 'best practices' in quality management. Managers in agri-food firms might ask themselves questions such as: *How should we start or strengthen the integration of quality management with our buyers and suppliers', What factors do influence (and how strongly) the integration of quality management with our suppliers and buyers* and *How can we benefit from integration of quality management systems?* The project has identified a number of important implications, summarised below:

1. Collaboration to improve performance

It turns out that firms that have higher levels of integration of quality management achieve higher levels of performance in terms of buyer satisfaction and revenue growth. However, it is necessary to find committed parties in the chain that share the firm's objectives with regard to quality management. Commitment can be regarded as the 'glue' that holds together successful buyer supplier relationships. Commitment can be enlarged by:

- Maintaining high quality standards and link up the own firm with exchange partners that have similar visions on quality management.
- Communicating quality information timely and by intensifying the relationships through personal contacts and visits with suppliers and buyers.
- Sharing the benefits from better quality management throughout the supply chain, and stimulating the notification of problems without directly imposing sanctions.

Enforcement of quality requirements should be avoided as much as possible. Strict enforcement does not lead to higher performance in most cases because:

- Strong enforcement of quality regulation has the potential to be destructive and initiates dysfunctional conflict behaviour, especially if sanctions are imposed that are perceived to be unjust or unreasonable and may ruin the necessary (long-term) relationships.
- If buyers use strong sanctions for non-compliance to quality requirements, suppliers might be faking compliance behaviour and will not notify their buyers in case of quality problems.
- Stringent enforcement by frequent or many controls de-motivates firms that are performing well and results in high and unnecessary monitoring costs for the enforcing firm.

2. Better use of quality data

Managers should be aware that due to the compliance with quality requirements, they possess a rich source of information about their quality performance over time. At the moment these quality measures are often only used to verify compliance. Analysing this data deeper might reveal the roots of quality problems and indicate ways to solve these problems.

3. Aligning quality strategy with firm strategy

Managers should integrate quality management with the commercial, financial and personnel strategy of the firm. By doing so, it will not be regarded as a bureaucratic burden and can be better aligned in the firm's processes. Motivation of the personnel could be further improved by developing effective procedures that are short and practical. If the only interest of a firm is to obtain a quality certificate, not supported by an appropriate quality strategy, the quality management system will not be successful in the long run. Managers should avoid practices that might decrease the perceived importance of good quality management by their employees.

4.2 Implications for policy makers

Policy makers might be interested in the answers to questions such as: *What hampers the self regulation of quality management in agri-food supply chains, How can we improve quality management of firms in agri-food supply chains* and *What is the role of the government with regard to inspections of quality management in the near future?* This project provides the following implications:

1. Application of '*control-on-control*'

Within self regulation the government should retain ultimate responsibility for quality assurance, especially with regard to the mandatory legal European requirements. Self regulation is likely to increase the overall level of quality management in agri-food firms. Good performing firms will become even more motivated to improve their quality management, because the governmental inspection frequency of their firms will decrease, lowering the administrative and financial burdens of the inspections. Bad performing firms will be controlled more frequently. Even if the vast majority of firms do the right thing, there is always the chance that irrational, incompetent and stubborn firms will produce serious harm. While relatively small and operating at the bottom of the market, these minority of firms cannot be ignored. As a result the effectiveness of the governmental inspections will increase, because the government is 'fishing where the fishes are'.

2. Uniform certification procedures

Policy makers should realize that even the traditional '*command-and-control* approach of governmental control is not a kind of golden standard for 100% compliance with quality regulations. Fraud will always be possible. However to minimize the chance of fraud, the procedures should be clearly described and supervised by an independent Council of Accreditation. This prevents the commercial relationship between audited firms and certifiers from hampering certifiers in their evaluation. Self regulation might even be more effective in preventing fraud -because certifiers know firms and develop relationships with them in which improvement of quality management is very important. As a result they have more insight in the problems and can help to resolve problems a firm has in complying with regulations better than governmental agencies. Moreover, a common sanction for repeated non-compliance with certified quality management systems is withdrawal of the certificate or exclusion from delivery. This is a severe sanction, because firms that are excluded from their chains no longer have the possibility to deliver to their buyers, which is a more stringent sanction than a fine.

3. Innovative approaches

It was shown in the survey conducted in the project that not *legislative demands*, but more consumer oriented factors such as increasing *media attention* and *societal demands for corporate social responsibility* have the most important impact on the integration of quality management in agri-food supply chains. Therefore, policy makers should focus on innovative approaches that positively emphasize the efforts of firms to deliver high quality foods, for example:

- Create awards for firms with 'best practice' quality management systems comparable to the corporate social responsibility award of the Dutch Ministry of Agriculture, Nature and Food Quality. Winners receive a lot of positive attention in the media.
- Develop a 'score card' including a number of criteria on which the quality management of firms should objectively be assessed. Based on this score card of quality performance a ranking list of firms can be composed and published. It is expected that this ranking list will start a kind of competition among firms in order to achieve a higher ranking.
- Publish the inspection results on the Internet. In order to safeguard their quality reputation firms may intensify the integration of quality management with their suppliers and buyers as a means of complying with quality management regulations (shame-and-blame approach).

4. Commitment instead of enforcement

Commitment and not enforcement lead to better performance with regard to quality management. This also has consequences for the government. The government works according to the inspection principle, which means that many details are checked extensively. Firms perceive this as an enforcement based way of working. In order to change this perception, the government should work according to the auditing principle. The added value of an auditor is that he helps the entrepreneur to find a balance between the quality requirements and the way these requirements should be met within the firm and this is perceived as a commitment based way of working. In this way, the inspection of quality requirements will be perceived more positively by firms. A 'cross compliance' approach as described in Box 1 could be a useful option.

5. Retain the advantages of 'control-on-control'

Policy makers should be sure that they do not develop too stringent requirements for self regulating systems if they transfer part of their responsibilities to the market. Recent research has shown that self regulation in other sectors such as health, higher education and environmental management did not lead to lower administrative burdens for firms (Dorbeck-Jung et al., 2005). Regulations of the government were replaced by all kinds of regulations of private organisations.

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Chain innovation benchmark; improving the innovation and co-operation capabilities of SMEs and innovation intermediaries

Wubben, E.[1*], Batterink, M.[1], Gardere, E.[2], Molegnana, F.[2], Pini, S.[3]

[1] Management Studies Group, Wageningen University, Hollandseweg 1, 6706 KN, Wageningen, The Netherlands, E-mail: emiel.wubben@wur.nl

[2] PEACRITT, 23 rue Jean Baldassini, 69 364 LYON Cedex 07, France, E-mail: gardere@peacritt.fr, molegnana@peacritt.fr

[3] Regione Liguria - Settore Servizi alle Imprese Agricole, Loc. Pallodola c/o Mercato, 19038 - SARZANA (SP), Italy, E-mail: stefano.pini@regione.liguria.it

[*] Corresponding author

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Abstract

Inter-organisational cooperation has become increasingly important for Small and Medium sized Enterprises (SMEs), but a cooperative innovation process is still regarded very complex. The Chain Innovation Benchmark project had the objective to 1) identify key success factors for inter-organizational innovation projects, and 2) to investigate the different roles of innovation intermediaries in the different stages of the innovation process, and identify lessons learned and examples of best practices for such organisations. Based on a multi-method approach conducted in the three participating regions, in-depth insights into best practices of cooperative innovation processes involving SMEs and innovation intermediaries were obtained. First of all, a number of innovation projects of SMEs in each of the regions were advised on how to improve their practices. Comparing these projects resulted in a number of key success factors, that if implemented in ongoing innovation projects, can improve the chances of success. Second, a program (OPTIréseaux) of collective projects aiming at enhancing innovation of SMEs in Rhône Alpes was evaluated, using a combination of workshops, a survey, and face-to-face interviews, involving the different kinds of actors taking part in OPTIréseaux. The results of the evaluation enabled the organizer of OPTIréseaux to improve it. Third, from our analyses of five innovation intermediaries, we learned how such intermediary organisations can be designed and function in a way that they can significantly enhance cooperative innovation projects of (agri-food) SMEs. To conclude, in the *Chain Innovation Benchmark* project we identified and discussed a set of 10 KSFs for in inter-organizational innovation projects and related best practices. The results can be used by actors, most notably innovation intermediaries, who want to engage in inter-organizational innovation projects.

1. Introduction

1.1 Background and objectives

1.1.1 Background

Inter-organisational cooperation has become increasingly important for Small and Medium sized Enterprises (SMEs) in the field of realizing innovations. Often, SMEs lack essential resources and capabilities to successfully innovate in-house (Narula, 2004). Nevertheless, there are at least five reasons why SMEs find it hard to establish and profit from inter-organizational innovation projects (Wissema and Euser, 1991; van Gils and Zwart, 2004). First, SMEs are often managed by their owners, the entrepreneurs, who are used to operate independently, and within a certain region. Cooperation with other organisations is unnatural for them. Second, cultural differences and lack of joint research experience hamper cooperation. For instance, most SMEs are unfamiliar with research organizations. Third, SMEs must be confident that the appropriability of the results of co-operative efforts is done in a fair way. Typically, they cannot enforce their will upon others. Fourth, on the one hand knowledge may spill over to other parties unintentionally, while, on the other hand, intended efforts for knowledge valorisation may remain underutilised. Finally, inter-organizational innovation projects may involve parties with divergent habits

and interests. A rise in the number and types of parties involved increases the complexity within the project, which, in the absence of related expertise, lowers the success rate of an inter-organizational innovation project. We may conclude that it is to the benefit of regions and its stakeholders to improve the innovation and cooperation capabilities of SMEs and their innovation partners.

An SME may find potential partners for inter-organizational cooperation from its own supply chain, network, or region, such as customers, suppliers, local authorities, and research institutes, but the partners can also be found elsewhere (Omta, 2002; Ritter and Gemunden, 2003). Several types of (regional) innovation intermediating organizations exist to support SMEs with their innovation processes (Smits and Kuhman, 2004; Howells, 2006). For instance, they may support the SME by identifying their innovation needs, articulating the knowledge demands, setting up partnerships, and managing the inter-organizational cooperation processes (Howells, 2006). However, surprisingly scarce is the knowledge on important questions with regard to, for instance, how innovation intermediaries operate best, and what their contribution to inter-organizational innovation projects is or should be (Dhanaraj and Parkhe, 2006; Klerkx and Leeuwis, 2007). The Promstap sub-project *Chain Innovation Benchmark* investigated cooperative innovation processes involving SMEs and intermediating organizations in different regions.

1.1.2 Objectives

The sub-project *Chain Innovation Benchmark* has two main objectives. First, the sub-project aims at obtaining profound insights in the key success factors for inter-organizational innovation projects. Second, the sub-project aims at finding out how innovation intermediary organizations can stimulate innovation and entrepreneurship by means of cooperation and knowledge networks. Ultimately the comparison of cooperative innovation activities from different European regions, can help SMEs and their partners to adapt innovation projects towards best practices. The innovation intermediaries can apply the lessons learned in their future practices, stimulating innovation and regional economical development.

The objectives of the *Chain Innovation Benchmark* project can be summarized as follows:

1. Identify key success factors (KSFs) for inter-organizational cooperation in innovation projects, and
2. Investigate the different roles of innovation intermediaries in fulfilling the KSF for inter-organizational innovations, and formulate related design criteria, best practices for such intermediaries.

In order to realize the objectives, *Chain Innovation Benchmark* investigated cooperative innovation processes involving SMEs and intermediating organizations. The focus has been on:

- The obstacles SMEs face in (inter-organizational) innovation projects
- Efficient and effective coordination of the cooperative innovation projects
- The roles and added value of innovation intermediaries

1.1.3 *Participants*

Three regions participate in the *Chain Innovation Benchmark* project: Gelderland (The Netherlands), Rhône Alpes (France) and Regione Liguria (Italy). The involved partners are Wageningen University, PEACRITT and the Agriculture Department of the Regione Liguria.

2. Materials and methods

2.1 Overall approach

Within the *Chain Innovation Benchmark* project, a multi-method approach was used. The combination of different methods and datasets enriches the analysis and makes the conclusions more robust. We conducted interviews with key actors (especially SMEs, innovation intermediaries and authorities) involved in cooperative innovation projects, and we carried out a survey among agri-food SMEs. Moreover, we had participatory research by fulfilling operational roles in a number of innovation projects. We were thereby able to disseminate expertise and provide tools, aiming subsequently at benchmarking and at improving individual innovation projects. Finally, the regional results were cross-analysed to benchmark regional best practices and to arrive at both (1) a final set of KSFs for cooperative innovation, and (2) design requirements for roles of innovation intermediaries fulfilling roles in inter-organizational innovation projects of SMEs. The three participating regions Gelderland, Rhône Alpes, and Regione Liguria, searched for and applied method(s) that were appropriate to arrive at results most suitable to their specific region.

2.2 Gelderland specific approach

2.2.1 WIAT analysis

For the region Gelderland, we applied the Wageningen Innovation Assessment Tool (WIAT) to 13 innovation projects (see annex 2). We applied WIAT to investigate the potential of innovation projects and provide 'early warning signals' during product development, by extracting the *tacit knowledge* from the project team. WIAT was used to assess in total 13 SME-driven (inter-organizational) innovation projects, with 57 respondents. The results of the innovation project was collected one year later. From the 13 projects assessed, 8 were considered to be successful, and 2 were obvious failures, and 5 projects were still undecided. Note that the numbers are too low to justify statistical inferences. Following the approach by Fortuin et al. (2007), key success factors for innovation could be determined.

2.2.2 Interviews

Furthermore, we conducted 12 in-depth interviews (using semi-structured questionnaires) with key actors (SMEs, project leader, innovation intermediaries) in cooperative innovation projects to gather insights into how to organize inter-organizational innovation projects. We took one typical innovation case, in order to obtain in-depth information concerning a successful inter-organizational innovation project (Batterink et al., 2006). Next, we investigated the roles and practices of 5 innovation intermediaries (see also par 2.5).

2.3 Rhône-Alpes specific approach

In the region Rhône Alpes, our focus has been on a collective reflection of the OPTIréseaux programme, which is running for 4 years, involving 75 firms and up to 96 SME-driven inter-organizational innovation projects (See Annex 1). The study involved all the different stakeholders taking part in OPTIréseaux. The study was monitored by a neutral consultant. We carried out the following activities:

- 2 workshops, with resp. SMEs, and OPTIréseaux experts and institutional experts.
- 1 questionnaire was sent out to SMEs in OPTIréseaux, with the processing of the 12 returned questionnaires.
- Face-to-face in depth interviews with stakeholders supporting OPTIréseaux, i.e. with a Regional Civil servant, a Civil servant in the Regional delegation of the Ministry of Agriculture, the Head of the agency monitoring training policies for SMEs, and a coordinator of a network of technological advisers for SMEs.
- Face-to-face interviews with PEACRITT staff, by the neutral consultant.
- A bibliographical study.

2.4 Regione Liguria specific approach

In the region Liguria we focused on the development and promotion of an innovation in mechanization in garlic production. Liguria has an economy with many small traditional mountain products. The garlic of Vessalico is such a much appreciated, traditional product. It is a worthwhile part of the network of slow–food products. The project involves the main producer, a cooperative of local producers, "a' resta", which produces the garlic following organic certified method. This is a pilot-project, because the results can be applied in many other mountain areas of Liguria.

The project takes up a problem for the whole region, common also in other sectors. The main problems that the garlic producers have relates to the very small scale of the farms, and the difficulty they have to reach their field with agricultural machines due to the mountains. In this demonstration project we took the following steps:

1. Starting with inspection of the farms.
2. Verifying the concrete needs of the producers
3. Problem solving – finding possible solutions to test in the field.

This project involves SMEs, the Liguria Region, and the University of Pisa - Prof. Peruzzi. More details and background can be found in Annex 3.

2.5 Inter-regional approach (innovation intermediation)

At the cross-regional level, the focus has been on innovation intermediaries. In total, 5 innovation intermediaries were studied: two from the Netherlands, one from France, one from Italy, and a cross-border organization. We focussed on their tasks and roles (cf. Howells, 2006), but also took into account the design requirements (cf. Kolodny et al., 2001). For the analysis of the innovation intermediaries, we combined interview data with related public documents. See table 1 for the results.

2.6 Dissemination of results

This Promstap sub-project used a number of dissemination means. First, individual innovation projects received tailor-made feedback during the projects (in Gelderland, and Liguria). Second, a joint multi-stakeholder meeting is scheduled in Rhône-Alpes, to discuss the role and functions of intermediary organizations in the management of collective inter-organizational projects and networks. Third, the innovation intermediaries received feedback via reports and individual presentations. Fourth, results were presented at conferences, e.g. the Promstap annual congresses in Genua, It. (2006), and Vidin, Bul. (2007). A final scientific article is planned for.

3. Results and discussion

3.1 Introduction

Due to the various methods and regional differences in empirical settings, a broad range of results could be obtained within this project. In this section we will start by presenting the results obtained in the respective regions. Next, we will elaborate the inter-regional results. We present per section the opinions on innovation obstacles, coordination requirements, and the key roles for innovation intermediaries.

3.2 Results in Gelderland

In this section, we first highlight the results from the WIAT application in innovation projects of SMEs. Second, we go in-depth by elaborating on the data from one typical inter-organizational innovation project, that was driven by a group of SMEs, using external knowledge. Finally, we will discuss the most important findings from the interviews with and documents from innovation intermediaries.

3.2.1 WIAT assessments

We learned from the WIAT assessments of 13 innovation projects carried by SMEs, that *team communication, product superiority* and *market volume* can be considered as key success factors (see figure 1). Interestingly, the same key success factors were found for large companies in the agri-food industry. Moreover, it was found that the successful projects, compared to failed projects, involved innovations of **relatively low technical complexity** and few radically new features. This means that SMEs should focus on projects aimed at developing new products or processes that are superior compared to existing ones, but they should be careful not to engage in (technologically) complex or very original projects. Besides, in the case of product innovation, SMEs should be confident about the market potential. Finally, cooperation and communication within the (inter-organizational) project teams should be of high quality. This last factor may even be a prerequisite, difficult to fulfil by SMEs inexperienced in innovation. Innovation intermediaries who do have such experience may fill this void by assisting the firms improving the cooperation process.

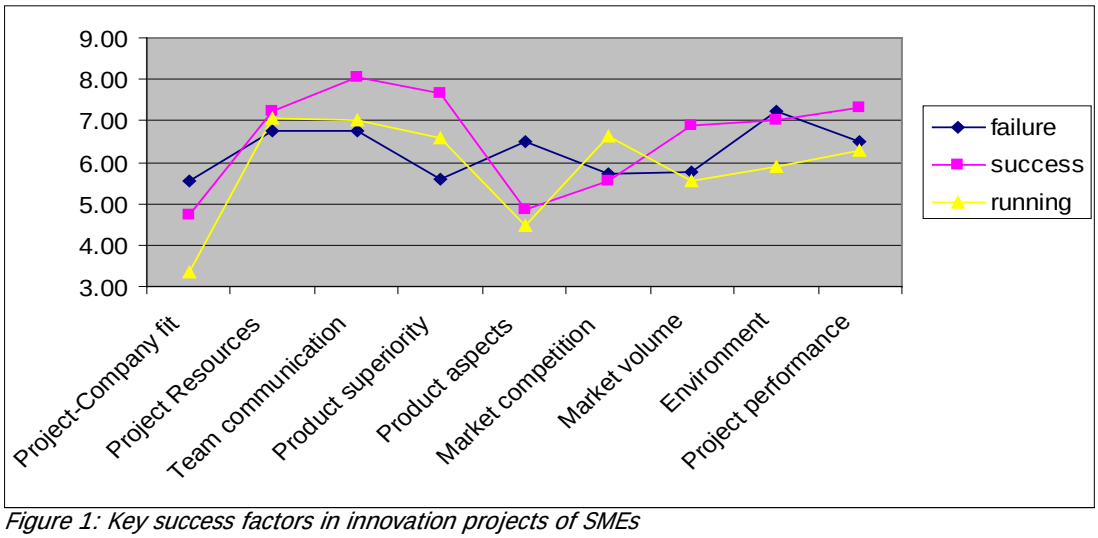

Figure 1: Key success factors in innovation projects of SMEs

3.2.2 In-depth case study of a successful innovation project

Based on the in-depth interviews with 4 key participants of an (high profile) inter-organizational innovation project (3 SMEs and 1 project leader, fulfilling the intermediation function), the following key success factors (KSF) were identified:

<u>KSF related to innovation obstacles</u>

To make a project a success, all participating companies must have a **strong drive**. Many SMEs dislike change and are unwilling to cooperate. To succeed SMEs should be familiar with the latest developments in the sector and must stay in the forefront of developments.

<u>KSFs related to project coordination and the role of innovation intermediaries</u>

A project should have a very **clear initial project plan**, including an orderly and feasible amount of goals, a set of activities and responsibilities for the partners, and detail communication. A project plan should be drafted prior to the formal start of the project and each partner should agree on it. An innovation intermediary can take on that role; setting up the project plan, translating the interests and requirements of the participants into shared goals. The plan should remain amendable to change during the project, as long as all partners agree.

From the start onwards, there should be **clear agreements about the property rights** of the developed technologies, including potential resulting patents. Problems and different opinions should be discussed in a transparent way. **Conflicts,** when they occur, **should be tackled immediately**. Innovation intermediaries can play a pro-active role in this.

The pilot study has been more extensively described in the proceedings of the first PROMSTAP annual congress (Batterink et al., 2006).

3.2.3 In-depth case study of innovation intermediaries

We also interviewed key persons from innovation intermediaries in order to obtain in-depth information on inter-organizational innovation projects. Most interviewees had experience with a large number of innovation projects. We identified the following key success factors (KSF):

KSF related to innovation obstacles

In general SMEs are unfamiliar with a) innovation, b) cooperation, and c) innovation subsidies. **Innovation intermediaries can reduce innovation obstacles**. They may trigger SMEs to develop ideas and help them to conceptualize them, resulting in innovation projects. Moreover, innovation intermediaries may help to develop necessary partnerships (including finding suitable partners, from the regional network of the intermediary), and to find project funding (e.g. by making complex subsidy arrangements accessible for SMEs).

Innovation intermediaries can **connect the world of the SMEs with the world of research**, between which there is normally a big gap. Intermediaries may help by pro-actively seeking the entrepreneurs (using different kinds of networking activities), and maintaining strong ties with research institutions.

KSF and design criteria related to innovation project coordination

Innovation intermediaries should focus on the process, **continuity and speed of the project** not on the content. Only then they can stay independent. Moreover, innovation intermediaries can add value as project coordinator by **guarding the cooperation process and by conflict handling.**

In order to prevent conflicts in the cooperative projects, innovation intermediaries should **use an personal approach**, with a focus on openness and transparency.

Design criteria related to innovation intermediaries design

When the office is **located close to the SMEs** (the target group), the innovation intermediary will be 1) better visible to the SMEs, 2) better able to quickly respond to their requests, and 3) regarded as more independent from the local government, or research institutions. At the same time, innovation intermediaries should remain connected with several research institutes.

When an innovation intermediary has **no structural funding**, they will become more focused on the actors that want to innovate, and will engage in projects that really matter (so called demand driven projects). Innovation intermediaries with structural funding, or with discretionary powers to assign subsidies to projects, tend to engage in projects initiated/driven by researchers or in subsidy-driven projects.

A **track record of successful projects** helps **to gain trustworthiness** from the SMEs. This can be a problem for innovation intermediaries.

3.3 Results in Rhône Alpes

By means of a survey among regional agri-food SMEs, and in-depth interviews with other actors, in the context of the OPTIréseaux programme of PEACRITT, we assessed the opinions on innovation obstacles, coordination requirements, and the key roles for innovation intermediaries.

KSF related to innovation obstacles

The enterprises involved in OPTIréseaux are mostly SMEs and very small enterprises whose manager is the only [contact] for Research. In Rhône-Alpes, high-tech research mostly addresses the big firms or groups having the financial capacity to ensure a 'technological transfer onto the field.' The Rhône-Alpes

agri-food sector comprises mainly of traditional smaller enterprises. A lack of understanding between stakeholders (esp. SMEs and researchers) was noticed and could jeopardize mutual relations: First, the mutual representations are often contrary, which makes the dialog difficult. Second, the time-related priorities are often contrary. Research wants to extend time-horizons as they favour experimentations, the production sector tries to save time for profitability reasons. Third, the objectives of SMEs and researchers are different: especially very small enterprises do not look for fundamental or complex innovations, but **look for technical solutions already approved** and tested. Fourth and final, recognition does not rely on the same principles: SMEs look for an economic and marketing recognition, which may result in consolidation or growth of turnover and jobs. In contrast, research gains fame thanks to the publication of results in scientific literature, which requires a partnership with firms that are outstanding in the scientific field. As a consequence, a KSF for inter-organizational innovation is the **usage of technical resources centres or innovation intermediaries, for they are closer to the industrial world**. They may deal with or even reduce these obstacles, thanks to their function of 'translating' or mediating between SMEs and researchers.

Various KSFs and design criteria related to innovation project coordination. OPTIréseaux does **make implementation clear and simple, by facilitating an administrative and financial frame**. OPTIréseaux allows for simple implementation, thanks to specific facilities: 'There is a predefined financial and administrative framework that makes things easier.' This is really appreciated by both the SMEs, the experts as well as by the public authorities, that prefers to work and contract with interface/intermediary organizations. In this section we will detail individual KSFs to innovation coordination, but first we mention two categories of favourable conditions to collaborative networks.

In general there are various favourable conditions to establish a collaborative network between stakeholders:

- Guarantee the complementarity of the competences and skills of the different stakeholders talking part to network
- **Favour trust**: a relationship is better based on benevolence, but it must also allow matters to be stated lucidly
- Build relationships based on equity
- Promote group autonomy, by stimulating co-responsibility and joint decision making
- Preserve time for training and mutual knowledge exchange.

Some further conditions address specifically enterprises who are not used to collaborative networks:

- Demonstrate to them the interest in working together in a network
- Put forward a flexible and simple device
- Valorize success stories by **systematic presentation of results**
- Formally guarantee confidentiality

<u>Design criterium related to gathering enterprises</u>

OTPTIréseaux appears as a device that favours the collective gathering of knowledge and the knowledge exchange between firms with different non-competitive products or from different geographical areas. Beyond the device, the PEACRITT had the KSF of **being a** '*door opener*' **to collectively analyze a problem and facilitate the linkage to support** the enterprises in the definition of solutions.

<u>KSF related to sharing the costs and the risks</u>

The various linkages within a network between the stakeholders (eg. enterprise-enterprise and enterprise-expert) **aims at reducing costs and risks of innovation projects**, which enhances the chances of enterprise continuity.

This device is a real lever for very small enterprises: they can set up and implement innovation projects, while benefiting from funds and a frame that will allow them to develop individually later on.

Role related to strong collective events

Within the context of OPTIréseaux Peacritt organizes a **platform day for sharing ideas**. This so called OPTIréseaux day is seen as a strong moment of exchange that encourages the articulation of ideas and views by and between enterprises, experts, and the regional authorities.

Role related to the exchange of practices

An original and highly valued component of OPTIréseux is **the optimisation of individual assistance and collective exchange**. A training and transfer modality for SMEs relates the exchange of practices. SMEs value it as a relevant transfer activity. The collective reflections focus on exchanging practices regarding different matters (e.g., process organization, project management).

KSF related to innovation intermediaries design

Finally we discuss the intermediary organizations themselves. The different stakeholders have strong expectations towards intermediary organizations. They need to:

- have a strong presence in the field, to identify new and know running projects
- **be neutral, especially to the experts**. This to identify the quality of the experts, and adapt their answers to SMEs' questions and problems. This criterium was found very important by all the institutional actors.
- encourage partnership
- **guarantee transparency** of the beneficiaries
- to encourage complementarities in a chain
- to ensure a follow-up and an **administrative frame** of the project
- to provide the enterprise with support for the financing and administrative engineering – to help the enterprises to find the right contact
- to ensure a watch-out to explore the future needs
- **to present, i.e. spread, the results**

The innovation intermediary is seen as a 'translator' that bridges the different worlds of different actors: esp. enterprises-enterprises, enterprises-experts, and experts-enterprise-public authorities.

3.4 Results in Regione Liguria

In Regione Liguria we focused on the development and promotion of an innovation in mechanization in garlic production. The main problem to solve for the producers was the weeds control. For this reason, after many different attempts in pilot fields, we experimented alternative methods, esp. mechanical and fire control. This should prevent the use of chemical infesting control. The first results are really encouraging ones and the interest of the producers is as well very high (see Annex 3).

This first year of experimental trials carried out in Vessalico was really promising. The innovative strategies allowed a more efficient weed control and a higher yield (+35%) and gross marketable production (+36%).

The operative machines appeared very effective, versatile and suitable to this interesting agricultural context. Furthermore, the machines are easy to use and cheap. However, further experiments would be necessary in order to improve the innovative technique. The effect of flaming on garlic should be studied under controlled conditions by means of a proper test bench. Next steps are:

- to test other procedures for other phases of the production, such as harvest;
- to complete the definition of a questionnaire for producers to collect data and assess the interest for the project;
- to collect scientific data to test the efficiency of the actions;
- to disseminate the results through leaflets and workshops;
- to develop a final report, identifying possible scenarios, to apply the best practices in similar situations.

3.5 Inter-regional results

For the *Chain Innovation Benchmark* project we combined the results from the different regions, to arrive at (1) key success factors for inter-organizational innovation projects, and (2) find out how innovation intermediary organizations can stimulate innovation and entrepreneurship by means of cooperation and knowledge networks. We made an inventory of results at the different levels, in particular the level of the innovation project, and the level of innovation intermediating organization (see table 1). The projects resulted 10 Key Success Factors (KSFs) for inter-organizational innovation projects, plus descriptions of how project participants can fulfil these KSFs. Furthermore, the table presents the related potential roles of the innovation intermediaries (abbreviated as IIOs) in fulfilling the KSFs, and the design criteria of IIOs that are crucial when they want to act in this role.

Table 1: 10 Key success factors for inter-organizational innovation and related fulfilment and design criteria for innovation intermediaries

	Key Success Factor identified	How to fulfil KSF	Role of innovation intermediaries in fulfilling the KSF	Design criteria of innovation intermediaries crucial for this role
1	Aim of realising superior solutions (e.g. products that are superior to existing ones) fulfilling a real need (e.g. for the SME, or in the market)	Only engage in projects that are demand driven, which means ideas must come from the SMEs, not from research or (governmental) bodies providing subsidies.	Assessing the drivers of participating SMEs. Triggering them to develop ideas. Trying to really understand why they want to participate.	IIOs have a strong network capability, and are close to the SMEs. They actively seek (new) entrepreneurs, in order to identify most promising or urgent innovation needs
2	Project objectives must be clear	An orderly and feasible amount of objectives, a set of activities and responsibilities for the partners, and the way of communication. All participants should agree about them, for the right reasons.	Find out if there are hidden agenda's. Understand why SMEs participate, also consider personal motives. IIO should take sufficient time for this.	IIOs have a personal approach – with a focus on the people
3	Agreements about costs and benefits	Property rights should be settled in an early stage. It can help to elaborate on best-, normal-, and worst-case-scenario's. SMEs must be willing to share.	As an independent party, an IIO can take the lead building an agreement taking into account the interests of all parties. IIOs have templates for contracts, covering the relevant issues in an efficient way. IIO can guard the fairness of this process.	IIOs are (financially) independent from the 1) content / knowledge, and 2) the money (subsidies). It is important that SMEs perceive the IIO as independent.
4	A complexity on the level of innovation technologies that is in concordance with the project team	Excellent access to appropriate knowledge source and know how to find the best knowledge provides. Clear knowledge demand articulation.	Since it is difficult for SMEs to formulate a knowledge demand, and to maintain a good overview of possible knowledge sources, IIOs can typically play a role here	IIOs have people who understand the problems of the SMEs, maintain good connections with a variety of knowledge providers
5	Flexibility in the process	Contract should not be detailed (see KSF 2) and during the process there should be little focus on it. Instead, stay open for the new developments and adapt towards them.	IIO can adjust the type and frequency of communication in order to adjust to the situation (e.g. in the case of problems)	IIOs should pro-actively track and tune running projects

	Key Success Factor identified	How to fulfil KSF	Role of innovation intermediaries in fulfilling the KSF	Design criteria of innovation intermediaries crucial for this role
6	Speed in and continuity of the project	Problems and conflicts should be tackled quickly and in an open way	As an independent party, an IIO can take the lead in handling conflicts. Stimulate transparency (concerning motives, opinions and results) in the project and focus on the persons, as most problems relate to the people	In order to encourage transparency and openness, IIOs a role model to the SMEs and act in an open and transparent way - on a personal level.
7	Clear procedures and tasks for participants	Set clear standards and allocation mechanisms	IIOs can, for instance, process the procedures proposed by subsidy providers in order to make it understandable and feasible for SMEs.	
8	Experience in innovation and cooperation	Include people with experience in innovation and cooperation	SMEs typically don't have much experience in cooperation and innovation, so experience is typically something an IIO can bring into the project	Track record of projects of the people. IIOs should stimulate internal discussions (among personnel) concerning experiences and problems in projects
9	Trust relations	All participants should act in a consistent way, be open and transparent with respect to their (personal) motives, opinions and actions.	IIOs should take the lead in acting in an open and transparent way. This must be shown during the meetings and any actions by the IIO.	Track record of projects enhances the trustworthiness towards the SMEs. Consistent and well articulated approach and philosophy of the IIO can complement track record.
10	Presentation of (early) project results	Pilots, prototyping, participants should be at test location, in order to gain confidence in the successful outcomes. Small go-no go moments.	IIOs can assure that relatively (financially) small go-no-go moments are build in the project and help in assessing the criteria	IIOs should organize a platform day, or a training and transfer module for SMEs and other stakeholders.

4. Conclusion

We conclude from the *Chain Innovation Benchmark* project that for many SMEs cooperation is the only way to make innovation happen. At the same time, however, cooperative innovation is perceived as a very complex activity. Innovation intermediaries play an important role in assisting the cooperating SMEs to innovate successfully. The *Chain Innovation Benchmark* project aimed to obtain profound understanding of how inter-organizational innovation can be carried in a successful way. More specifically, with regard to the first objective (see introduction), the *Chain Innovation Benchmark* project we identified 10 KSFs and elaborated how actors who aim to innovate in a cooperation can deal with these KSFs (see table 1).

With regard to the second objective, the Chain Innovation Benchmark investigated 5 innovation intermediaries in order to identify best practices and to share lessons learned. Next to the identification of a number of best practices (see table 1), we found that some best practices are typically related to the way an innovation intermediary is designed. For instance, in order to be able to assist SMEs, innovation intermediaries should be acting independently from large organizations (e.g. the local government, or a research institution). Moreover, we noticed that successful innovation intermediaries typically had a flexible, personal approach to the participating SMEs.

In addition to our overall findings, it is worth to repeat some specific results obtained in the individual regions here. First, in Gelderland region, 13 innovation projects carried out by SMEs were approached in order to assess the KSFs. These projects were provided with project specific feedback for improving the project. Second, in Rhône Alpes the successful OPTIreséaux programme was evaluated. PEACRITT, which is the organizer of OPTIréseaux, but also other innovation intermediaries can use the results of that evaluation for improving their programmes or setting up ones similar to OPTIréseaux. Finally, in Regione Liguria, *Chain Innovation Benchmark* project assisted in the development and promotion of a mechanization innovation in garlic production of Vessalico. This first year of experimental trials carried out in Vessalico was really promising, as shown by the great interest of local producers. The new technologies resulted in higher yield and grown marketable production.

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Annex

Annex 1: Description of the OPTIréseaux programm

The principles

OPTIréseaux is a device initiated by the PEACRITT in Rhône-Alpes, in the agrofood sector. It is a quite innovative device that can be summed up as follow:

OPTIréseaux is a general framework that allows implementing programs based on collective and *individual* [1] actions:

- addressed to regional agrofood SMEs
- proposed by a group of complementary and united experts (laboratories, universities, free-lance consultants, training institute, research organizations…)
- focused on a subject in relation with innovation, technical or organizational development and that answers a need shared by regional SMEs.
- Selected through an annual tender call. Generally, 5 programs are selected per year by members of professional organizations and SMEs that compose the selection committee.

The stakeholders

The SMEs

Each of the programs needs to gather at least 6 SMEs (up to 12) The SMEs need to have a quite precise internal project in mind in relation to the subject the program focuses on. For example, 6 enterprises gathered in a program about inventory control engage themselves to implement a project about inventory control on the field.

The also engage themselves to take part to collective actions with the other SMEs. In counterparts, they pay only 25% of the costs produced by their projects.

The experts

The experts support the SMEs and coordinate the group pedagogically, scientifically, technically, administratively and financially speaking.

The PEACRITT

The PEACRITT is the guarantee of the device and has a role of facilitator between the experts and the SMEs. It ensures the exchanges between all the stakeholders taking part in OPTIréseaux through collective seminars gathering SMEs and experts from different programs. Every year, it organizes the OPTIréseaux, open to all the SMEs and experts in Rhône-Alpes as well as regional and national institutional actors. This event aims at promoting the device and attracting new persons.

The public authorities

OPTIréseaux is 75% financed by the Region and the regional delegation of Agriculture Ministry.

OPTIréseaux so far

OPTIréseaux device has been implemented for 4 years. 14 opti-réseaux programs has been developed, involving 14 experts and 75 enterprises. Up to 94 projects have been implemented in the enterprises with the help of OPTIréseaux, meaning 2,1 M euro investment.

1 The activities are individual (diagnostic of the project of each involved enterprise, technical assistance, training in the enterprise, engineering) and collective (training workshop, exchange of practices).

Annex 2:

By using the *Wageningen Innovation Assessment Tool (WIAT)*, a diverse set of "ongoing" innovation projects has been evaluated. WIAT is an innovation assessment tool developed specifically for improving agrifood innovation projects. With WIAT, assessments of ongoing projects are compared with historical innovation projects[2] that ended successfully or as a failure. As such detailed information was provided to the participating projects, from which 8 were from SMEs located in the participating PromSTAP regions (see table 1). Especially the weaknesses and threads identified by WIAT were discussed in the project reports and concrete guidelines were provided for the management for improving the projects. Dealing with innovation always means dealing with company sensitive information, because it involves the development of new products and new processes. Therefore, the project reports are kept confidential. Most projects included some kind of cooperation with external organizations. In this set of projects, customers were evaluated as the most important partner for innovation. Competitors, universities, research institutes and sector organizations were also important cooperation partners in these projects, whereas suppliers and consultancy companies were the least important partners.

Table 2: Assessed innovation projects by region

	East Netherlands (Gelderland)	Netherlands (other)	France (Rhône-Alpes)	total
SME (<= 250 employees)	6	5	2	13

WIAT as a tool can be used in future innovation projects. Using the WIAT questionnaire and the benchmark values from historical successful and failed projects, future projects can also be provided with important management information. For instance, innovation intermediaries can use the tool for innovation projects they have under supervision. When applying WIAT, early warning signals can be picked up in order to improve the projects. As the WIAT database grows with innovation project date, it should be possible to build specific sub sets of projects so future projects can be benchmarked against better comparable projects (e.g. a sub sets of only SME-projects, cooperation projects or regional projects).

Annex 3

Mechanization innovation in Liguria

Introduction

The "Centro Interdipartimentale di Ricerche Agro-Ambientali Enrico Avanzi" and the "Dipartimento di Agronomia e Gestione dell'Agro-Ecosistema - Sezione Meccanica Agraria e Meccanizzazione Agricola" of Pisa University, in co-operation with the Liguria Region, carried out a demonstrative and experimental open field trial on organic garlic in the municipality of Vessalico, a small town placed in the Ligurian hinterland. This activity was carried out within the Promstap Interreg European Project.

The aim of this activity was to introduce a model of efficient mechanization chain in this very interesting agricultural context, that is characterized by very small terrace fields, in which a particular and high value garlic ecotype is cultivated.

The mechanization has principally to solve three different problems: planting, harvesting and weed control. The first and the second problems were partly solved by a market research carried out by the researchers of Pisa University: few models of commercial operative machines (pneumatic planters and potato diggers modified on purpose for this context) were found but not tested.

Innovative machines for physical (non-chemical) weed control, built and improved by the University of Pisa, were adapted and tested during a specific experimental trial carried out during 2007.

2 A paper with the results of WIAT applications in agrifood prospector companies will be presented at the 2007 IAMA-conference in Parma, Italy

The operative machines for physical weed control

In the course of the experimental trials, three different mounted operative machines for physical weed control were used. The working width of all these implement was 1,4 m, while a short description of each of them is reported below:

- the rolling harrow is a very versatile machine, and it can be used both for false seedbed technique (pre-planting interventions) and hoeing (post-emergence interventions). It is equipped by two gangs of tools flanged on two parallel axels: spike disks on the front and cage rolls on the rear. The axels are connected by a chain drive with a ratio equal to 2, that means that rolls rotate with a double peripheral speed with respect to spike disks. The machine allows a good weed control and a good separation between weed roots and soil. The soil is tilled and crumbled till 3-4 cm and the working speed can reach 8-9 km/h. For post-emergence treatments, the machine can work from 15 to 90 cm of inter-row space. This machine was utilized on garlic just for pre-planting weed control interventions;
- the flaming machine controls weeds by means of an open flame, generated by common LPG combustion. It was equipped by 3 rod-burners 50 cm wide. During the experimental tests, treatment were carried out in correspondence of the crop emergence and in post-emergence, because garlic is a tolerant plant, but flaming is normally used on vegetable crops before seeding or transplanting or in pre-emergence. The working speed was 3 km/h and four different LPG pressures were tested (from 0,2 up to 0,5 MPa),
- the precision hoe, is characterized by 6 elements each one bearing one horizontal blade rigid element and two different kinds of elastic tools for selective weed control on row crop (torsion weeders and vibrating tines). The machine is also equipped by a precision guidance system, with a steering handle, driven by a back-seated operator.

The experimental trial

During the experimental trial, an innovative strategy of weed control and crop spatial arrangement was tested and compared to the traditional organic garlic cultivation.

The innovative strategy included a stale seedbed technique (carried out by means of the rolling harrow and the flaming machine) and post emergence interventions (carried out by the precision hoe and flamers). In order to maximize the machines efficiency and the crop yield, garlic was manually planted with 20 cm inter-row space (in order to simulate the work of a precision planter).

The traditional strategy included 50 cm inter-row space planting (by a on purpose modified one-row potato planter) and weed control was carried out by means of a little self propelled walking operator rotary hoe.

Different techniques were also tested within the innovative strategy, following a split-plot design with three replicates: 4 different flaming pressures in correspondence to emergence (0,2; 0,3; 0,4; 0,5 MPa) X 4 different post-emergence treatments (hoeing with torsion weeders; hoeing with vibrating tines and torsion weeders; post-emergence flaming and no post-emergence treatments).

Weed flora density and the main crop parameters were assessed during the experiment.

Results

The innovative machines allowed to reach a very good weed control, as shown in figure 2, where dry weed biomass at harvest, for the two different systems, is reported. Conventional strategy was characterized by a 5 times higher values with respect to the alternative technique.

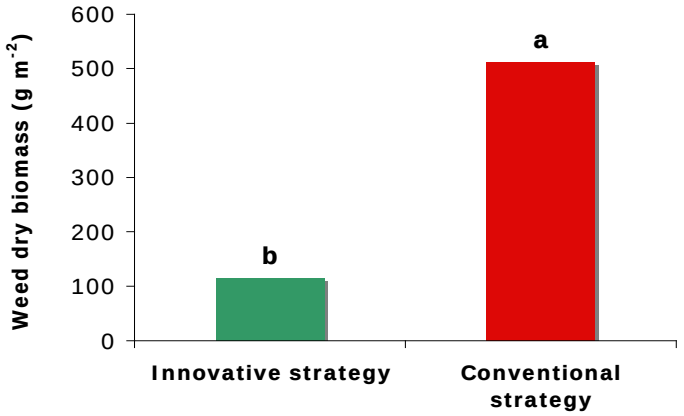


Figure 2: Weed biomass at harvest on organic garlic in Vessalico.

Concerning with innovative strategy yields, higher values were observed when lower LPG pressure decreasing were used to perform flaming treatment at crop emergence (figure 3). Probably the crop suffered from the hardest treatments. However garlic was always able to recover.

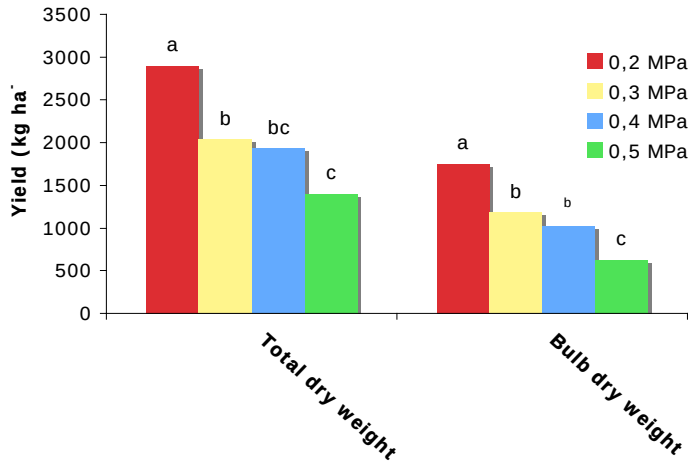


Figure 3: Garlic yield obtained with the innovative strategy during the experimetal tests carried out in Vessalico.

With regard to yield and gross marketable production comparison between the two systems, the innovative strategy allowed to reach significant higher yields (+35%) and GMP (131000 vs 96000 €/ha) (fig. 8, 9 and 10).

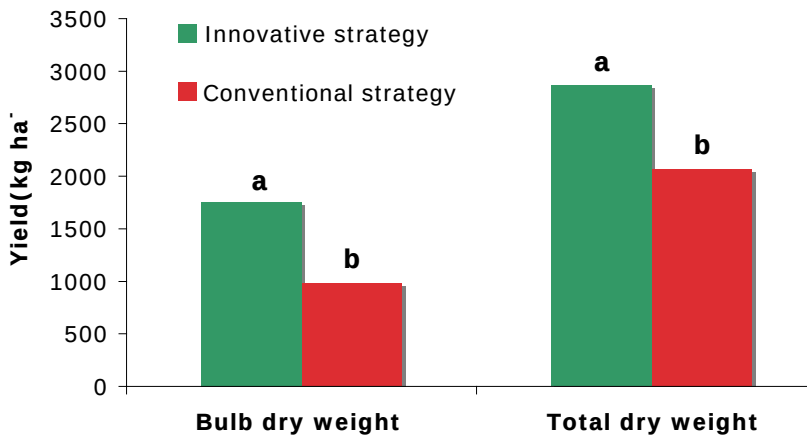


Figure 4: Organic garlic yield obtained in Vessalico during the experimental trials carried out in 2007

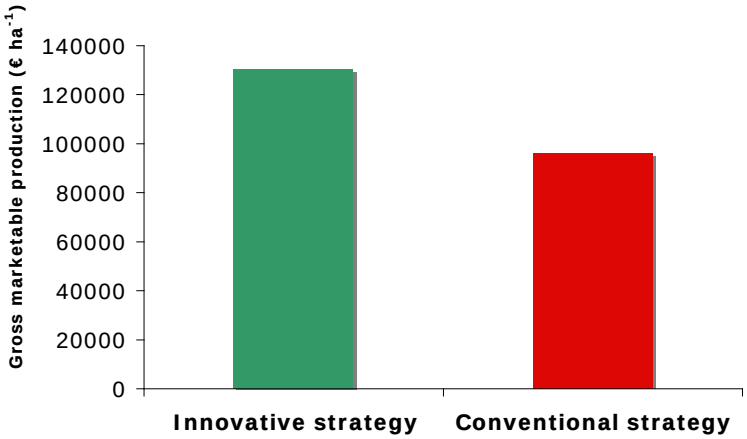


Figure 5: Organic garlic gross marketable production estimated in Vessalico during the experimental tests carried out in 2007

Quality standards in the enterprise environment – cost/benefit, best practice and training

Krieger, St.[1], Schiefer, G.[1], Gardere, E.[2], Molegnana, F.[2], van Plaggenhoef, W.[3] & Trienekens, J.[3]

[1] Institute of Food and Resource Economics, Meckenheimer Allee 174, D-53115 Bonn, E-mail: st.krieger@uni-bonn.de, schiefer@uni-bonn.de

[2] PeaCritt, 100 route de Paris, 69260 Charbonnières les Bains, France, E-mail: gardere@peacritt.fr, molegnana@peacritt.de

[3] Wageningen University, Hollandseweg 1, 6706 KN Wageningen, The Netherlands, E-mail: Jacques.Trienekens@wur.nl, wijnand.vanPlaggenhoef@wur.nl;

Abstract

Enterprises in the agri-food sector are increasingly confronted with the need to adjust their production processes and operations to the requirements of quality systems and to implement these requirements into their own individual integrated process management system. Occupational-health- and environmental systems need to be implemented in addition to quality systems. The economic problem is to search for and find the efficient combination of management systems. The project involved the development of an advisory system to support the calculation of costs and benefits of quality systems, the analysis of best practice solutions for the implementation of quality systems and the creation of a training concept for quality systems. The development of a conceptual framework for the calculation of costs and benefits is based on expert knowledge and experience, literature analysis, surveys. The result is the advisory system "QualintSys". Referring to the implementation of quality systems the focus was on the improvement of efficiency. The identification of "Best Practice" solutions and a number of recommendations to firms to achieve "best practice" quality management systems is the aim of the interviews, which were done by the University of Wageningen. The implementation of quality systems and also environmental and occupational health systems needs training, which is an important step for enterprises. Partners developed 12 good practices for training of occupational health and management in general.

1. Introduction

In the past years, a number of issues and trends have brought increased attention into safety and quality considerations in the agri-food sector. This includes the "mad cow" disease crisis and expansion of the international trade of food, fuelled by advances in production, transport, information technology and other deployments in the cooperation of supply chains. In order to promote food trade and maintain consumer' s trust in product quality and safety, quality management is of high importance for agri-food enterprises. Safety and quality standards, assurance systems and a legislative frame-work could be built around the business concept "Quality management". The development of quality standards with focus on processes is not a new concept, it has begun to receive attention in the eighties. Systems based on "good practices", encompassing good agricultural, good hygienic, good manufacturing and good trade practice were developed. Since the nineties, the international standard ISO 9000ff. has become popular in the agri-food industry. The reason for the development of the ISO 9000 ff. was the publication of a consistent norm, which formulates a framework for quality management. In 1993, the European Union officially recognised the HACCP concept as a standard production method for food manufactures to implement and maintain a production control system. Furthermore, quality systems have been developed with specific requirements for the agri-food industry and with a focus on supply chains and networks (Krieger & Schiefer, 2004; Luning et al., 2002).

Different organisations, both public and private, developed these specific quality systems. Whereas mandatory food safety and quality systems exist, enterprises often have a choice of whether or not they should adhere to a specific system of norms and regulations. Hence, cost and benefit considerations are likely to be taken into account in decision processes regarding safety and quality management system adoptions.

Quality system standards could contain requirements related to

a. The organization of production processes (e.g. setting requirements to the utilization of pesticides in farms),
b. The management of the quality system (e.g. requirements concerning the documentation; setting of a quality policy),
c. Product characteristics like quality (e.g. cleanliness), safety (e.g. pesticide residue) and au thenticity (e.g. geographical origin) and
d. The infrastructure environment (e.g. special requirements to the size of a cot) (e.g. Giovan nucci & Reardon, 1999; QS, 2007; IFS, 2004).

The requirements of different quality standards could be congruent. Therefore a com-parison of the different requirements is a solution to find accordance of different quality systems. The benchmark and harmonisation of different quality standards have started during the last years. Feasible approaches for the harmonisation and benchmark of quality standards are the following:

i) Benchmark with the result of an acceptance between different standards: two checklists are benchmarked and small differences are matched
ii) Benchmark of standards and the development of an additional checklist (e.g. QSGAP)
iii) Development of a Task Force with participants of quality standard owner with the result of a benchmark of quality standards (e.g. European Meat Alliance)
iv) Development of main criteria for the benchmark of quality standards (e.g. Global Food Safety Initiative Guidance Document) (Luning et al., 2002)
v) A “one way” benchmark, where one quality standard is basic for the benchmark (e.g. Global-GAP-Benchmark) and
vi) Development of a new standard with the harmonisation of different standard requirements (e.g. ISO 22000, GlobalGAP) (Dreusch, 2006; Mazé et al., 2006).

These current developments are the basis for the developed advisory model to calculate costs and benefits of quality standards. The content of the advisory model is next to the developed decision support tool “QualintSys”, a SWOT-Analysis framework, an optimization model and a hierarchical order of cost and benefit categories.

The identification of “Best Practice” solutions within the project for the implementation of quality systems describes a number of recommendations to firms to achieve “Best Practice” quality management systems based on a number of in depth interviews in three agricultural sectors. These practices give firms ideas about the way they could improve their quality management system and their relationships with customers and suppliers. However, a model is an abstract and simple representation of reality and “best practices” are descriptions of reality. The implementation of quality systems and also environmental and occupational health systems needs training, which is an important step for enterprises. For training support, the project developed training modules for enterprises, e.g. for training in occupational health standards and management in general.

2. Materials and Methods

The advisory model is the basic for the estimation of costs and benefits of quality systems. The development of the conceptual framework of the advisory model involved the specification of an optimization model, the description and categorisation of quality system requirements, the organizational and content specific components for a cost and benefit calculation model and the analysis of case studies which demonstrated deficiencies in the implementation of quality systems. In a structured development process this framework was transferred into the internet based decision support system “QualintSys”, which provides an efficient, flexible and individual information basis about quality system requirements. In the development of the database of “Qualint-Sys” the following methods have been used: Cost Utility Analysis, Analytical Hierarchic Process (AHP) and SWOT-Analysis.

The advisory system for the calculation of costs and benefits of quality systems was evaluated within case studies. The evaluation demonstrated the applicability of the advisory system for choosing an optimal quality system implementation combination as well as for the implementation of integrated quality systems.

In addition, to the costs and benefits, enterprises, that want to adopt new quality management systems, may be interested in their quality management position compared with other firms in their sector. Furthermore, they may be interested in advices, which may help them during the implementation of new quality management systems. By means of the outcomes of a large-scale survey, it becomes possible to benchmark its own position with the averages of Dutch firms in the poultry meat chain and fruit and vegetable chain. In this part of the project, a number of quality and performance related indicators along with their scores are described. Indicators consist of variables that have an impact on quality management in the chain such as external pressures, information exchange by means of ICT, specific investments, commitment and the quality strategy of a firm. Next, a number of variables, which is affected by integration of quality management, are defined such as commitment, enforcement, buyer satisfaction and revenue growth. The model, which was used in the survey, is described in Figure 1.

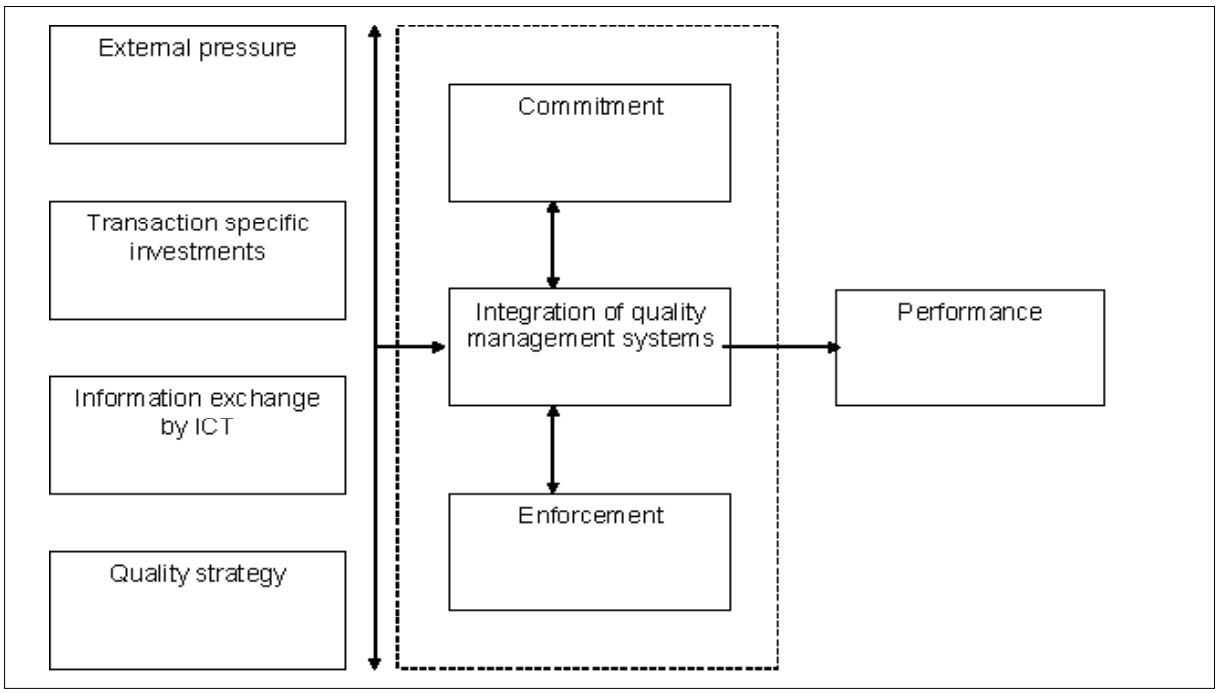


Figure 1: Research model for the survey

Furthermore ten interviews with primary producers, processors and/or traders in the three chains and experts from certification organizations and governmental agencies were accomplished. The objective is to come up with examples of 'best practices' about the way quality management and self-regulation systems could be organized. It provides recommendations for managers based on these 'best practices'. More information about the relationships between the variables and the best practices for quality management derived from the survey can be found in the PromSTAP project 'Best Practice Quality Management Systems'.

Data were collected during the period from October to December 2005 by means of a paper based self administrative survey sent to the owners and the quality managers of the firms. This method was selected because the purpose was to examine patterns of associations, which requires quantifiable data and a large enough number of responses to allow for statistical testing. Little secondary data (data not gathered for the immediate study at hand) regarding the topics of the present study were available. The information that was available was often descriptive, fragmented or anecdotic in character.

In the run of the project, the PEACRITT organized and moderated five workshops whose aim was to analyse the practices of managers regarding occupational health management, but also, following the participants' needs, management in general: staff motivation, communication, relation with the customers… Each workshop gathered between 3 and 6 enterprises.

On the basis of a core question collectively decided upon, each participant alternatively presents one's situation, practices, success and difficulties. The other members ask questions in order to make him/her precise, clarify and argue some elements. This exchange can integrate external expertise's contribution, if it is opportune. In our case, the head of the IHIE (Institute for Industrial Hygiene and Environment) attended the workshop in order to contribute and bring expertise about precise points tackled in the run of the exchange.

The promising practices and the pitfall are identified, formalized and written by the moderator, in order to build a resource for the participants. It can be relevant to foresee some study visits to see the practices.

Table 1: Key conditions for the success of a workshop, depending on the actor

The enterprise	The moderator	The expert
- To have respect for what the others say: no judgement - To play the game: to be active, to ask questions, to try and answer the others as precisely as possible - To be listening to the other - To be curious in order to understand the other's point of view - Not to keep the floor - To be open to other method of work - To tackle an issue and be ready to change one's practices.	- To define and guarantee the rules necessary to the exchange: respect, listening, benevolence, open-mindedness, confidentiality, co-responsibility - To trust the group's will to exchange and produce - To prepare the workshop (to build a tool able to efficiently capitalize the exchange + to give the instructions to the external expert – role sharing, position of each one) - During the workshop, to take notes, reformulate on a board - To preserve time for the participants to think and ask questions.	- To trust the group's will to exchange and produce - To bring one's knowledge in relation with the participants' practices and knowledge - Not to react immediately to statement or practices that seem to be aberrant from the expertise point of view.

3. Results and Discussion

3.1 Advisory model for cost and benefit estimation

The aim of the advisory model is the development of an integrated description model to simplify the management of different quality, environmental and occupational health systems in the agri-food industry and the development of a framework for the calculation of costs and benefits of the different systems.

3.1.1 Main elements of this advisory model are:

1. QualintSys: A decision support model with connection of requirements of cost and benefit categories,
2. The development of a hierarchical order of benefit and cost categories within expert interviews (support tool: AHP),
3. A SWOT-Analysis for the estimation of direct benefits concerning the implementation of a system and
4. The Cost-Utility Analysis for connection of results of QualintSys, interviews and SWOT-Analysis.

And with these elements the following goal function has to be fulfilled:

Optimization model

Goal function:

(4.1) $$\text{Max } \partial U \Big/ \partial C = \frac{\left(\sum_{j=1}^{n}\sum_{i=1}^{m}\left(U_j \times X_j\right)\right) + U_d}{\left(\sum_{k=1}^{l}\sum_{i=1}^{m}\left(C_k \times X_k\right)\right) + C_d}$$

(4.2) $X \cap$ all KO-Criteria

(4.3) with $X \geq 0, U \geq 0, C \geq 0$

3.1.1.1 QualintSys

Content of QualintSys:

Audit and implementation requirements (information out off the manuals that include requirements and interpretations of different quality standards and requirements of environmental and occupational health standards) and the categorisation of these requirements (through benchmark) are the basic of the database “QualintSys”. The result of this benchmark is the presentation of requirements, which are part of both selected systems or which are specific for one system. A categorisation was an important step to find a basis for the estimation of costs and benefits.

Functionality of QualintSys:

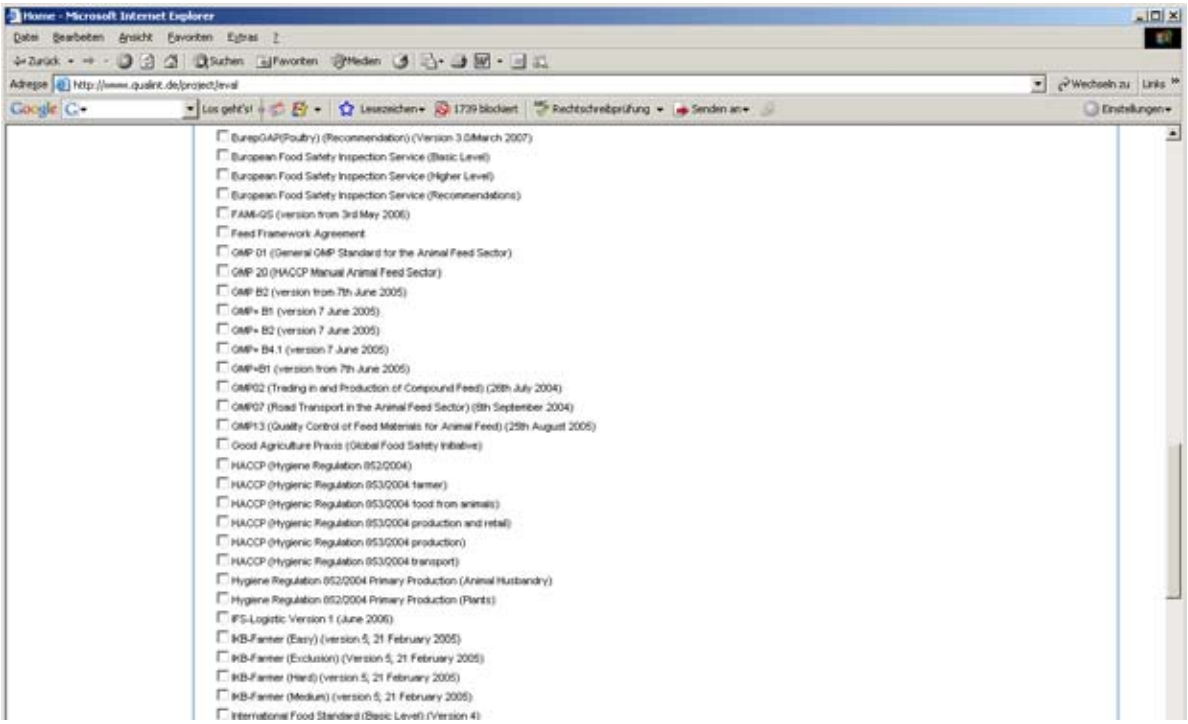
The Functionality of QualintSys is presented in the following table 2 (Explanation see annex).

Table 2: Key conditions for the success of a workshop, depending on the actor

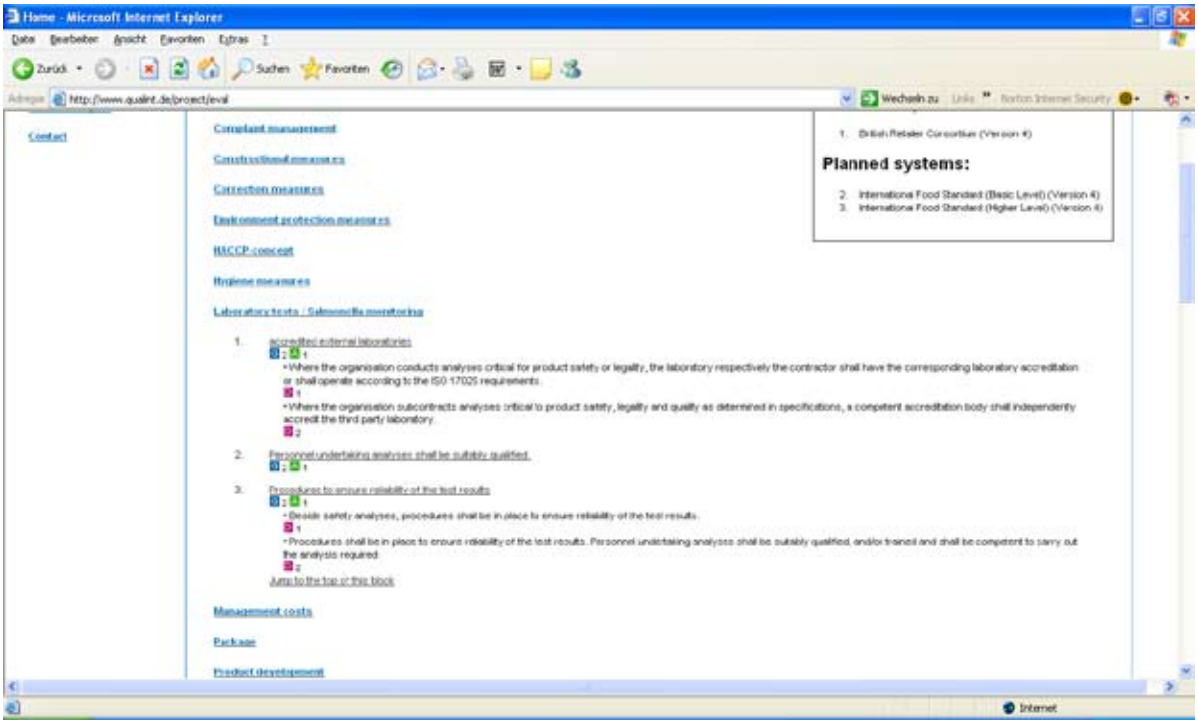
Numbers	Run of the decision support system	Content of QualintSys	Operationalization
1.	Choosing of language	German, English, French (partly)	Translation of standards
2.	Implementation of existed quality systems (Screenshot 1)	Selection of international quality, environmental and occupational health standards	Actual - situation of the enterprise concerning quality standards
3.	Implementation of new quality standards (Screenshot 1)	Selection of international quality, environmental and occupational health standards	Future - situation of the enterprise concerning quality standards
4.	Choose of operation		
a)	Audit checklist	Benchmark chapter sorting	Benchmark of requirements
b)	Department	Department sorting	Benchmark of requirements
c)	ISO-chapters	ISO-chapter sorting	Benchmark of requirements
d)	Cost categories	Indirect cost sorting	Benchmark of requirements
e)	Benefit categories	Indirect benefit sorting	Benchmark of requirements
5.	Result presentation		
a)	Audit checklist	Benchmark chapter sorting	Checklist (alphabetical order)
b)	Department	Department sorting	Checklist (department specific)
c)	ISO-chapter	ISO-chapter sorting	Checklist (ISO 9000 chapter sorting)
d)	Cost categories (Screenshot 2)	Indirect cost sorting	Checklist with cost category sorting
e)	Benefit categories	Indirect benefit sorting	Checklist with benefit category sorting

Numbers	Run of the decision support system	Content of QualintSys	Operationalization
5.	Elimination of legal requirements	Marking of legal requirements	Checklist with reduced requirements
6.	Check of results list and elimination of still fulfilled requirements	Result checklist	Checklist with reduced requirements
7.	Presentation of result checklist	Final checklist with requirements	Summation of final requirements

The following two screenshots will give an inside into the internet presentation of QualintSys.



Display 1: List of quality systems (choose of implemented and additional quality systems)



Display 2: Output: summary of fulfilled requirements and additional requirements

3.1.1.2 Hierarchical order of cost and benefit

The Analytical hierarchic Process (AHP) provides a method for decomposing a complex decision problem into a hierarchy of more easily comprehended sub-problems. When evaluating this hierarchy, the AHP considers measurements and other objective data about its various elements, but its essential nature is to work with the decision makers' judgments about the meaning and importance of that information. It also works with their judgments about intangible aspects of the decision (Meixner & Haas, 2002). During this project the AHP was a method for the development of a hierarchical order for costs and benefit categories of quality systems.

3.1.1.3 SWOT-Analysis

The function of the SWOT-Analysis is to find the strengths and weaknesses of an enterprise and to analyze which opportunities and threats it owns in special situations. A framework for a SWOT-Analysis was developed to find a basic for the estimation of direct benefits, which could be considered after the implementation of a quality system. The user could implement his actual situation and he could find the opportunities and threats of a quality system implementation.

3.1.1.4 Cost-Utility-Analysis

The purpose of the Cost-Utility Analysis is to estimate the ration between the cost and the benefit. Cost is measured in monetary units. Benefit needs to be expressed in quantitative values. However, unlike cost-benefit analysis, the benefits do not have to be expressed in monetary terms (Rinza & Schmidt, 1992). An aggregation of the developed results and the calculation of the costs and benefits were done within the Cost-Utility-Analysis.

3.1.1.5 Case Study

The case study should show the verification of the developed advisory model and it should give first results concerning costs and benefits of quality systems. The case study is a grain processing enterprise with an IFS and ISO 9000 certification, which has to decide, if it implements ISO 22000, BRC, SQF 2000 or a combination of these standards. The first step is the choosing of the additional requirements, which the enterprise has to fulfill for a new certification with QualintSys. The presentation of the results is divided in cost and benefit categories.

Figure 2 and 3 present the results of the interviews with AHP and expert choice. Two grain processors were asked to estimate the costs, if changes in the specific categories have to be done for a certification. The highest costs the interviews reveal concern changes in the process level, followed by infrastructure/ equipment, administration and product quality/food safety (see figure 2).

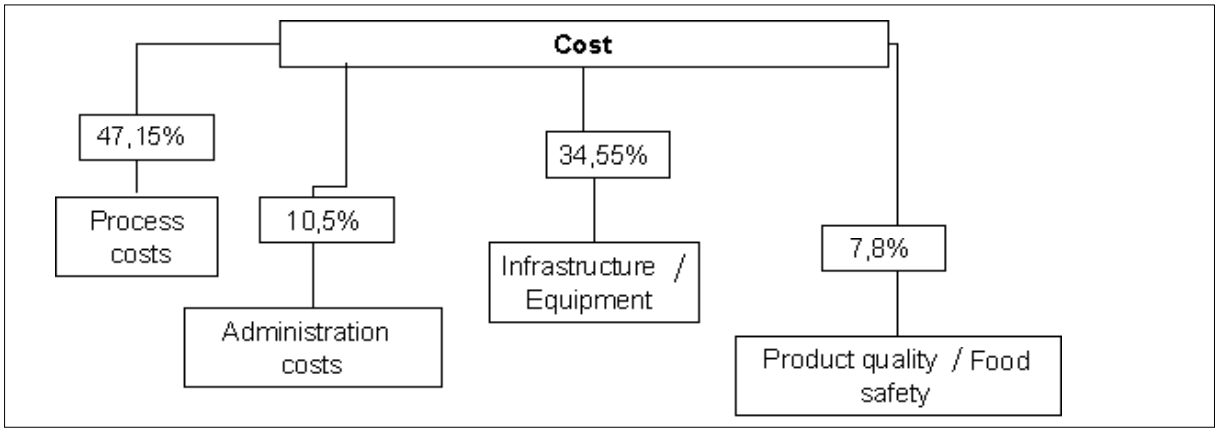


Figure 2: Hierarchical order of cost categories

Benefits have to be arising after the implementation of a quality system in food safety, in process, market entry etc. (see figure 3).

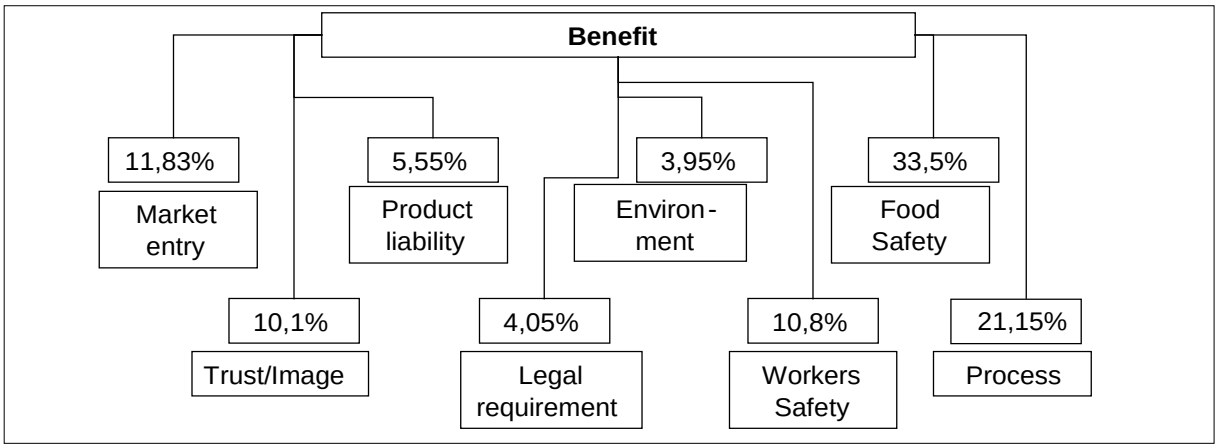


Figure 3: Hierarchical order of benefit categories

The next step is the SWOT-Analysis (see table 3).

Table 3: SWOT-Analysis

Strength	Weaknesses
Market entry *Market position*: Good image Relative high market share *Customer-supplier-relationship:* High quality philosophy **Image/Trust** *Product quality:* Good product quality *Customer satisfactory:* *Process quality* Good functional processes **Product liability** *Risk management* Product liability insurance *Crisis Management* Traceability system Organized crisis management with crisis management group	**Market entry** *Market position:* Good be better *Customer-supplier-relationship:* Long contracts **Image/Trust** *Product quality:* Not optimal quality *Customer satisfactory:* Not good customer satisfactory measure Lot of customer complaints *Process quality* Process optimization is possible **Product liability** *Risk management:* No electronic support discussion *Crisis Management*
Opportunities	**Threats**
Market entry - Global market entry - Much buyers ask for it - Customer pool can be also the same in the future **Image/Trust** - Higher transparency and trust in B2B - Reduction of supplier audits **Product liability** - Detail requirements - Higher self regulation	**Market entry** - External pressure for implementation - Competition between quality systems (f.e. IFS & BRC) - Development of new systems from traders (f.e. Tesco, Carrefour, ...) **Image/Trust** - Global problems if deficits arise - No „B2C“ quality system - No label **Product liability** - Exclusive reliance on quality systems - No stages cross information collection

The next step is the aggregation of all results into the cost-utility analysis (Read much more in Krieger, 2008). The results are presented in table 4. The best alternative for this enterprise is to implement the SQF-2000 standard.

Table 4: Decision support table for the implementation of a quality system

Value / Quality standard	Utility value x weighting	Costs	Utility value / Costs
ISO 22000	2,4729 * 0,4305	15.369,98€ * 0,5695	0,12
BRC	2,0452 * 0,4305	14.147,85€ * 0,5695	0,11
SQF 2000	1,5589 * 0,4305	8.277,69€ * 0,5695	**0,14**
ISO 22000 + BRC	4,588 * 0,4305	27.286,45€ * 0,5695	0,13
ISO 22000 + SQF 2000	3,2703 * 0,4305	23.442,13€ * 0,5695	0,11
BRC + SQF 2000	3,2954 * 0,4305	20.827,25€ * 0,5695	0,12
ISO 22000 + BRC + SQF 2000	4,956 * 0,4305	35.364,12€ * 0,5695	0,11

3.2 Best practice

In total 399 firms reacted to the survey to select "Best Practice" solutions for the implementation of quality management. Table 5 shows the distribution of the respondents across the chains:

Table 5: Number of firms per chain

Firm	Number of firms		
	Poultry meat	Fruit and vegetables	Total
Primary producers	116	151	267
Traders/processors	34	98	132
Total	150	249	399

Although the response rate was not high for poultry meat processors, data on the number of employees and the yearly turnover showed that many big firms in this chain had returned the questionnaire. Taking a turnover of 5 million Euros per year as a cut-off value between small and large firms, a response rate of 35% was achieved for this group1. For fruit and vegetables, 24 traders and/or processors with a turnover of 25 million Euros per year returned the questionnaire. A turnover of 25 million Euros a year is regarded as the turnover dividing small and large traders on the domestic market (Frugi Venta, 2006). If it is assumed that all these 24 traders and processors are active on the domestic market, a response rate of 67% has been achieved in this group. For primary producers the selection of larger firms had already been made before sending the questionnaire, because much more information about size for these groups of firms was available at the Product Boards. Data from big firms is advantageous, because these firms cover a large part of the total market.

3.3 Training – Good practices

Twelve practices have been identified with the enterprises, which are directly related to occupational health or management in general. First the report sums up the main issues covered by the occupational health management, the critical points to take into account and the good practices able to tackle those critical points.

1 According to a spokesman of the Product Boards of Livestock, Meat and Eggs in the Netherlands there are approximately seventeen big slaughterhouses and forty big cutters (Ms. Ariënne Visser, personal phone call, December 2005). She stated that previous research in this sub-group had obtained lower response rates.

Main issue covered by security at work and identified by INRS experts

- Analysis of accident at work and professional diseases
- Regular checking and maintenance of the equipment
- **Behaviour of the enterprise towards the sub-contractors**[2]
- Behaviour of the enterprise towards temporary workers
- **Prevention of emergencies**
- Purchase of new equipment and products
- Conception of posts and work situations
- Occupational health
- Implementation of prevention general principles
- Regulation watch
- Implementation and update of unique document
- Implementation and updating of the action plan
- Objectives and monitoring indicators
- Training program
- **Human resources**
- Involvement and exemplarity of the management
- **Communication**
- Practices regarding managerial quality, security, environment
- **Policy**

After the identification of good practices by enterprises, INRS developed training indicators and practices for these good practices (see table 2).

Behaviour of the enterprise towards the sub-contractors

INRS Indicators	Prevention plans, loading and unloading protocol		
INRS practices	The two firms do specific assessments of the risks. The prevention plan is forwarded and commented to the employees. The firm looks after the right implementation of the plan.		
Enterprises' practices	**To visit an enterprise that is (likely to be) a customer with the staff**		
	Aim	**Implementation**	**Success conditions**
	- To give the staff a sense of responsibility by showing them the consequences some careless gestures or behaviour can have on the whole process - To show that 'there can be more difficult and constraining rules elsewhere' - To allow a distance	To visit an enterprise and ask the employees to report in a form what they are astonished at	

2 In heavy characters, the points for which together with the enterprises we have identified promising practices thanks to the workshops.

Prevention of emergencies

INRS Indicators	List of the risks; fire brigade; Evacuation plan; Description of scenario; Sticking up emergency numbers; Instructions in case of emergency		
INRS practices	An intervention team has been trained in using the tools; Emergency tools and exits are free; Evacuation plans are always stick up, in every section of the firm; Scenarios of extreme emergency are tested every year, to habilitate the intervention and evacuation procedures. A crises cell is planed		
Enterprises' practices	**To simulate an emergency situation the employees can face**		
	Aim	**Implementation**	**Success conditions**
	To evaluate if the reflex facing danger or emergency are acquired	- To simulate a fire alert but in the darkness to avoid too much predictability - To tell a worker a scenario showing a danger and ask him/her 'and now, what would you do?'	

Human ressources

INRS Indicators	Organization chart, definition of functions		
INRS practices	There is a person in charge of security in the enterprise; he/she bears all the security actions. The other employees consider this person as their adviser. Everybody's missions regarding security is defined (authority, competences and means)		
Enterprises' practices	**To delegate among the staff, reference persons in charge of forwarding the security instructions towards their colleagues**		
	Aim	**Implementation**	**Success conditions**
	- To serve as an example - To play on the 'peers' dimension	To find intermediary persons and officialize them in a go-between management position	- The referent has to be voluntary, coopted by the other employees and know the other's activities in the firm - Repression should not overcome prevention and pedagogy: he/she ensures a role between a tutor and a trainer - To take care that the problems and questions rose to the referent are taken into account by the management

Communication

INRS Indicators	Minutes of the security-related meetings, notice board, internal newsletter, intranet		
INRS practices	Communication is on regular basis. It can concern a category of employees more than others. For example, 'a security moment' in the run of a production meeting. The results regarding security and the employees' proposal are posted in the workshop		
Enterprises' practices	**To illustrate the security instructions with familiar pictures**		
	Aim	**Implementation**	**Success conditions**
	- To make the acquisition of the instructions easier since the workers recognized themselves in the situation it is referred to - To authentificate the message - To rely on the visual memory of the worker	- To display next to the name of the first aid workers the staff need to call in case of problem their photo, with a touch of humour - To display on the post sheet the photos of the enterprise's employees	- Not to hesitate to vary and change the media in order to avoid that they are not 'seen' any more. - To work with the good and the bad example

Policy

INRS Indicators	Posted policy (place, numbers?) Minutes of the information meetings for employees (frequency?)		
INRS practices	The policy is adapted to nature of activities and the size of the firm. It takes into account the results of risk assessment and precise the strategic objectives. It is known from all employees The firm's value are concealable with the respect of the human being, transparency and social dialog		
Enterprises' practices	**To internally communicate on the enterprise's project**		
	Aim	**Implementation**	**Success conditions**
	- To encourage the sense of belonging to the company - To give more autonomy to the staff - To ensure that the external speech meets the internal speech	At the staff entrance, to display a post where the enterprises' project is indicated, at the same level as the security instructions	

The developed good practices for management in general will be translated into English in the future. All these results will be displayed on the website (www.qualint.de) monitored by Bonn University (see screen shot).

4. Conclusion

In order to answer the most important question in the introduction: "Which combination of quality systems is the most efficient economic solution for an enterprise?" an advisory model was developed. The content of the advisory model is a decision support model "QualintSys", which provides a benchmark of quality standards and a categorisation of requirements into costs and benefit categories. Additional to the decision support model, methods for the calculation like the Analytical Hierarchy Process and the

SWOT-Analysis were basis for the cost-utility analysis. Case studies give first values for the orientation of costs and benefits. Next to this important calculation of costs and benefits of quality systems, best practice solution were developed to create the best way of self regulated quality management systems in the agri-food supply chains and good practices concerning the training of occupational health and management in general.

Quality managers in agri-food firms might ask themselves question such as: "How should we start or strengthen the integration of quality management with our buyers and suppliers?", "What factors do influence the integration of quality management with our suppliers and buyers" and "How can we benefit from integration of quality management systems?" The project has identified a number of important implications concerning collaboration to improve performance, better use of quality data and align quality strategy with firm strategy.

Twelve good practices have been identified concerning the training of management in general and occupational health. This paper has in detail presented the identified five good practices for the training of occupational health, which concern: the behaviour of the enterprise towards the sub-contractors, prevention of emergencies, human resources, communication and policy.

Implications for policy makers

- Policy makers might be interested in the answers of questions like: "Which requirements of private standards are legal?" "Which influence do quality standards have on enterprises?" "How can the public and private inspection of enterprises be optimised?"
- The results of this project answered some of this questions and additional there are some possible recommendations for the public sector to improve agri-food quality and safety:
- The intensification of cooperation between public and private initiatives in the part of quality management and food safety would be a beginning to minimize deficiencies and to decrease control costs.
- The implementation of more private control systems in combination with public control can be a possibility. Controls can be supported with a standardized checklist by public and private organisation which includes quality systems and public demands.
- The intensification of capacity building activities. An advantage would be uniformly designed training courses for both private companies and public agencies' staff.
- Promoting lower variety of quality systems. This is also an area that can be improved with the support of public organisations. A need for a more standardized approach to compliance, harmonisation or a two-way acceptation of different quality systems would be necessary.
- Higher sanctions and more publicity, when an enterprise breaks the legal or private requirements would be necessary.
- Heightened consumer awareness of the benefits of quality and safety. More consumer education and demonstration of benefits of improved quality and food safety are desirable (Krieger & Schiefer, 2007).

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Annex

Information sheet about "QualintSys"

Different organisations, both public and private, developed these specific quality systems. Whereas mandatory food safety and quality systems exist, enterprises often have a choice of whether or not they should adhere to a specific system of norms and regulations. Hence, cost and benefit considerations are likely to be taken into account in decision processes regarding safety and quality management system adoptions.

Quality system standards could contain requirements related to

- The organization of production processes (e.g. setting requirements to the utilization of pesticides in farms),
- The management of the quality system (e.g. requirements concerning the documentation; setting of a quality policy),
- Product characteristics like quality (e.g. cleanliness), safety (e.g. pesticide residue) and authenticity (e.g. geographical origin) and
- The infrastructure environment (e.g. special requirements to the size of a cot) (e.g. Giovannucci & Reardon, 1999; QS, 2007; IFS, 2004).

The requirements of different quality standards could be congruent. Therefore, a com-parison of the different requirements is a solution to find accordance of different quality systems. The benchmark and harmonization of different quality standards have started during the last years.

QualintSys is an internet based, flexible and multilingual decision support tool for the estimation of costs and benefits of quality systems. A quality system benchmark and the categorization of the requirements are content of "QualintSys". The categorization was

- In connection with departments
- In connection with ISO-9000 chapters
- In connection with cost categories
- In connection with benefit categories

The aim of a connection to departments was a fast information flow to the responsible person. ISO 9000 chapter connection were developed for a better and structured documentation of the requirements.

The calculation of cost and benefit of quality standards needs the development of a cost and benefit taxonomie of quality system requirements, which was done during the project. These cost and benefit categories present the basic for the hierarchical order of costs and benefits concerning a quality system and the estimation of cost and benefit. QualintSys presents at a result a decision support model for the implementation of quality systems.

Valorising mountain food products

Gardère, E.[1], Beucherie, O.[2], Cevasco, A.[3], Burlando, R.[3]

[1] PEACRITT, 23, rue Jean Baldassini, 69364 Lyon Cedex 07, France, E-mail: gardere@peacritt.fr

[2] ISARA-Lyon, Team 'Marketing and strategy of the enterprises', 23, rue Jean Baldassini, 69364 Lyon Cedex 07, France, E-mail: beucherie@isara.fr

[3] REGIONE LIGURIA, 113 v. G. D'Annunzio, 161621 Genova, Italy, E-mail: annalisa.cevasco@fastwebnet.it, raffealla.burlando@regione.liguria

Keywords: Mountain products, valorisation, sustainable development, marketing, production, process, quality

Abstract

In the framework of a former European 5th FP project1, 13 organizations from 8 countries2 wrote the European Charter for Mountain Quality Products that establishes 5 principles a **quality** mountain product needs to comply with. Today the Charter is ratified and signed by 54 local, national or European governmental and non-governmental organizations. Yet, the Charter is a political document that needs to be translated into a practical tool (specifications for instance) to be used by economic stakeholders: enterprises, exploitations, customers…

The project Val'mountain aims at assessing the Charter in order to give its promoters feed-back about its strategic relevance as well as its economic and technical feasibility. The three partner regions address the potential future users of the Charter, namely enterprises and exploitations (or their representatives) situated in a mountain area, in order to collect their opinions and suggestions about the Charter. Regione Liguria wanted to check a study according which mountain products attract the consumers, by prospecting 320 of them.

The results prove to be slightly different from a region to another; yet the main conclusion is similar: while the consumers show an interest in mountain products, the producers are quite suspicious about its marketing added-value, even those who already comply with the Charter's principles. Besides, some interviewees raise awareness about the simplicity and credibility, both necessary, of a system controlling the implementation of the 5 principles of the Charter.

This statement raises another question: can the Charter be adapted to meet the producers' expectations without loosing its very substance?

The results are likely to be used by Euromontana who wants to develop the Charter. Any stakeholders whose aim is to promote mountain products and territories can be interested in the results too.

1. Introduction

1.1 Background and objectives

The stakes of mountain products' valorisation

The mountain food products needs to be valorised because: **1)** on the one hand, they are from territories undergoing **natural handicaps** that make **production and processing more difficult** and expensive; **2)** on the other hand, the **natural conditions** (fresh air, quality pastures exempt from chemical fertilizers, altitude, flora diversity, clean temperate water of high oxygen content, microclimate, type of soil…) and the **particular human know-how** developed to answer the natural constraints, gives rise to food products with **organoleptic specificities** the consumers look for. Indeed, a thorough study3 carried out on 122 mountain products, states that regarding the animal products we can notice a distinct

1 Mountain quality products project, 2002-2004
2 Scotland, Spain, France, Greece, Norway, Poland, Italy, Rumania
3 Study carried out in the framework of Mountain Quality Products project

taste, aroma, a strong muscle build, a better distribution of fat, a firm texture, an absence of parasite and a reduced risk of disease. As far as the vegetal products are concerned, they proved to benefit from an absence of viruses, a nice color, a good taste, comparatively better texture and consistency etc.

France and Italy have a national regulation4 aiming at valorizing mountain products. But this is not enough, for two reasons: not only these regulations are not valid for the EU market; moreover the French regulation, in particular, does not guarantee **quality** mountain products since the requirements are altitude-related only and bear no environmental concern. Indeed, according to the French decree, intensive and industrial farming of pigs can lead to a 'sausage' packaged with the indication 'mountain products', if the exploitation is at least at 600 meter altitude. Now, the idea of quality connected to mountain geography is hard to justify in this case.

The European Charter for Mountain Quality Products aims at answering these two aspects: having a **European** strategic tool to develop agrofood stakeholders in mountain areas; ensuring a minimum quality level for mountain products marketed as such by introducing the notions of sustainable development, biological and cultural diversity.

The Charter was written by 13 regional organizations in the framework of a project in the 5th FP. It was ratified in December 2005. Today, it is signed by 54 governmental and non-governmental organizations. The Charter indicates 5 principles guarantying a quality mountain product:

1. raw materials must be derived from a mountain region
2. processing must be carried in a mountain region
3. production must take into account concerns related to sustainable development
4. production must attempt to maintain the biodiversity and heritage of mountain
5. production must be able to guarantee at all times the transparencies of information to consumers

Objectives of Val' mountain

The objective of Val' mountain is to make enterprises and producers assess the Charter. Regarding three main points:

- the potential marketing and commercial added value
- the technical and economic feasibility of the 5 principles
- a possible control system to assess the compliance to these principles.

At the end of the project, we need to answer the central and final question: **to what extend the European Charter for Mountain Quality Products is a relevant and strategic tool to valorise mountain products and develop economic activities in the mountain territories?**

The answers are expected to be forwarded to the writers of the Charter who need to have feed-back from the potential future users of this tool.

Participants

Three regions participate in the Val'mountain project: Rhône-Alpes (France), represented by the PEAC-RITT, Regione Liguria (Italy) and Vidin (Bulgaria)

2. Materials and methods

2.1 Overall approach

The two partner regions showed an interest in assessing the Charter because all of them cover quite an important mountain territory. Yet, the regional context is not completely similar, which explains the dif-

4 Décret no 2000-1231 du 15 décembre 2000 relatif à l'utilisation du terme « montagne » in France

ferences between the three partners' approaches in the project. Therefore, each region has conducted a qualitative survey, but relying on different tools and/or panels.

2.2 Rhône-Alpes specific approach

The survey was conducted both by the PEACRITT and ISARA-Lyon (the team 'marketing and strategies of the enterprises'). First of all, we identified Rhône-Alpes enterprises and exploitations displaying a **communication implicitly or explicitly referring to the images conveyed by mountain**, which implies the use of the very word 'mountain', the name of a massif, a picture of a mountain landscape on the packaging, the advertising brochure, the website…

In order to identify which enterprises and exploitation are **situated in a mountain zone**, we referred to a national administrative classification based on the FEOGA regulation. In France, we will say that mountain zone covers territories at least 600 meter high, but there can be exceptions, depending on the declivity.

We tried to prospect in the different mountain areas in Rhône-Alpes: the Alps (Savoie and Haute-Savoie), le Mont-Pilat (Loire) and la Drôme des Collines (Drôme.) However, we are obliged to recognize that **most of our interviews took place in the Alps.**

We surveyed **5 representatives of chain unions and the general or Quality manager from 12 agrofood enterprises, regarding 7 types of products**: dairy, salt meat, honey, pasta, bread/biscuits, syrup and beer.

2.3 Liguria specific approach

First of all, we identified products that could be considered as mountain products according to the principles of the Charter.

We then designed a questionnaire for producers in order to understand if:

- some or all of their products are produced following the principles of the Charter
- they find the Charter a useful instruments for a better promotion of their products.

Relying on this questionnaire, **4 cheese producers situated in a mountain area** (+/= 600 meter altitude) were interviewed.

We also prepared a **questionnaire for** consumers – we propose to 320 consumers we met during one of the most important Cheese fairs in Italy (21/24 September 2007). The aim of the questionnaire was to verify the interest of consumers about mountain products.

2.4 Inter-regional approach

We organized study trips in Haute-Savoie and Liguria in order to better know the different regional realities, regarding the production, the process and the marketing of mountain products. One progress meeting was organized in Liguria in order to confront the methodology used in each partner region. The 1st PromSTAP congress in Genoa (It) gave the opportunity to have a glimpse at the first results in the three regions. The final Congress in Vidin allows us to compare more deeply the regional results in order to produce a synthesis with a European dimension… at least an interregional dimension.

2.5 Dissemination of the results

The results and the main conclusions of the project will be forwarded to Euromontana. Euromontana is the European multisectoral association for co-operation and development of mountain territories. It embraces regional and national mountain organisations throughout greater Europe, including regional

development agencies, local authorities, agriculture organisations, environmental agencies, forestry organisations and research institutes. Its mission is to promote living mountains, integrated and sustainable development and quality of life in mountain areas. In order to achieve this, Euromontana facilitates the exchange of information and experience among these areas.

Euromontana initiated the project that gave rise to the European Charter for Mountain Quality Products. To that respect, it looks for feed-back from potential future users (enterprises, exploitations… but also consumers)

3. Results and discussion

3.1 Introduction

Due to the regional differences and the various methods, we prefer starting by presenting the results obtained in the respective region. Next, we will elaborate the inter-regional results.

3.2 Results in Rhône-Alpes

3.2.1 The current communication on mountain

Most of the products prospected are qualified by the enterprise as products issued from mountain territories through the use of Savoie, Alps and its derived, as well as DOP and PGI appellations. The underlined elements are linked to the comprehensive image of the territory where the enterprise is located. For example, some firms that are situated in an industrial zone in Savoie, in the suburb of quite large town, will put forward the bucolic image of the Alps, with mountain landscape. On the contrary, only a small part is qualified as 'mountain products': mostly the sausages, honey and some cheeses.

These products are marketed on a local, regional, national scale or exported. For the national or international trade, the mountain identity proves to be more relevant than for the local trade. On the other hand, on the local scale, the strategies are different depending on the type of the region that is considered. The territories that rely on tourism and benefit from a high identity prefers communicating on the specific area rather than on the generic mountain. On the contrary, simple mountain identity is privileged when the considered territory has an image weakly developed, regarding tourism and gastronomy in particular.

Table 1: The more relevant communication on mountain image according to the situations

	National and international trade	Local trade
Famous area: tourism, gastronomy, high identity	The very word mountain and its derived	The name of the region, the massif, the town/village
Area with a low identity		The very word mountain and its derived

3.2.2 The assessment of the Charter's principles

Relying on the interviews, we can assess the Charter's principles from the enterprises' point of view.

1st principle: the mountain origin of the raw materials

The prospected beekeepers already comply with the principle. For the cheese sector, this does not raise any major problem, apart from seasonality difficulties. As far as the porcine chain is concerned, while a mountain pork chain does exist on the national level, the enterprises mention the critical difficulty to be provided with mountain-traced raw materials. All the more than a few years ago, some slaughterhouses were funded to close their doors… For the other products (cereals, beer, syrup) the criteria is barely considerable.

2nd principle: the location of the process in a mountain area

The second principle is not a problem for the interviewed salt meat producers. On the contrary, it seems to be impossible for some cheeses whose maturing takes place in the plain. Generally speaking, the economic constraints seem to be too strong to relocate the industrial tools up to mountain zones. Moreover, the Alps image is sufficient and does not imply any constraint, compared to the Charter.

3rd and 4th principles: preservation of the environment and of the cultural diversity

These two principles are unanimously acknowledged as positive and important. They fit in with the images conveyed by mountain and the strong evolutions of the expectations. Therefore, it becomes more and more a segmentation criteria the mass marketing looks for.

5th principle: transparency of the information for the consumers

This notion is difficult to assess: how communicating on the mountain origin of the products and the location of the process, if the concerned enterprises cannot comply with the first two principles of the Charter?

Table 2: Summary of the assessment of the principles depending on the products

	Origin of the raw materials	Location of the process	Environment concern	Transparent information
Cheese	☺	☹	☺	/
Salt-meat	☺/☹	☺	☺	/
Bread/biscuits	☹	☹	☺	/
Honey	☺	☺	☺	☺
Beer/syrup	☺	☹	☺	/

3.2.3 Conclusions

We can notice a paradox: while the consumers and the customers look for genuine mountain products, very few enterprises are interested in the Charter. Indeed, most of them consider having other less restricting tools as efficient as the Charter: Savoie's identity, DOP, PGI, regional brands... Moreover, the adaptation to the principles would give rise too many supplementary costs compared to the marketing and economic stakes. However, it is worth noticing that there is a stronger interest from the **porcine chain.** The enterprises are ready to adapt the supply and would not be reluctant at a control system by a third party.

Regarding the **honey chain**, the beekeepers already comply with the Charter: yet, they are small stakeholders and are somehow afraid of a heavy control system. They would privilege a simple declarative system but this means a strong cooperation from the part of the public control authorities whose means are already weak with regards to their task.

Now, we should prospect more deeply some French territories (Pyrénées, Vosges, Massif-Central), that are not as touristic as Savoie and Haute-Savoie that were predominant in our panel in order to assess our results on a national scale.

3.3 Results in Liguria

3.3.1 The producers' point of view

Till now the four producers we interviewed promote their products as traditional ones, according to the national law "Atlante dei prodotti tipici" and none of them used words or other indication that can relate their products with mountain products, even if all of them have their enterprises in mountain area.

All of them worked in an environment that respects the principles of the Charter:

1st principle: the mountain origin of the raw materials
All cheese producers follow this principle, and it is not a problem for them.

2nd principle: the location of the process in a mountain area
The second principle is not a problem for the interviewed producers.

3rd and 4th principles: preservation of the environment and of the cultural diversity
These two principles have been considered very important and all producers consider that they give the idea of the differences and of the identity of the single cheeses. But even if they find them important they underline that it is a typical value that traditional products emphasize as positive and relevant.

5th principle: transparency of the information for the consumers
They agree about the importance to give clear information to the consumers about the processing phases in order to guarantee about safety and mountain origin, even if they do not have suggestions about method to do that.

However, they are a bit suspicious about the Charter as instrument of promotion, even if they don't exclude it could be an instrument.

3.3.2 The consumers' point of view

The results we obtained were very interesting because the answers were similar even if:

- the people came from different regional areas in Italy;
- the interviewed were women or men;
- the people had different school levels or different professional activities.

What is clear for them is the concept of mountain products, more than any other kind of label (even Bio – Doc – Dop or IGT).

The answers show the following figures:

- 90% of the consumers believe that mountain products are better and more genuine than the other ones.
- 75% of consumers are ready to pay something more in order to have on their table controlled and safe mountain products and to help to maintain the mountain landscape.
- All the consumers believe that it's necessary to improve the quality and the safety of food products.

3.3.3 Conclusions

According to the results of the two surveys we meet the following paradox: consumers are very interesting in genuine mountain products and they are able to recognize them and they want to buy them even if they cost a bit more than other products. On the other hand the producers has no so much enthusiasm for the Charter and they do not give added value to mountain label.

Probably the next steps could be an opened discussion about the paradox at regional level to understand and to define the possible strategies for the future.

4. Overall conclusion

We can notice a paradox in both regions: the notion of mountain in food stuff indisputably represents for the consumer an added value for which they are ready to pay more. Therefore, valorising the mountain character seems a relevant policy, the one chosen by the Charter. But, even if it has been signed by numerous national chains, institutions and UE governments, the Charter is not approved unanimously by

the interviewed producers. Either some of the charter's principles are restrictive, so only a few productions are concerned if we have a look at the survey's results in Rhône-Alpes. Or, some of the producers do not believe in the added value potentially brought by the communication about the compliance with the Charter's principles. It is the case of the producers prospected in Liguria.

Therefore, the Charter would not be a relevant tool?

On the one hand, our survey does not pretend to be comprehensive: many territories in Europe need to be explored and prospected. In particular, it seems that the case studies have been conducted in two regions that benefits from strong territorial identities, often valorised by DOP or PGI. The notion of 'mountain products' is in this case often implicit for the consumers, even if these products are not totally produced and processed in a mountain area.

On the other hand, the Charter proves to be more strict and ambitious regarding the information to the consumer as well as the land management for European mountain area. Many French examples (in other regions than Rhône-Alpes) show that the interest in the use of the word 'mountain' is likely to modify the chain strategies and even the industrial strategies.

Then, the charter has the virtue to raise on a European level the question of mountain products' valorisation, which remains a necessity for the maintenance of economic activities and land management in European mountain areas, all the more in the current modification of the CAP financial aids. (ex: suppression of the French financial aid for the Quality pork in mountain area in 2007)

Eventually, it seems to us that the Charter can become a relevant tool if its implementation goes together with an accompaniment of the enterprises that want to follow its principles:

1. A financial support: aid to get supplies of mountain food raw materials
2. A strategic accompaniment: clear information about the possibilities given by the different marketing tools to differentiate quality products (including the word **mountain** and the other explicit references to mountain that could come from the practical application of the charter) + support for the diagnosis and the implementation of sustainable strategies based on the communication about mountain identity and values of a product or an enterprise.
3. A technical and logistical accompaniment: for example, in order to transfer a workshop from the plain to the mountain.

Annex

1. European charter for mountain quality food products

Whereas:

the aims of the signatories are to make a contribution to the maintenance and the sustainable development of viable economic activities in mountainous regions in Europe,

these economic activities must be based in particular on a viable model of agriculture in mountain territories, mountain agriculture on both small and medium-sized family farms is exposed to increasingly severe pressure from competition, especially with the 2003 reform of the CAP, the most fragile zones are threatened with the abandomnent of agricultural activity, and mountain agriculture is consequently in need of positive discrimination in the various policy areas,

it is essential, above all in mountain areas, to preserve the biodiversity and to improve the quality of environment, and to maintain rural areas and landscapes, to maintain and develop local tradition, culture and collective heritage specific to each territory,

the micro-enterprises and Small and Medium Enterplises (SMEs) processing agricultural products take part in the sustainable development of these mountain areas,

the future development of mountain areas will also be achieved by the engagement of young generations with the land in activities that require creativity, innovation and dynamism,

on the occasion of the Brussels conference on Community Policies and Mountain, 2002, European commissioner, Franz Fischler, mentioned that „we must develop the concept of „quality products" in mountain areas, that will enable to inerease the consumers trust and to support our primary sector",

Considering:

recommendation 1575 (2002) of the Council of Europe on the introduction of a quality label for food products derived fram hill farming,

the final declaration of the second European Mountain Convention in Trento (2000),

the French and Italian initiatives with regard to the use of the term „mountain" for agricultural and food products,

the results of the 2002 - 2004 study on quality mountain food products conducted by Euromontana and 13 partners in 8 European countries within the framework of the 5th Framework Programme for Research and Technological Development (RTD) of DG Research of the European Commission,

Whereas:

smallholdings in sparsely populated areas, far from market places and often with inefficient road infrastructures, have higher costs in the first marketing stages[5],

the integration of agricultural production into a local economy constitutes a success factor for its development,l

there ean be two different types of quality mountain products[5]:

- either unique and non-reproducible products, due to specific breeds or varieties, and/or traditional know-how eclusive to a defined production area,
- or products with special characteristics solely due to the fact that they come from a mountain environment,

5 Result of the 2002 - 2004 project on quality mountain products, lead by Euromontana with 13 partners in Europe (5th Framework Programm for RTD - DG Research of the European Commission

the majority of the characteristics of mountain products are influenced by the conditions specific to mountain territories, which depend on the one hand on the physical characteristics of the mountain areas (relief,climate, etc.) and on the other on human factors, as the inhabitants of the mountain areas have developed knowledge peculiar to their area[5],

making reference to mountains on products, either explicity (through the use of the word „mountain") or implicitly (geographical name) has an extremely positive effect on the purchasing behaviour of European consumers[5],

promotion strategies for mountain products have all the more chance of succeeding if they integrate or take account of[5]:

- the research and development programmes and quality control systems in the production area,
- the cooperatives, organisations and collective and associative structures in the production area with shared responsibilities throughout the entire sector,
- the special identification of the quality of the product with its own official certification and quality control structure of a protected Designation of Origin (PDO)/ Protected Geographical Indication (PGI) with its certification system,
- the most appropriate trading network,

the existing official systems for designation of quality and origin of food products at national and European level are not always appropriate to the specific issues of identification of mountain quality products1 and that any future European scheme should, in any event, fulfil those existing systems,

the existence of the following has proved essential for measures to promote mountain products to have at their disposal[5]:

- economic support from the Europeall Union, national and/or regional authorities for agriculture and primary production activities in the production area,
- economic support from the regional authorities for cooperatives or collective and associative organisations and structures or even to small local enterprises,
- support from the regional authorities or professional agricultural organisations for the emergence and creation of cooperatives and collective organisations or structures,
- support from the authorities to facilitate acces to know-how, and to research and technological development,
- financial recognition of the benefits in terms of public goods

Considering the importance of access to information and exchanges of experience concerning food products, their production methods and sales and communication strategies between massif mountain areas and different countries for dynamism and innovation.

The signatories of the present charter undertake to respect, defend and promote the following five principles in their own actions:

1. Mountain products are manufactured using primary materials produced exclusively in a mountain area, as defined by the Member States and validated where necessary by the European Commission (e.g. mountain areas identified by the Member States within the framework of Regulation EC 1257/99 or mountain areas toi be identified by the Member States for the post-2006 European regional policy), with the exception of primary materials which, for natural reasons, cannot technically be produced in mountain areas. Animal production in mountain areas must always demonstrate a link with mountain territory.

2. All strategies in the processing of products are to take place in a mountain area, as defined by the Member States and validated where necessary by the European Commission (e.g. mountain areas identified by Member States within the framework of the regulation CE 1257/99 or mountain areas to be identified by Member States for regional European policy post-2006)

3. Enterprises and farms which process primary agricultural resources in order to manufacture mountain products must be adapted to their geographical environment. They must take into account the concerns connected to sustainable development. The production methods used respect the environment and in particular the water quality present in the territory in question and integrate erosion risks.

4. The production and processing structures for mountain food products must encourage in their activity the maintenace of biological, genetic and cultural heritage of mountain areas, the development of the local knowledge-base of mountain areas and the management of rural areas and landscapes.

5. Enterprises and farms which produce and/or process primary agricultural materials for mountain products must be able to ensure traceability to provide transparent provision of all information relative to the product's manufacturing conditions (production/processing). In this way, they must satisfy the legitimate expectations of consumers to be given any information that will allow them to appreciate the mountain characteristics of the products and the values (transmitted in a positive way) of mountain farming.

2. Interview guidelines in Rhône-Alpes

I/ Current communication on the mountains products in the firm

1. Does the firm sell mountain products? Which ones? Since when?

2. Which part do those products represent in the global activity of the firm in terms of turnover/ sales volume?

3. On which market do you sell off your products:

   O Local (in percentage of sales):
   O Regional, specify (in percentage of sales):
   O National, specify :
   O European, specify :
   O Worldwilde, specify :

Why those markets ?

4. What is your distribution network for the mountain products:

   O Direct sales on the production areas
   O Retailers
   O wholesalers
   O Fairs, markets and similar
   O Collective catering (canteens, hospitals, organizations...)
   O Catering out of the place of residence (cafés, restaurants...)
   O Mass marketing
   O Others, specify :

Why those networks?

5. With which commercial arguments do you communicate at the present time with your clients (buyers)?

   O Mountain origin
   O Regional origin/ local origin /name of the territory you are located in
   O Others, specify :

On which positive pictures do you actually communicate with your consumers?

O Mountain origin
O Regional origin/ local origin /name of the territory you are located in
O Others, specify

6. Are you able to quantify the importance of each of these positive pictures in terms of results (turnover, fame, and so on) *(If yes, ask for the result if possible)*

7. In between all the pictures mentioned in the question 5, which one is the most positive that you (wish to) highlight? Why?

8. Which communication formats and means do you use to show that your products (or some of them) are elaborated in mountain area?

O Use of the « mountain » term
O Use of a local geographical term. Which one?
O Use of suggestive pictures of mountain or of the local geographical place
O Use of a suggestive commercial brand
O Use of an official sign of quality (DPO, GPI...)
O Use of other communication notes: which ones?
O Use of different and combined solutions: which ones and how?

→(do not forget to gather the labels, commercial leaflet)

O List of the media and publicity action:

- fair, markets and similar
- in shops
- billboard and notices
- radios
- Internet
- TV
- papers
- others, specify:……

9. What is the actual sales progress (in percentage) of the mountain products in your firm? Is this progress in accordance with the goal of the firm? If not, what are the main reasons according to you?

II- Assessment of the charter

10. You had a look at the Charter for quality mountain products. Globally speaking, what do you think about this charter? Do you asses that it could be a useful tool in developing your firm's strategy? Especially on the marketing and commercial level?

11. Would you figure out making your communication strategy evolve in using criteria of this charter? (*simple respect of the regulation or want to be more positioned on quality)*

A) Are all your raw materials and others steps of your products' process actually in a mountain area (at least at 600 meter altitude according to the carter)? If not, which ones? And why?

B) Because you are producing mountains products, do you actually put forward in your firm,

- O The sustainable management of environment, which means of :
  - Water? How (description of the process)?
  - Biological diversity? How?
  - Landscape and preservation of the rural spaces? How?
- O The development of local know-how? Which ones and how? (the know-how in the process, example : in the respect of local know-how, water management technique, biodiversity and so on)
- O The social development? How? (Example: part of the local workers in the firm)
- O Food safety of your products? How?
- O Traceability of the conditions of processing your raw and industrials products? How?

12. **A)** If this charter should be conveyed into measurable and verifiable criteria, can you identify some difficulties to implement it in your firm :

    - O Economic?
    - O Technical (raw material that can not be made in mountain, for example)?
    - O Technological (process)?
    - O Others, specify ?

    B) Do you think those different criteria would be easily measurable and checked? According to you, what would be the constraints/limits not to go beyond in the organisation of controls?

13. Would the respect of the charter imply valorising and complementary requirements (that are above the regulation) on which you wish to communicate? If yes, which ones?
14. Do you have the feeling that you would be missing commercial and marketing solutions if you put those ones forward? If yes, specify?
15. Are there important criteria/aspects that have not been mentioned during this interview that would help highlighting mountain products, if they were in the charter?

Conclusion:

Ask him/her if he/she is interested in:

- Having a feed back of this study and the analysis that would be made out of it;
- Taking part of an information meeting in a few months about this subject.

N.B.- *A document summarizing the 5 principals of the charter and presenting Val' mountain project has been sent to the interviewed person before. The day of the interview the interviewer is in possession of this same document if necessary.*

Scheda di Intervista – Progetto: VALMOUNTAIN							
ANAGRAFICA AZIENDALE						T/F/cell	e.mail
Azienda	Nome						
	codice Fiscale						
	Partita Iva						
Titolare	Nome						
	Cognome						
LOCALIZZAZIONE DELL'AZIENDA						zona montana (distanza dai centri urbani e altitudine)	%
Sede Legale	Indirizzo						
	Localita						
	Comune						
Centro Aziend.	Indirizzo						
	Localita						
	Comune						
Stabilimento trasformaz	Indirizzo						
	Localita						
	Comune						
Superficie aziendale	TOTALE (Ha)						
	SAU (Ha)						
PRODUZIONI AZIENDALI							
DESCRIZIONE DELL'ALLEVAMENTO / dati provenienza materie prime							
tipo	razza	Capi n.	di cui stab fissa	di cui al pascolo	altro	zona montana (distanza dai centri urbani e altitudine)	%
Bovini							
Ovini							
Caprini							
Suini							
PRODUZIONE MATERIE PRIME e TRASFORMATI						zona montana (distanza dai centri urbani e altitudine)	%
tipo	Materie prime	qli	trasformati	qli	note		
Bovini	carne						
	latte						
Ovini	carne						
	latte						
Caprini	carne						
	latte						
misto	latte misto						
Suini	carne						
ACQUISTO MATERIE PRIME						zona montana (distanza dai centri urbani e altitudine)	%
tipo	Materie prime	qli	trasformati	qli	note		
Bovini	carne						
	latte						
Ovini	carne						
	latte						

Caprini	carne						
	latte						
misto	latte misto						
Suini	carne						
SOSTENIBILITÁ DEL PROCESSO PRODUTTIVO							
SU SUPERFICI IN PROPRIETÁ/POSSESSO DELL‘AZIENDA							
indicare il carico di bestiame medio in rapporto alla SAU				UBA/Ha	si	no	note
bovini							
ovini							
caprini							
L‘azienda rispetta le indicazioni UE relative alla condizionalità?							
in merito all‘utilizzazione agronomica degli effluenti di allevamento							
in merito alle direttive sull‘identificazione e registrazione degli animali							
in merito al divieto di usare sostanze ormonali e simili							
in merito all‘attuazione del Pacchetto Igiene*							*nota
in merito alle misure comunitarie di lotta contro le malattie animali**							**nota
in merito al benessere degli animali (Dlgs n.146 del 260306)							
in merito alla protezione del suolo***							***nota
in merito alla protezione del pascolo permanente****							****nota
L‘azienda utilizza foraggi, mangimi ed integratori di provenienza extra aziendale?							
foraggi							
mangimi							
integratori ed altro							
Quanto incidono mediamente gli alimenti di provenienza extra aziendale?							
foraggio extra aziendale in rapporto al tot foraggi							
mangimi + integratori in rapporto al tot razione alimentare							
gli alimenti eztra aziendali sono prodotti in comprensori montani?							
SU SUPERFICI NON IN PROPRIETÁ/POSSESSO DELL’AZIENDA							
indicare il carico di bestiame medio in rapporto alla SAU				UBA/Ha	si	no	note
bovini							
ovini							
caprini							

L'azienda rispetta le indicazioni UE relative alla condizionalità?							
in merito all'utilizzazione agronomica degli effluenti di allevamento							
in merito alle direttive sull'identificazione e registrazione degli animali							
in merito al divieto di usare sostanze ormonali e simili							
in merito all'attuazione del Pacchetto Igiene*							*nota
in merito alle misure comunitarie di lotta contro le malattie animali**							**nota
in merito al benessere degli animali (Dlgs n.146 del 260306)							
in merito alla protezione del suolo***							***nota
in merito alla protezione del pascolo permanente****							****nota
MANTENIMENTO DELLA BIODIVERSITÁ E DEL PATRIMONIO DI TIPICITÁ							
L'azienda rispetta le indicazioni UE relative alla condizionalità?							
in merito alla conservazione degli habitat naturali (DPR 120503 n. 120)							
in merito alla conservazione degli habitat nelle zone a protezione speciale*							*nota
in merito al mantenimento degli elementi caratteristich del paesaggio							
l'azienda alleva razze tipiche locali?							
l'azienda adotta metodi e mezzi tradizionali nel processo di trasformazione?							
QUALIFICAZIONE E COMMERCIALIZZAZIONE DEL PRODOTTO							
Destinazione produzione	Percentuale		Marchi	si/no	note		
autoconsumo			bio				
vendita diretta			agriturismo				
conferimento coop			etichetta aziendale				
negozi di qualità			Protez Geografiche				
GDO			altro				
altro							
altro							
l'azienda è oggi in grado di garantire trasparenza di informazioni ai consumatori?							
se si, indicare quali percorsi sono stati avviati							

se no, indicare se si intende proce-							
dere in tal senso							
ritiene soddisfacente la capacità della sua azienda							
di posizionarsi sul mercato?							
il marchio „prodotti di montagna“ potrebbe fornire							
una migliore identificazione							
dei suoi prodotti sul mer-							
cato?							
intende fornire indicazioni e suggerimenti circa i							
fabbisogni per garantire al suo							
prodotto un migliore acces-							
so sul mercato?							
ANNOTAZIONI VARIE							

3. Questionnaire for the survey to the consumers in Liguria

Caratteristiche consumatore

Nome

Età: 0-20 20-30 30-40 40-50 50-60 oltre

Sesso: Maschio Femmina

Comune di residenza

Professione

Titolo di studio:

diploma scuola obbligo diploma superiore laurea

Consumo di formaggi

Che tipologia di formaggi consuma preferibilmente:

Freschi (stracchino mozzarella.....) Semi stagionati (caciotta formaggetta...) Stagionati (parmigiano...)

Consuma preferibilmente formaggi:

O biologici
O DOP
O Marchio industriale
O Marchio aziendale
O Non ho preferenza
O Altro.....

Quante volta consuma formaggi nella dieta settimanale?

1 volta 3 volte 5 volte

tutti i giorni mai

Dove acquista i formaggi prevalentemente?

Nei negozi specializzati Nei supermercati

Attraverso Gruppi di acquisto Direttamente dai produttori

Formaggi di montagna

Consuma formaggi di montagna

raramente solo in vacanza a volte
spesso mai

Ritiene che rispetto ai formaggi di qualità certificata (bio – DOP) e /o tradizionali, i formaggi di montagna abbiano caratteristiche di qualità superiore?

O No, li considero tutti uguali
O No, credo che quelli tradizionali siano i migliori
O No, preferisco quelli a marchio industriale
O Forse, ma non sono certa/o
O Si, credo siano i più qualitativi, perchè gli animali che vivono in montagna sono più sani
O Non so

Sarebbe disposto/a ad acquistare ad un prezzo superiore un formaggio di montagna se le fosse garantita la reale qualità e l'origine?

O Si, ma non più del 3% in più
O Sì, anche il 10% e oltre avendo la certezza della qualità
O Forse qualche volta
O No, non credo

Sarebbe disposto/a ad acquistare ad un prezzo superiore un formaggio di montagna, sapendo che quella cifra in più può aiutare a mantenere il territorio montano, permettendo che ancora qualcuno viva e lavori in luoghi meno accessibili?

O Sì, perché penso sia giusto e utile per tutti
O Sì, qualche volta, ma credo che non spetti a me contribuire al sostegno delle attività
O Forse
O No, non mi pare una motivazione per cui pagherei di più

Altro

Ritiene che il formaggio di montagna sia più sano a tutti gli altri formaggi?

O Si, credo sia vero
O Credo che siano uguali agli altri formaggi certificati e/o tradizionali
O No, credo siano migliori gli altri
O Non lo so

Ha da fornire delle indicazioni e suggerimenti circa il modo migliore di proporre un prodotto di montagna sul mercato?

Monitoring systems for mycotoxin contamination

Spadaro, D.[1], Dehne, H.W.[2], Gullino, M.L.[1], Lorè, A.[1], Kostov, I.[3], Minuto, G.[3*] Schlang, N.[2], Tinivella, F.[3], Trentin, R.[3], Garibaldi, A.[1]

[1] Centro di Competenza per l'innovazione in campo agro-ambientale (Agroinnova), Università di Torino, Via Leonardo da Vinci 44, 10095 Grugliasco (TO), Italy

[2] Rheinische Friedrich-Wilhelms-University, Institute of Crop Science and Resource Conservation, Nussallee 9, D-53115 Bonn, Germany

[3] District Governors Office, 6 Dunavska str, BG-3700 Vidin, Bulgaria

[*] Corresponding author, Email: cersaa.direzione@sv.camcom.it

1. Introduction

Grapevine is susceptible to attacks of different fungi deriving from soil, plant material or store room contamination that may produce mycotoxins, secondary metabolites that are human carcinogens or potential human carcinogens. The presence on grape of mycotoxigenic fungi may eventually result in wine contamination causing a variety of subacute health problems to consumers (Sweeney et al., 2000).

For instance, different plant pathogenic fungi, among them *Aspergillus carbonarius*, which is highly mycotoxigenic, produce ochratoxin A (OTA). OTA is a strong nephrotoxin for many animal species, causing kidney disfunctions and alterations of the urinary system as well as appearance of carcinomas (Creppy, 1999).

On grape *A. carbonarius* can colonize bunches very early during the growth stage, often starting before veraison. OTA can easily transfer from grape to wine if proper monitoring systems and prevention/control measures are not established both during cultivation and vinification. It has been proved that both incidence and concentration of the toxin are higher in wines from lower latitude regions and they increase passing from white to rosè to red wines (Battilani and Pietri, 2002).

Some field practices such as the control of certain pests (e.g. powdery mildew and grape moths) or early picking of grapes can play an important role in the development of mycotoxigenic fungi in the vineyards and, therefore, in the subsequent mycotoxin content detected in wines. It has been observed that, during vinification, the initial content of mycotoxins may vary depending on the different stages. Specifically, it decreases gradually throughout alcoholic fermentation, racking and malolactic fermentation, after which it represents about 1/10 of the starting content value. Therefore a correct management of the vinification process can be of crucial importance in the production of a mycotoxin free wine (Battilani et al., 2003).

The wine chain is an important economical resource for many European regions. Besides producing high quality wines responding to the consumer requests, the wine producers and the wine industry must guarantee for their survival and to keep or increase the current sales and occupational levels, the absence or a low level of ochratoxin A (OTA).

Liguria in Italy, North Rhine-Westphalia in Germany and Vidin in Bulgaria are three wine-producing regions:

- Liguria is specialized in production of Rossese, Ormeasco, Vermentino, Pigato and Sciacchetrà wines, most of them are high quality wines not very well known outside Italy;
- Vidin is situated in the most North-Western part of Bulgaria and is placed on the Danube. Since the ages of the Venetian tradesmen the region has been well-known for its local red wine Gamza, and since the middle of XX century also for its Merlot and Cabernet Sauvignon.

The Regulation (CE) N. 123/2005 fixes the maximum tolerable level of OTA in wines and other grape derivatives to 2,0 µg kg^{-1}, imposing to every European wine region the adoption of effective control strategies in case of OTA contamination potential

Wine represents an emerging production and market sectors even in emerging and developing economies. Wine exports from third producing countries to Europe are increasing (Pantini, 2006). A number of novel methodologies and products for detection and control of mycotoxin contamination in wine are available. Together with more traditional methods such as High Pression Liquid Cromatography, new easy-to-handle methods have been introduced into the market which allow a rapid and accurate detection of OTA in different food preparations. It must be stressed that an efficient control of mycotoxigenic fungi should be pursued already during cultivation phases through an accurate management of crop viarables and the adoption of control strategies towards mycotoxigenic fungi based on the use of specifical pesticides (Battilani and Pietri 2002).

The management of fungal diseases is one of the main points for a successful cultivation of cereals. Most of the cereal pathogenic fungi only have an influence on the yield quantity. But some of the species are also able to produce mycotoxins. These mycotoxigenic fungi are a big problem for the production of healthy food. Most of the cereal pathogenic fungi which are able to produce mycotoxins belong to the groups *Fusarium, Aspergillus* or *Penicillium*. However the most important genus of mycotoxigenic fungi related to cereals is *Fusarium*. Species of this genus occur all over Europe and can cause the *Fusarium* head blight (FHB) disease of small-grain cereals. The most important *Fusarium* species for Europe are *Fusarium graminearum, F. culmorum, F. poae* and *F. avenaceum*. They are able to produce a broad range of mycotoxins (Table 1)

Table 1: Most important mycotoxigenic Fusarium species (Bottalico and Perrone, 2002, modified)

Species	Mycotoxin
F. graminearum	DON, NIV, ZEA, Ac-DON, FUS
F. culmorum	DON, ZEA, ZOL, NIV
F. poae	NIV, BEA, DAS, FUS, ENS
F. avenaceum	MON, BEA, ENS

Ac-DON: Monoacetyl-deoxynivalnols (3-Ac-DON, 15-Ac-DON); BEA: Beauvericin; DAS: Diacetoxyscirpenol; DON: Deoxynivalenol; ENS: Enniatins; FUS: Fusarenone X (4-Acetyl-NIV); MON: Moniliformin; NIV: Nivalenol; ZEA: Zearalenone; ZOL: Zearalenols

These mycotoxins are a severe risk for human and animal health because of their acute and immunotoxic potential (Deoxynivalenol and other trichothecenes) or their hormone-like effect and genotoxic potential (Zearalenone).

The regulation (EC) No. 1126/2007 fixes the maximum tolerable level of Deoxynivalnol to 1250 µg/kg in unprocessed cereals and 500 µg/kg in processed cereals. The maximum tolerable level of Zearalenon is 100 µg/kg in unprocessed cereals and 75 µg/kg in processed cereals.

The production of mycotoxins cannot be influenced directly and effectively by agronomic actions or use of fungicide. The management of FHB is the key factor to reduce the mycotoxin contamination of cereals. For an effective FHB management it is crucial to know which species are involved in the disease in a particular region because the species are dispersed either by rain splashes or wind which has an impact on the diseases management. To learn more about the species complex of FHB and to deduce recommendations for the disease management wheat samples from Liguria and North Rhine-Westphalia were examined for their infection level and species complex.

2. Materials and methods

2.1 Monitoring of mycotoxigenic fungi

At “Centro Regionale di Sperimentazione e Assistenza Agricola” (CERSAA) trials were carried out in experimental vineyards in order to evaluate the influence of some crop management practices on the development of mycotoxigenic fungi (particularly *Aspergillus sp.*). For this purpose 6 different vine cultivars typically grown in Liguria Region (Ormeasco, Rossese, Vermentino, Vermentino 84, Lumassina and Pigato) were taken in consideration. Three different watering volumes were adopted (no irrigation, 10

mm of water/week, 2x10mm of water/week) through a drip irrigation system. Two different disease management techniques were considered: one foreseeing the use of cyprodynil + fludioxonyl based pesticide (Switch, Syngenta) twice at 800 g/ha and the other one not foreseeing the use of this compound. Vineyard was managed through common practices adopted in Liguria Region.

Four surveys were carried out in 2006, three in 2007. Ten bunches were collected for each replication and treatment, 5 berries per bunch were picked and washed in 500 ml sterile water added with Tween 20. 100 µl of water was plated on selective and semi-selective media (Pollastro, 2006; see annex 1). 3 dilutions were carried out and 3 plates per each dilution were prepared. Plates were incubated for 3 days at 25-27 °C. Number of colony forming unit (CFU) were counted in relation to average berry surface (CFU/mm^2).

A simplified wine making process was carried out according to annex 2. Development of mycotoxigenic fungi was assessed on fresh grape juices plating 100 µl coming from 3 different juice dilutions (10^{-1}, 10^{-2}, 10^{-3}) on the media described in annex 1.

2.2 Statistical analysis

Data collected were first analysed through Kruskal-Wallis test assuming as cluster factors: variety, irrigation and pesticide application. If test showed significant differences among groups ($P< 0,05$), data clustered according to omogenous factors were processed by the analysis of variance and, in the case of significant differences ($P< 0,05$), average values were compared through Tukey's test (varieties) and through T test (pesticide application).

2.3 Monitoring of OTA in the wines produced from the experimental trial

Fresh must (50g) was mixed with 50 ml of methanol and 5 ml of 0.1 M orthophosphoric acid in a blender for 2 minutes. The mixture was filtered through a glass microfibre filter and the filtrate collected in a graduated cylinder. An aliquot (12.5 ml) of the filtrate was diluted to 100 ml with a solution of polyethyleneglycol and sodium bicarbonate, and 10 ml of the diluted extract was passed through the Immunoaffinity column. OTA was eluted with 2 ml of methanol, completely evaporated with a gentle stream of nitrogen and redissolved in 0.5 ml of mobile phase.

The wine (10 ml) was diluted with 10 ml of a solution of polyethyleneglycol and sodium bicarbonate. The mixture was filtered through a glass microfibre filter and the filtrate was passed through the Immunoaffinity column. OTA was eluted with 3*0.75 ml of methanol, completely evaporated with a gentle stream of nitrogen and redissolved in 0.5 ml of mobile phase.

The lees and the skins were dried for 12 h at 70°C. Five grams of dried sample were extracted with 30 ml of acetonitrile and water (60:40 v/v) by shaking for 60 minutes. After filtration, 6 ml of filtrate were mixed with 44 ml of a water solution of polyethyleneglycol and sodium bicarbonate. The mixture was filtered through a glass microfibre filter and the filtrate was passed through the Immunoaffinity column. OTA was eluted with 3*0.75 ml methanol, completely evaporated with a gentle stream of nitrogen and redissolved in 0.5 ml of mobile phase.

2.4 Assessment of ochratoxin A (OTA) content in commercial wines

At the Centre of Competence for the Innovation in the Agro-environmental Sector (Agroinnova) 217 samples of wines coming from Liguria Region (years 2003-2004-2005-2006), 77 samples coming from all around Italy and 11 samples coming from Vidin Region, Bulgaria, were analyzed. Analysis procedure was validated according to the existing legislation (EC 2002/26) and some parameters were evaluated in order to confirm the reliability of the procedure. At the same time OTA content was determined on different substrates (wines, skins, fresh musts, lees) coming from the experimental vineyards sited at CERSAA.

The wine (10 ml) was diluted with 10 ml of a solution of polyethyleneglycol and sodium bicarbonate. The mixture was filtered through a glass microfibre filter and the filtrate was passed through the Immunoaffinity column. OTA was eluted with 3*0.75 ml of methanol, completely evaporated with a gentle stream of nitrogen and redissolved in 0.5 ml of mobile phase.

2.5 HPLC

Samples were analyzed in a HPLC Agilent series 1100 formed by a degasser, an autosampler, a quaternary pump, a thermostated column and a fluorimeter. An analytical column RP-18 (150 mm x 4.6 mm i.d., 5 µm) with a pre-column was used. The mobile phase, eluting at 1 ml min-1, consisted of an isocratic mixture of acetonitril:water:acetic acid (45:45:10) for 18 min. 100 µl of sample were injected onto the HPLC column and the retention time of OTA was 6.15 min.

The amount of OTA in the final solution was determined by using a calibration graph of concentration versus peak area and expressed as ng/ml, achieved by injection onto the HPLC column of 100 µl of standard solutions of OTA (Sigma Chemical Co.). The standard solutions had concentrations of 0.5, 1.0, 5.0, 10.0, 25.0, 50.0 and 100.0 µl l^{-1}.

2.6 Monitoring of mycotoxigenic fungi in wheat

Thirty-two wheat samples were examined in 2006 (3 from Italy and 29 from Germany). The German samples were taken from different farming systems. 6 from naturally formed soil and 8 from virgin soil (recultivation after open pit mining). Another 15 samples were taken from one single wheat field to look for the in-field spatial distribution of *Fusarium spp.* and mycotoxins. Several wheat cultivars were used in this examination (Table 2).

Table 2: Wheat cultivars used in experiments

Location	Soil properties	Cultivar
Italy	Naturally formed soil	Soissons (3)
Germany	Naturally formed soil	Dekan
		Hattrick (2)
		Tommi
		Tuareg
		Winnetou
	Virgin Soil	Dekan (4)
		Drifter (4)
	Field with 15 samples	Dekan

Two hundreds kernels of each sample (4 x 50 kernels) were bedded on *Fusarium* selective Czapex-doxiprodione-dicloran-agar (CZID). The Petri dishes were incubated at 25°C for 5 days. Outgrown mycelium was transferred to Petri dishes with potato-dextrose-agar (PDA) and carnation-leaf-agar (CLA). After another period of growth of 14 days the isolates were identified morphologically according to the method of Leslie and Summerell (2006).

The DNA extraction for the molecular identification was done with the "Wizard Magnetic DNA Purification Kit for Food" (Promega GmbH, Mannheim). 20 mg of ground wheat kernels of each sample were used as starting material. Primers Fp82F (CAAGCAAACAGGCTCTTCACC) and Fp82R (TGTTCCACCTCAGTGACAGGTT) were used to detect *F. poae* (Parry and Nicholson, 1996). All PCRs were done in a volume of 30 µl (2 µl of DNA solution, 0.6 µM of each primer, 80 µM dNTPs). PCRs were carried out using the following protocol: 2 min initial denaturation at 94 °C, 40 cycles of 1 min at 94 °C, 30 s at 60 °C, 1 min at 72 °C and a 10 min final extension at 72 °C.

2.7 Mycotoxin assessment

The 15 wheat samples taken from one field in Germany were examined for mycotoxin contamination with a multimethod based on a LC-MS/MS method . It is possible to detect and quantify over 60 mycotoxins in a single run with this method (Spiteller et al., unpublished). The mycotoxin assessment was done at the Institute of Environmental Research at the University of Dortmund (Workgroup M. Spiteller).

3. Results and Discussion

3.1 Monitoring of mycotoxigenic fungi

Year 2006

Berries result contaminated by *Aspergillus sp.* already at first survey (31/7/06) with higher values (CFU/mm^2) recorded on white berries (Pigato, Vermentino, Vermentino 84 and Lumassina varieties). Contamination tends to increase during time (Figure 1). The application of cyprodinil+fludioxonyl based fungicide, a compound which is also registered for grey mould control, caused a significant reduction of the development of mycotoxigenic fungi (Figure 2). Effect of watering volumes was not significance and this fact, at least in 2006, is due to the heavy rains occurred during the trials and closed to the surveys. Contamination level by Aspergilli assessed in fresh grape juices tend to become similar in the ones obtained from white as in red berries (Fig. 3); this behavoiur is more clarly observed on MEAB selective medium.

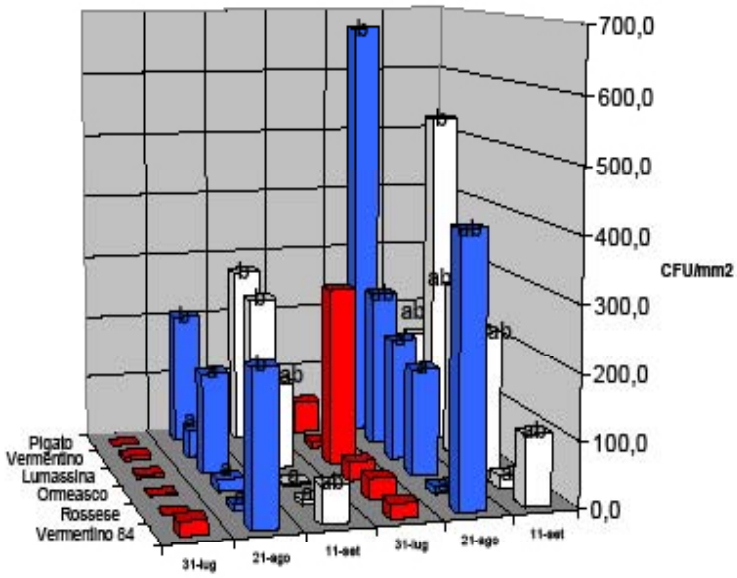
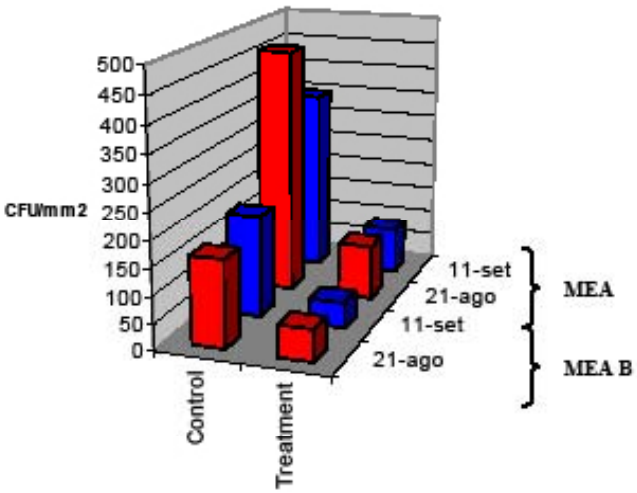


Figure 1:
Aspergillus contamination assessed in experimental vineyards during 3 subsequent surveys and expressed as CFU/mm2 of berry surface (Albenga, 2006). Values expressed by bars marked with the same letter do not statistically differ according to Tukey's test (P=0,05) within the same survey. No letters stands for absence of significance.

Figure 2:
Effect deriving from the application of Switch (a.i. cyprodinil+fludioxonyl, Syngenta; 2 treatments at 800 g/ha) on the development of Aspergilli assessed on MEA and MEAB media and expressed as CFU/mm2 of berry surface (Albenga, 2006). Data about 6 varieties. Differences between treated and non treated (control) are significant according to T test.



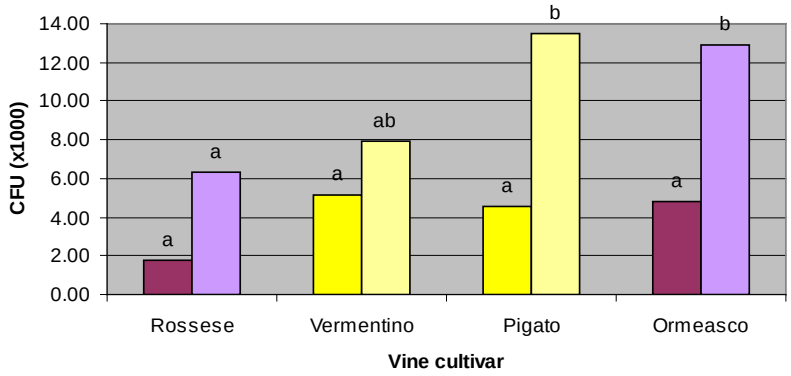


Figure 3:
Contamination by Aspergilli in fresh grape juices obtained by different varieties (Albenga, 2006). Values expressed by bars marked with the same letter do not statistically differ according to Tukey's test (P=0,05).

Year 2007

Contamination of berries by *Aspergillus sp*. in the vineyards were lower than in 2006 and this was due to the less conductive climate conditions registered. Berries of Lumassina variety (white) were the only ones on which *Aspergillus sp*. could be isolated (Figure 4). Application of cyprodinil+fludioxonyl based fungicide confirmed the positive results obtained in 2006 significantly reducing the contamination caused by *Aspergillus sp*. (Figure 5). Relevant to fresh grape juices a higher level of contamination than in 2006 was recorded with particular regards to Rossese, Vermentino and Ormeasco varieties (Figure 6). Neither in 2007 a significant effect caused by different irrigation volumes could be observed.

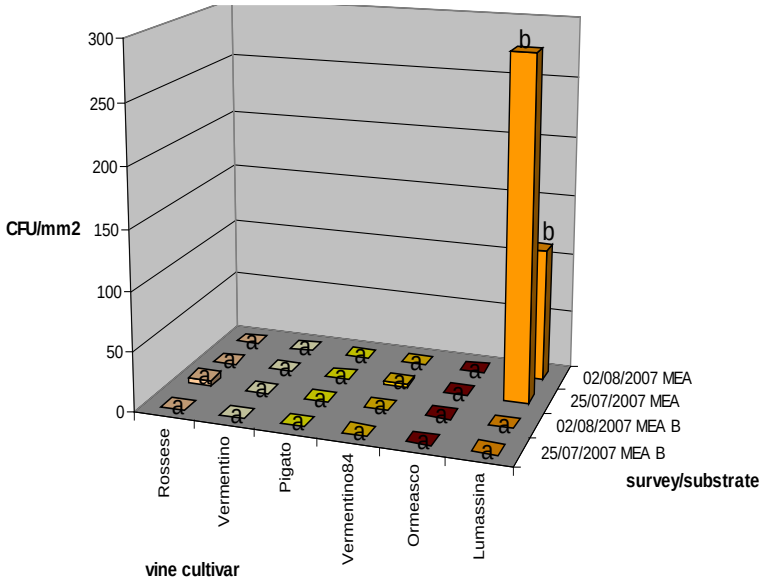


Figure 4:
Aspergillus contamination assessed in experimental vineyards in 2 subsequent surveys and expressed as CFU/mm2 of berry surface (Albenga, 2007). Values expressed by bars marked with the same letter do not differ statistically according to Tukey's test (P=0,05) within the same survey No letters stands for absence of significance.

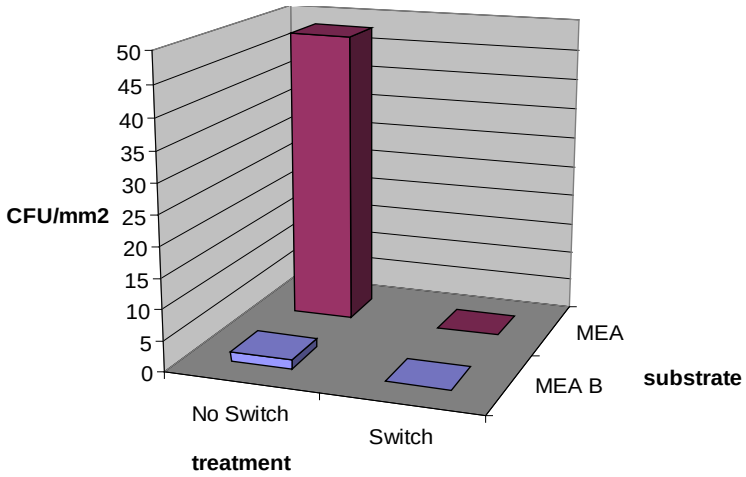


Figure 5:
Effect deriving from the application of Switch (a.i. cyprodinil+fludioxonyl, Syngenta; 2 treatments at 800 g/ha) on the development of Aspergilli assessed on MEA and MEAB media and expressed as CFU/mm2 of berry surface (Albenga, 2007). Data about 6 varieties. Differences between treated and non treated (no Switch – Switch) are significant according to T test.

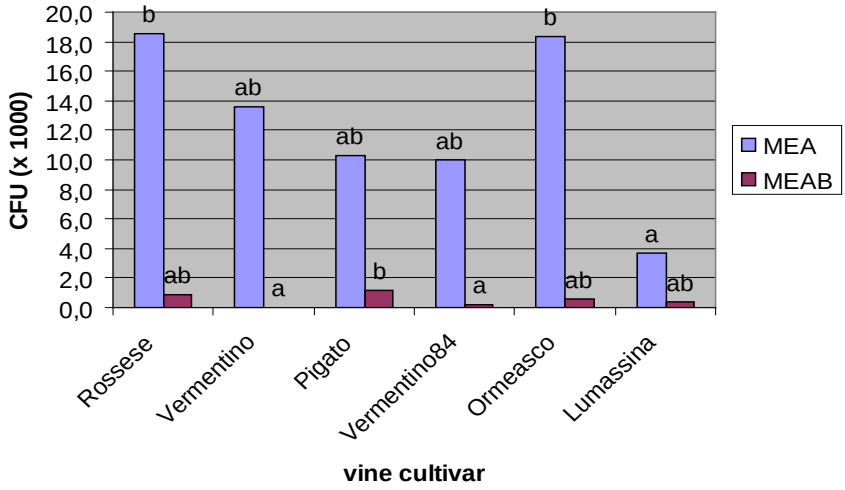


Figure 6: Contamination by Aspergilli in fresh grape juices obtained by different varieties (Albenga, 2007). Values expressed by bars marked with the same letter do not differ statistically according to Tukey's test (P=0,05).

3.2 Monitoring of OTA in the wines produced from the experimental trial

The analysis carried out on samples coming from the wines produced from the experimental trials showed that chemical treatments with cyprodinil and fludioxonil, have a strong effecton the reduction of the *Aspergillus spp*. growth, and in particular on the development of *Aspergillus carbonarius*, causing also a reduction of the OTA in grapes and in the derived products (Table 3).

Table 3: Contamination by ochratoxin A (OTA) assessed in different matrixes obtained during wine making process carried out in Albenga (2006) and depending on the application of the a.i. cyprodinil+fludioxonyl (treated – not treated)

	Variety	Must	Wine	Lees	Skins
Not treated	Vermentino	7.86	10.67	17.14	-
	Pigato	3.07	8.45	12.18	-
	Rossese	5.87	8.81	36.60	36.15
	Ormeasco	1.77	-	2.50	14.40
Treated	Vermentino	0.70	1.14	-	-
	Pigato	1.50	2.98	-	-
	Rossese	0.87	1.78	8.46	8.35
	Ormeasco	0.85	-	1.55	6.00

From the table, lees, together with skins (for red wines), appear to be the substrate where OTA tend to accumulate during the wine making process. Yeast and bacteria involved in the wine making process are normally able to adsorb OTA, so that with sedimentation and lees elimination, OTA content is significantly reduced.

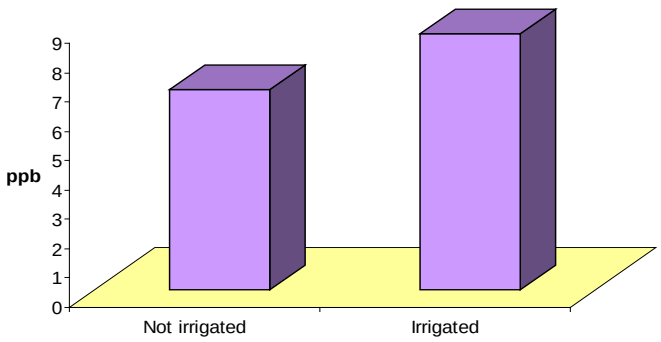


Figure 7: Mean concentration of OTA in the irrigated and not irrigated samples.

Considering the effect of the level of irrigation on the OTA production (Figure 7), the limitation of is a positive factor in order to contain the OTA production, but in our experiments, due to adverse climatic conditions, it is difficult to evaluate this parameter. From the analysed samples, the not irrigated samples have an OTA concentration lower (6.810 $\mu g\ Kg^{-1}$) than the irrigated ones (8.7221 $\mu g\ Kg^{-1}$).

3.3 Assessment of ochratoxin a (OTA) content in commercial wines

OTA content in Italian and Bulgarian wines as well as in the wines collected in Liguria was lower than the threshold established by law with the exception of a very few percentage of Southern Italian red wines correspondent to a percentage of 1% of overall samples which showed an OTA concentration higher than 2 ppb. No significant differences in OTA content between red and white wines produced in Liguria region were observed.

Considering the 217 Ligurian wines analysed, 76% of the samples had detectable levels of OTA, although the mean concentration was low (0.079 ppb). The most contaminated varieties were two red ones: Ciliegiolo, followed by Sangiovese. Considering the area of production, the wines produced in the province of La Spezia generally had higher levels of OTA, followed by the wines produced in the province of Savona. Concerning the comparison between red and white wines, the last ones present a slightly higher but not significantly different level of contamination. Looking finally at the year of production (2003-2004-2005-2006), the wines produced after harvesting 2006 and 2003 have higher OTA levels (Figure 8).

Analysing the results of the wines coming from different Italian regions, most of the samples are contaminated by OTA, but rarely above the threshold impodsed by the European Regulation 123/2005. Only few samples of wines produced in Southern Italy (Nero d'Avola or Cirò) had high mean concentrations, sometimes superior to 2 ppb.

The samples analysed present a contamination level and incidence lower in the white than in the red wines and with a decreasing value from 2003 to 2005.

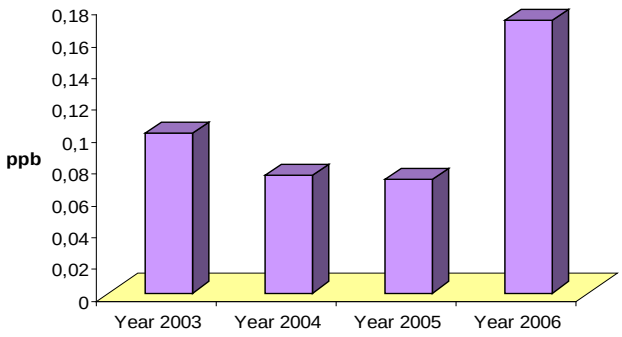


Figure 8: Mean concentration of OTA in wines produced in the years 203, 2004, 2005 and 2006.

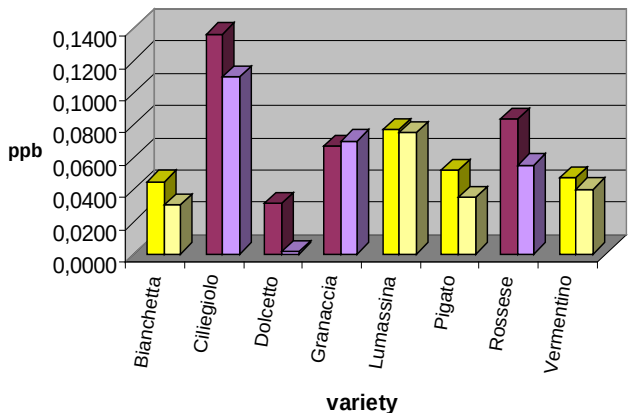


Figure 9: Contamination by ochratoxin A (OTA) assessed in different wines obtained from varieties typically grown in Liguria Region.

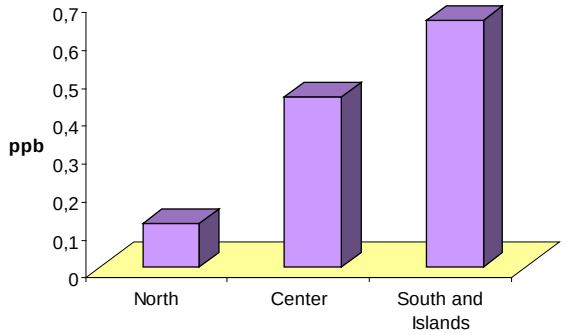


Figure 10: Comparison of the mean concentration of OTA in wines produced in Northern, Central and Southern Italy.

Table 4: OTA levels in different wines produced in Bulgaria

Wine	Year	Colour	OTA ppb
Gamza	2006	red	0.053
Cabernet Sauvignon	2004	red	0.038
Cabernet Sauvignon	2006	red	0.044
Merlot	2006	red	0.054
Cabernet Sauvignon	2005	red	0.057
Gamza	2006	red	0.023
Merlot	2006	red	0.057
Merlot	2006	red	n.d.*
Merlot	2004	red	0.038
Cabernet Sauvignon	2006	red	n.d.
Gamza	2004	red	n.d.
** n.d. not possible to be determined*			

3.4 Wheat samples from naturally formed soil, Germany

Six wheat samples were taken from conventional farms in North Rhine-Westphalia. The infection level ranged between 4% and 11,5% (Fig. 11). *Fusarium avenaceum* and F. proliferatum were found in all samples, whereas *F. poae* and *F. graminearum* were only found at low levels in 3 and 4 samples, respectively. There was a co-occurrence of F. poae and *F. verticillioides* in 3 samples and neither *F. poae* nor *F. verticillioides* were found in one sample singly.

The early summer of 2006 in Western Germany was relatively dry. Only low and short rainfalls were recorded. The climatic conditions at the stage of wheat flowering were not optimal for infection by *Fusarium* species. The late summer was very hot and dry, no rainfall was recorded in last three weeks before harvest. The dryness in the early summer and at stage of flowering resulted in a low incidence of *Fusarium* head blight. *F. graminearum* and *F. culmorum*, which are normally the predominant species in Western Germany, were only found at a very low incidence. Other species, which are normally typical for maize, like *F. proliferatum*, were found more frequently. It is likely that the maize *Fusarium* species are better adapted to higher temperatures than the wheat *Fusarium* species.

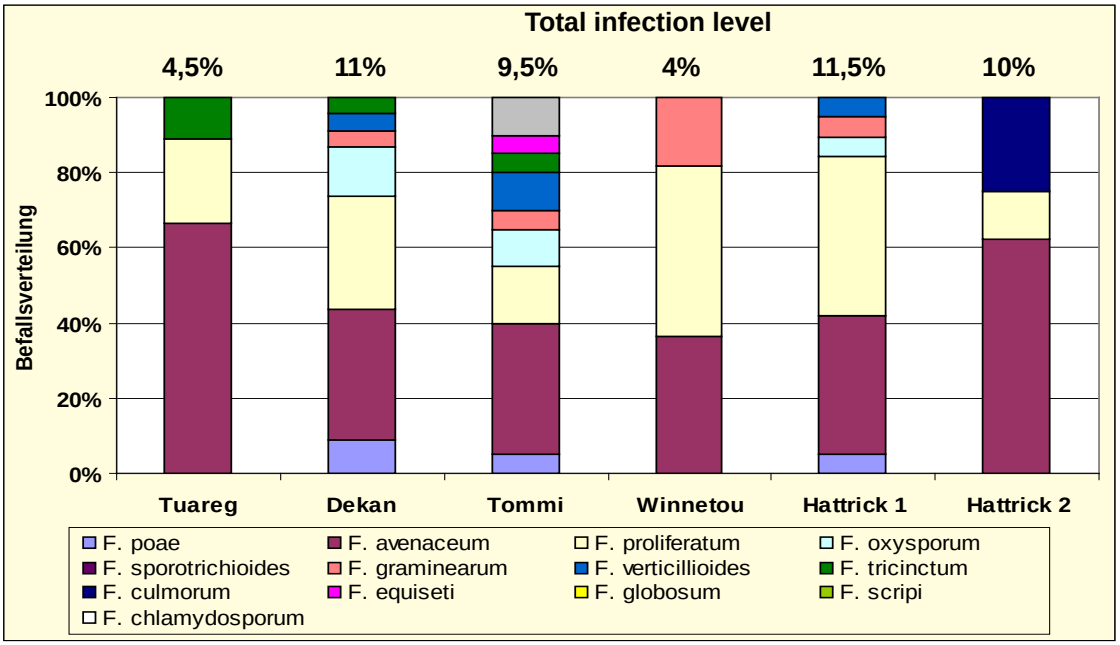


Figure 11: Level of Fusarium infection and species complex, 6 samples from naturall formed soil, Germany

The climatic conditions of the summer 2006 in Germany would then have favoured the maize *Fusarium* species compared to the wheat *Fusarium* species. This may be an explanation for the relative low incidence of *F. graminearum* and *F. culmorum* in North Rhine-Westphalia in 2006. In comparison to *F. graminerum* and *F. culmorum*, *F. avenaceum* was found more frequently in this samples. *F. avenaceum* is known to be an important species in North Rhine-Westphalia. Good adaptation of this species and a wide dispersion in the region may result in a high inocolum level. This could lead to higher infection levels although the climatic conditions were not optimal for an infection with *Fusarium*.

3.5 Wheat samples from virgin soil, Germany

Eight samples (2 cultivars) were taken from virgin soil. This soil results from recultivation after open put mining. The soil is a nutrient-rich, mineral substrate with a low content of organic matter. The total infection level showed a broad range from 0,5% to 30% (Fig. 12). F. poae were present in nearly all samples. *F. avenaceum* and *F. proliferatum* co-occurred in 3 samples and were not found singly. *F. tricinctum* occurred in 6 out of 8 samples but was predominantly found in cultivar Drifter. *F. graminearum* occurred in 3 out of 8 samples and was predominantly found in cultivar Dekan. This could mean that the cultivar Drifter is more susceptible to *F. tricinctum* and the cultivar Dekan to *F. graminearum*. The higher the total infection level was the more species were found in the sample (Dekan 4 and Drifter 1). Overall the incidence of *F. graminearum* and *F. culmorum* was relatively low. For the low incidence of *F. graminearum* and *F. culmorum* the same explanation should be valid like in the above-named samples.

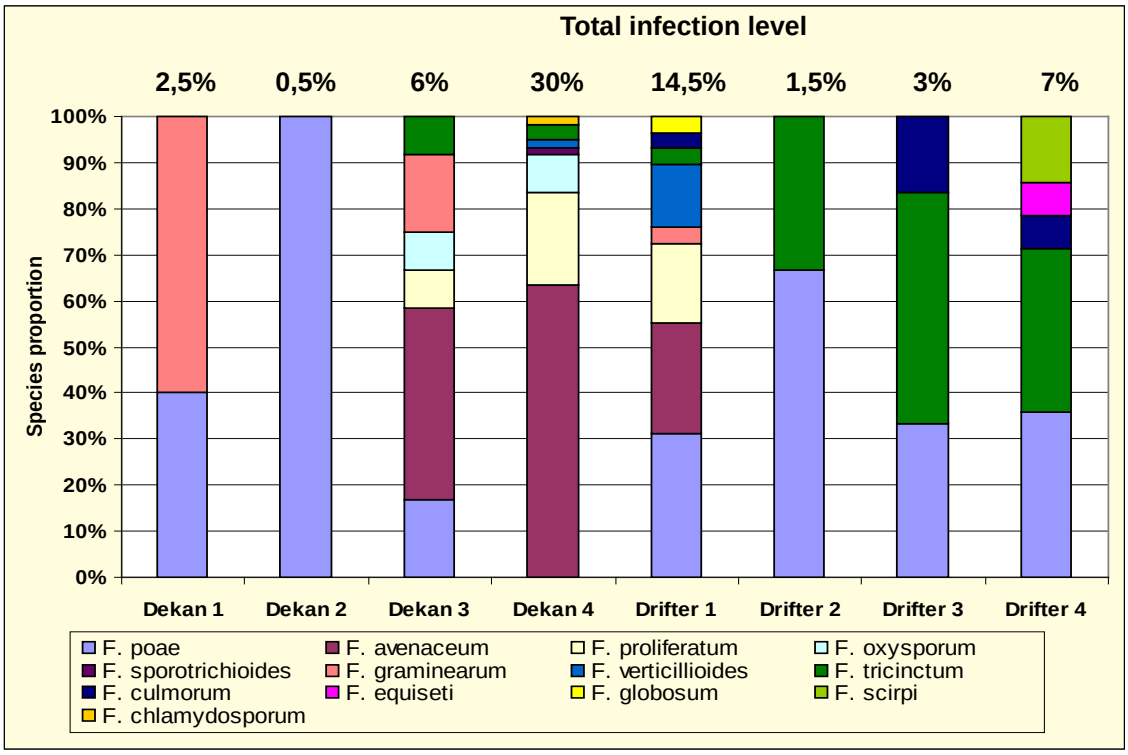


Figure 12: Level of Fusarium infection and species complex, 6 samples from virgin soil, Germany

Comparing the species complex of the wheat samples from naturally formed and from virgin soil one can see that the complex consist of nearly the same species. Only the proportion of the species changes. *F. avenaceum* and *F. proliferatum* were predominant in the samples from naturally formed soil whereas F. poae occurred most often in the samples from virgin soil. After recultivation the substrate of the virgin soil has an organic matter content of nearly zero. Also the rate of soilborne pathogens is close to zero. Infections of plant pathogens have to establish first. *F. avenaceum* and *F. proliferatum* are soilborne plant pathogens whereas *F. poae* is airborne. It is likely that the climatic conditions are more favourable for the former species but the spores were not dispersed over the fields. The spores of *F. poae* may have

been distributed much more faster by wind and spread over larger areas. This could be an explanation for the predominance of *F. poae* on virgin soils.

3.6 Wheat samples from Italy

Three wheat samples from Italy were examined for infection with *Fusarium* species and the species complex. Samples were taken from the same cultivar to avoid a inter-cultivar effect. The total infection level was lower than in Germany and ranged between 3% and 4,5% (Fig. 13). *F. proliferatum* and *F. verticillioides*, two typical maize *Fusarium* species, were found in all three and in one sample, respectively. F. poae were also found in all samples. *F. culmorum* and *F. graminearum* were not found in any sample.

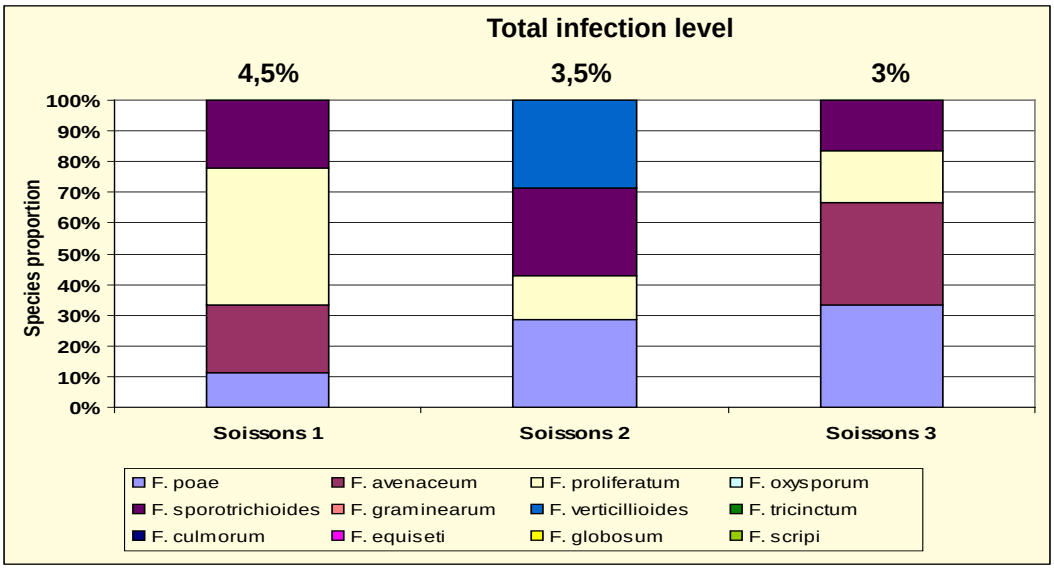


Figure 13: Level of Fusarium infection and species complex, 3 samples from conventional farming, Italy

The climatic conditions in Italy, Region Liguria, are warmer and more humid than in North Rhine-Westphalia. The warmer conditions may favour maize Fusarium species, which are better adapted to a warmer climate. The total infection level is low and it is known from the German samples that more species are found if the total infection level is higher. In the Italian samples only a small spectrum of species can be found. This may be a sign for unfavourable conditions for a Fusarium infection. In this case it is likely that only the best adapted species or the species with highest inoculum level will occur.

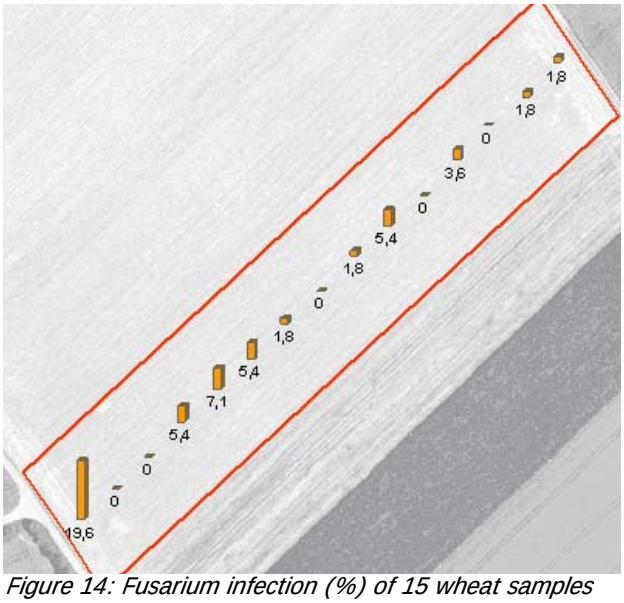


Figure 14: Fusarium infection (%) of 15 wheat samples taken from field K6, spatial distribution of the disease

3.7 Spatial distribution of Fusarium species

Fifteen Samples (cv. Dekan) were taken from one wheat field. The samples were examined for infection with Fusarium species, both microbiological and for one species also with a species-specific Polymerase Chain Reaction method (PCR). The wheat fields were sampled in a row (Fig. 14). In most cases an infection with Fusarium species were found. The highest incidence was found at sampling point 1 with 19,6 % on the other sampling points the incidence ranged between 1,8 % and 7,1 %. Only five different species were found at the 15 sampling points (Fig. 15). F. verticillioides had the highest incidence at a single sampling point (namely 16% at sampling point 1). F. poae was the species which oc-

curred in the most cases when Fusarium was found. The other 3 species were found infrequently. The infection level was relatively low in this field but it is observable that the same species were found all over the field. The high incidence at sampling point 1 could be explained with the spatial position of the sampling point. The field border characterized by a hedgerow at the south-western edge. The main wind direction in this region is west. The lower wind exposure on this point could lead to a more humid microclimate which is favourable for fungal infections.

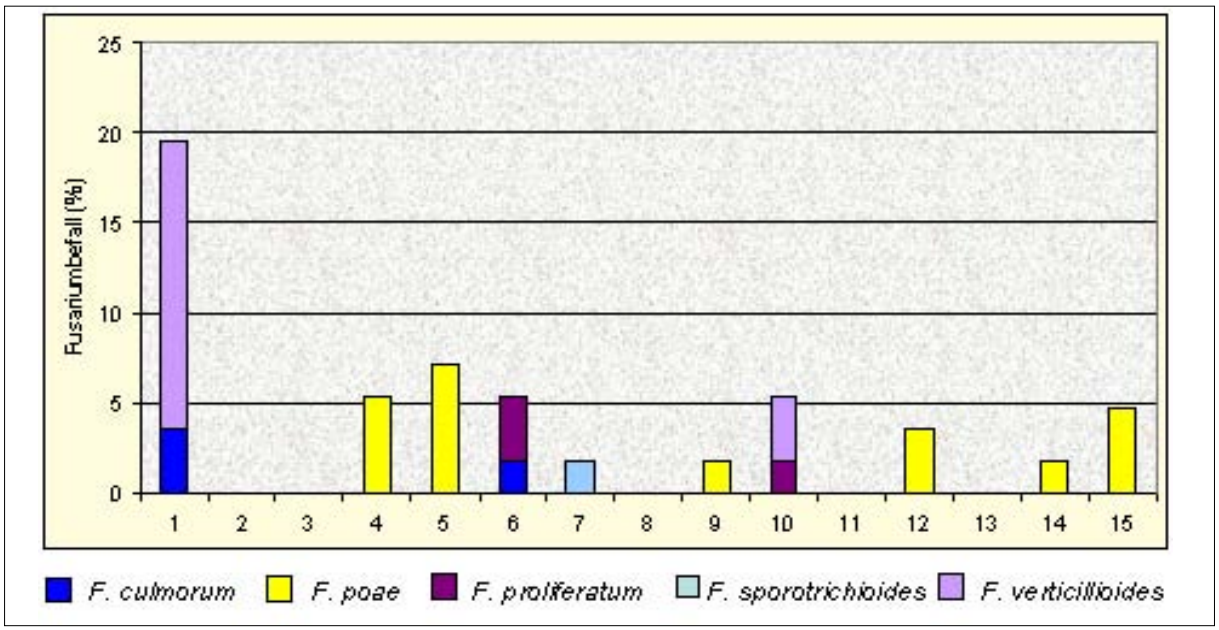


Figure 15: Fusarium infection and species complex of the 15 wheat samples taken from field K6

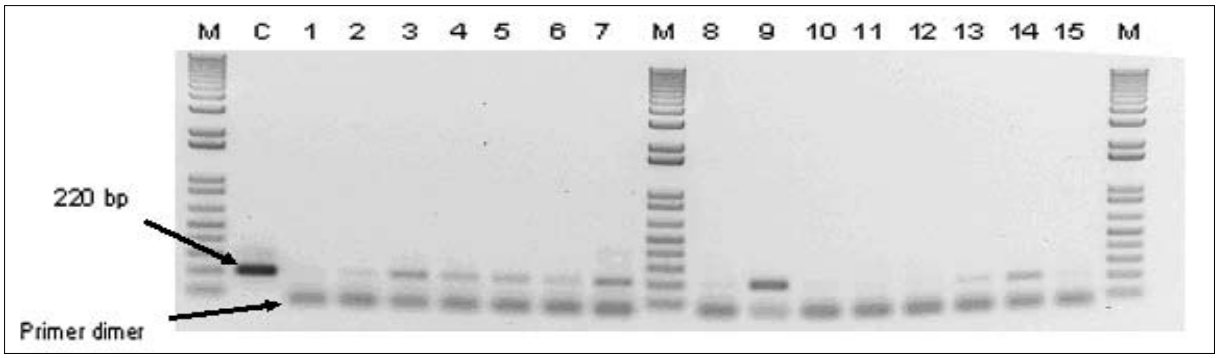


Figure 16: Species-specific PCR for Fusarium poae; M: 1kb molecular marker; C: positive control; 1-15: samples 1 to 15 from field K6

With a DNA based assay, a PCR with species-specific primers for *F. poae*, the pathogen *F. poae* was found at every sampling point (Fig. 16). With a microbiological assay F: poae was only found at sampling point 4, 5, 9, 12, 14 and 15. The last three weeks before harvest dry and warm weather conditions predominated in this region. With a microbiological assay only living organism can be detected. Due to the unfavourable weather conditions it is possible that most of the *Fusarium* species die off in the last weeks before harvest. They could not be detected by microbiological assay but the DNA of the dead organisms still remain in the plant an can be detected with a molecular assay.

3.8 Mycotoxin contamination

The 15 samples taken from field K6 were examined for Mycotoxin contamination with a multi- analysis-method. Three mycotoxins were mainly found: Deoxynivalenol (Fig. 17), Ochratoxin A (Fig. 18) and Enniatin B (Fig. 19).

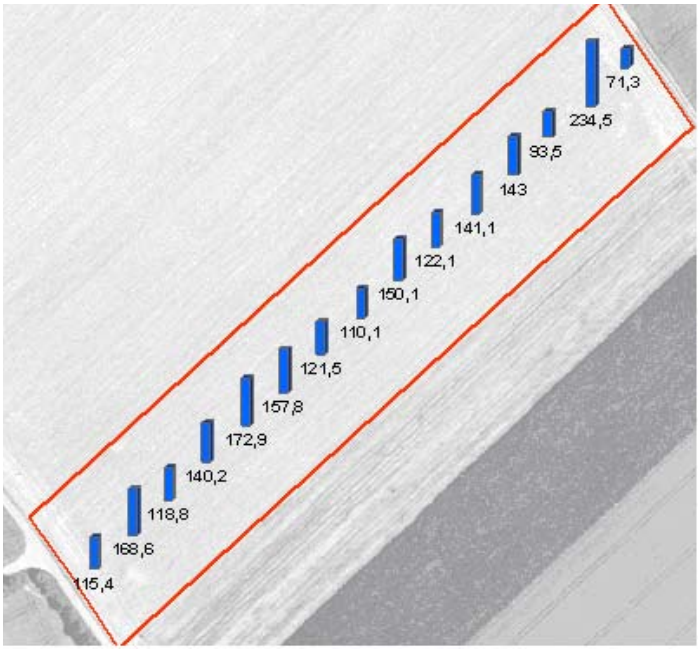


Figure 17: Deoxynivalenol content (µg/kg) of 15 wheat samples taken from field K6

Deoxynivalenol (DON) were found at every single sampling point (Fig. 17). The contamination ranges from 93,5 µg/kg to 234,5 µg/kg. No sample overran the maximum tolerable level for DON fixed by Regulation (EC) 1126/2007. It is noticeable that DON also were found were no *Fusarium* was detected by microbiological assay (cp. Fig. 15, sampling point 2, 3, 8, 11 and 13). A reason why *Fusarium* mycotoxins are found were no *Fusarium* species seem to be is the same reason like why *Fusarium* was detected by molecular but not by microbiological methods. Apparently the DON contamination is not clustered in the field but seem to be distributed relatively homogenously. This could be of great interest for mycotoxin monitoring.

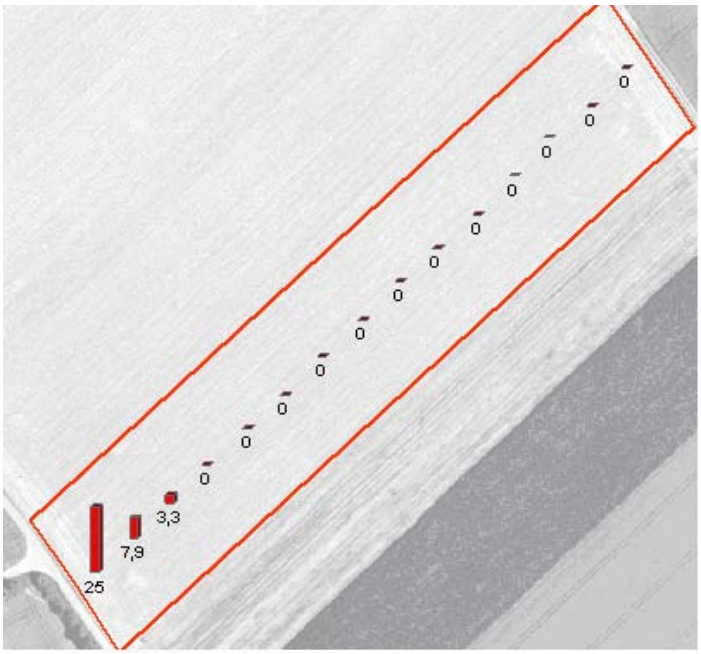


Figure 18: Ochratoxin A content (µg/kg) of 15 wheat samples taken from field K6

Ochratoxin A (OTA) is not a *Fusarium* mycotoxin but as explained in former chapters it is one of the most dangerous mycotoxins found in wine and cereals. In field K6 it was only found at three sampling points in the south-western part of the field (Fig. 18). The maximum tolerable level for OTA is 5 µg/kg according to Regulation (EC) 1126/2007. Two of the three contaminated samples overran the threshold. The highest concentration of OTA was 25 µg/kg, a five time overrun. This contamination occurred at sampling point 1 where also the highest Fusarium incidence was recorded. The same reason which seem to be causative for the high Fusarium incidence may be an explanation for the high OTA contamination, too. The changed microclimate due to the hedgerow at this field border. OTA contamination is apparently not distributed homogenously but aggregated in hot spots.

Enniatin B (ENB) is a mycotoxin produced by a broad range of fungi. Also some Fusarium species are able to produce it. In field K6 ENB was found in two-thirds of the samples (Fig. 19). The ENB content of the contaminated samples ranged from 6,3 to 281,7 µg/kg. No maximum tolerable level is defined for ENB but it is known to be cytotoxic. In comparison to DON and OTA which are apparently distributed homogenously and aggregated, respectively, ENB seems to tend to occur more aggregated. Too little is known about production of ENB by *Fusarium* species to give an definite answer. Also the potential of danger by ENB has to be assessed more accurately to decide whether a contamination as high as 280 µg/kg is tolerable or not.

Figure 19:
Enniatin B content (µg/kg) of 15 wheat samples taken from field K6

4. Conclusions

Mycotoxins can be a severe problem in wine production which must be carefully monitored although all samples analyzed in the frame of this project, with very few exceptions, proved to be contaminated by OTA at a level which is higly lower than the threshold established by the European law. The survey carried out in Liguria Region showed that no significant differences in OTA content between red and white wines could be assessed, but that different levels of contamination by ochratoxigenic fungi can be observed depending on vine cultivar. It is stressed the efficacy of pesticide application for the control of mycotoxigenic fungi in the vineyards since the activity of these compounds can have a positive effect even during the wine making process reducing the OTA content. Anyway this practice should be carefully evaluated and based on a real disease pressure for a more sustainable management of the vineyard.

Relevant to cereals, although the maximum tolerable levels of mycotoxins were not overran in most cases, mycotoxins were obviously present in nearly every sample. This means that there is a potential of high and severe mycotoxin contamination given in the field. In Years where the weather conditions are more favourable for fungal infections it is possible that there will be much higher concentrations of mycotoxins. The results taken out of these examinations also showed that not only the typical expected plant pathogens can lead to problems but also rather unexpected species which are normally found on different but close related plants. It is worth to take a closer look at these species like the maize Fusarium species F. proliferatum and F. verticillioides in the future since they are important mycotoxigenic plant pathogens. It seems also reasonable to expand the monitoring to mycotoxins which are rather unexpected in cereals like Ochratoxin A and Enniatin B.

Some recommendations for a mycotoxin monitoring system can be therefore drawn:

a. The results show that the focus in mycotoxin monitoring should not only be on the ‘common’ mycotoxins Deoxynivalenol and Zearalenon but also on rather unexpected mycotoxins in wheat like Ochratoxin A;

b. In the case of Deoxynivalenol, where the distribution seemed to be homogenously, it should suffice to examine a mixed sample for the whole field;

c. In the case of Ochratoxin A, which seemed to be rather aggregated in foci, a different sampling system is recommendable:
   - risk factors, favouring an infection with ochratoxigenic species in wheat have to pointed out more clearly

- these risk factors can than be mapped, for example with geographical information systems (GIS)
- mycotoxin monitoring can then firstly be done in the defined high risk areas

d. The recommended Ochratoxin A monitoring system could also be used for other mycotoxins for a first estimation of the contamination level

e. In practical monitoring multi mycotoxins methods should be used where it is possible to better overview the contamination status of rather uncommon or unexpected mycotoxins

f. The Research should, where it is possible and reasonable, not focus on one or two mycotoxins but look for more mycotoxins

Experimental activities were followed by different initiatives aiming at improving the knowledge of the European legislation related to mycotoxins, promoting its implementation, and proposing solutions to prevent or reduce the risks of mycotoxins in the food chain, both at the regional and local, level, along the whole food chain, involving all the stakeholders, from the farmers to the consumers. Meetings, seminars, infodays, exchanges of students were organized for a better practice transfer among partners. On a major extent the wide variety of occasions for meeting and knowledge and technology exchange will be able to promote the economic activities – agriculture, food industry and tourism - of the three regions involved.

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Annex

1. Receipt for the preparation of selective and semi-selective media

MEA
Malt extract 20 g/l
Agar 20g/l
Cloramphenicol 50 mg/l
Clortetraciclin 50 mg/l
Dichloran a.i. 0,2% w/v in 1ml ethanol

MEA-B
As described for MEA plus boscalid a.i. 10 mg/l

2. Wine making process

Fermentation starter was produced using glucose (100 g/l) and yeast Saccharomyces cerevisiae (Zymoferm, Franke prodotti enologici, Susa (TO), Italy) (20 g/l) in sterile and deionised water. It was put at 25 °C for 72 hours. Juiced obtained from smashed bunches were filtered through a sieve (0,5 mm), then distributed into plastic vessels suitable for food storage and the starter was added (200 ml/l of must). Juices were stored in a climatic chamber at 25 °C till the fermentation process was naturally over. Red berry skins were kept in contact with musts during fermentation while white ones were removed. Once fermentation stopped, temperature was lowered to 4 °C for 24 hours in order to facilitare the natural separation between musts and lees.

Monitoring Systems

- 6 Regions
- 7 Sub-Projects
- 26 Project-Partners

Priorities

Improvement of integrated food safety and monitoring systems in international food chains

Sub-themes

- Cold Chain Management and multi-function traceability requirements
- International coordination of implementation approaches
- Supporting monitoring systems in complex supply chain scenarios

Sub-Projects

- INQAS
- SafeFoodGuide
- Microbiosafe
- MonStratFood
- GeoQuality
- Innofruit & QualiTools

Innovative Systems in the field of food quality and safety

Kreyenschmidt, J.[1], Hansen, T.B.[2], Kampmann, Y.[1], Christensen, B.B.[2], Aabo, S.[2], Lettmann, T.[3], Bruckner, S.[1], Kostov, I., van Beek, P.[4] and Petersen, B.[1]

[1] Institute of Animal Science, University of Bonn, Katzenburgweg 7-9, 53115 Bonn, Germany

[2] The National Food Institute, Technical University of Denmark, Mørkhøj Bygade 19, 2860 Søborg; Denmark

[3] Institute of Household Technology, University of Bonn, Nussallee 5, 53115 Bonn, Germany

[4] University of Wageningen and Research Centre, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

Abstract

Determination of shelf life is the most important company planning issue concerning fresh food in pork chains, because there are two ways to keep quality of fresh food products in supply chains on desired levels. Either by spending effort on cooling the product during the stay in the chain or by spending effort on speeding up the goods' flow by cutting production and transportation lots. Thereby safety aspects play an important role. In each stage of the chain the growth of spoilage as well as pathogenic bacteria has to be under defined levels. The main objective of INQAS was the development of a "Decision Support Tool" (DST) to improve food quality and safety in dependence of storage temperature and sojourn time concerning optimal adjusted distribution systems for small and medium sized enterprises. Thereby the DST consists of three firstly independent modelling parts. A spoilage model to describe the freshness loss, a risk model to derive the prevalence and concentration of pathogen microorganisms and an economic model, where total logistic and chilling costs are minimised while keeping the growth of microorganisms in the chain below some pre-specified threshold value. The practical application of the suggested modelling approach in pork chains firstly demands detailed knowledge about processing and distribution factors influencing food safety and quality. Thus, the planned modelling approach also has to take into account the heterogeneous structures of pork chains in European countries (GER, NL, DK, BL) to determine the relevant data sets. Thus a questionnaire was send to stakeholders in the meat chain in all four partner regions to get detailed information on factors and critical points that influence food safety and quality as well as information on logistical structures of meat chains. In addition, temperature measurements in the cold pork chain were generated to ensure a comprehensive chain mapping. From the collected data sets laboratory models for studying the growth rates of microorganisms (specific spoilage indicators) in meat and meat products have been established. As result a kinetic shelf life model has been validated to simulate static (isothermal) and dynamic (non-isothermal) storage conditions. At the same time the risk model has been established by combining collected data for *Salmonella* occurrence in minced pork and pork loins with growth rates of *Salmonella* in minced pork at different temperatures. In the last step a two echelon economic model approach was derived.

1. Introduction

Pork meat and its products are very perishable due to their high water activity and nutrient content (Krämer, 2004). Besides hygienic factors while the production and packaging process temperature conditions in every stage of the supply chain have huge impact on spoilage of pork meat. Thereby the microbiological status of fresh pork is mainly dependent on hygienic conditions during slaughter, dissection and packaging while the increase of freshness loss is mainly depended on temperature conditions during storage and distribution. Thus, storage of fresh meat above suggested storage temperatures causes a shorter shelf life of the product and possibly supports the growth of pathogen microorganisms (McMeekin, 1997). Therefore shelf life directly correlates with cooling-effort and sojourn time during processing, distribution and storage and thus shelf life determination is a multi-factorial process integrating food quality, food safety and economical parameters. In the pork supply chain storage management is mainly based on the FIFO-Principle (First In First Out) with no regard to freshness and quality status

of the product. This means possible economical loss because the latest production is not always the freshest.

Therefore, the main objective of the project was the development of a "Decision Support Tool" (DST) regarding shelf life, safety and economic aspects. Consideration of practical requirements in pork supply chains generates a predictive model which provides actors in the chain with information on how to distribute efforts with respect to cooling-processes (technological issue) and reduction of sojourn time (logistical issue). Always under the assumption, that the amount of microorganisms may not exceed a defined level. By considering all these aspects, a DST is a big advantage for participants in the meat chain. Thus, the development of a DST concerning shelf life of fresh pork will support activities of all actors in pork chains by considering temperature and sojourn time in every stage simultaneously with cost minimisation.

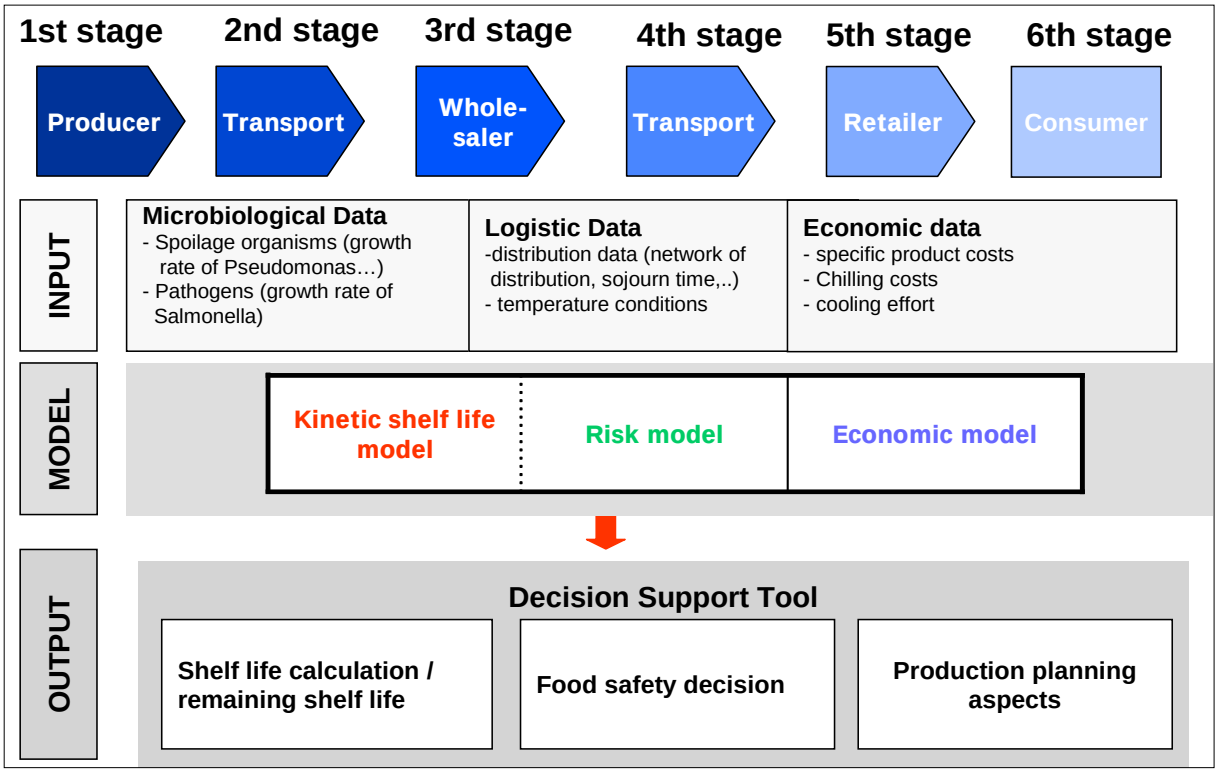


Figure 1: Overview of the structure of the Decision Support Tool

2. Materials and methods

Important prerequisite for the development of the "DST" is a detailed knowledge about chain specific parameters in each of the 4 named countries. Thus in a first step a standardised questionnaire was compiled with specific information regarding quality control aspects, temperature and storage monitoring, packaging aspects and technical details regarding cooling aspects, etc. The questionnaire was addressed to slaughterhouses, processing- and transport companies, wholesaler and retailers in the European countries (Germany, Denmark, the Netherlands, Bulgaria). The analysed data served as framework for the formulation of the optimisation approach (economic part) and the conduction of the laboratory measurements concerning realistic time-temperature-scenarios.

Accordingly, the development of the models was divided into three firstly independent parts: (1) Shelf life investigations, (2) risk/exposure investigations and (3) derivation of an appropriate economic model. Each partner was responsible for the development of one model part: North-Rhine-Westphalia developed the kinetic shelf life model, Denmark was responsible for the development of risk/exposure model and the economic model was developed in the region of Gelderland.

1. Shelf life model:

For shelf life studies pork loin samples and modified packed minced meat were stored under controlled temperature conditions. Samples were stored at five different isothermal temperatures between 2°C-20°C. Additionally 19 time series under dynamic temperature conditions were conducted to validate the model (LETTMANN, 2007). Samples were taken at appropriate time intervals. For every measurement five samples of each product were investigated. A total of 1558 samples have been investigated until now (698 minced meat/860 pork loins)

The following freshness parameters were used to characterize the spoilage process:

- microbiological analysis: Total Viable Count (TVC) (Plate Count Agar, Merck), Pseudomonas ssp. (Pseudomonas Agar Base+CFC Supplement, Oxoid) and Impedance measurement for minced meat (BiMedia 002a, SyLab).
- sensory evaluation: A four point hedonic scale was used. The parameters texture, colour and odour were evaluated by a trained sensory panel. The results were summarised in a sensory index

The development of the microbiological parameter over time was fitted with the Logistic-growth function (Eq. 1) for minced meat and in addition with the Gompertz function (Eq. 2) for pork loins. To expand the shelf life model a product specific heat transfer coefficient was derived using the assumptions of "Newtons Law of Cooling".

Equation 1

$$\log(N(t)) = \log\left(N_{min} + \frac{N_{max} - N_{min}}{1 + \exp\left(-\mu_{max} \cdot (t - \tau_{lag})\right)}\right)$$

with: N = microorganisms per g (time t), μ = specific growth rate (h-1), τ = lag. Phase (h)

Equation 2

$$\log N(t) = \log N_{min} + N_{max}\left(-\exp\left(-\mu_{max} \cdot (t - M)\right)\right)$$

with: N = microorganisms per g (time t), μ = specific growth rate (h-1), M = time when growth rate reaches its maximum in h

The temperature dependence of the kinetic parameters was modelled using the Arrhenius approach (Eq. 3)

Equation 3

$$k = k_0 \cdot \exp\left(\frac{-E_a}{R\vartheta}\right)$$

with: k = reaction rate constant (μ in h-), Ea = Activation Energy in kcal/mol, R = ideal gas constant in J mol-1 K-1, ϑ = Temperature in K

2. Risk model:

Prevalence and concentration of Salmonella.

In Denmark, 4,944 samples of fresh pork cuttings as well as 2,172 samples of fresh minced pork meat were collected at retail. For detection of *Salmonella* the samples were analysed qualitatively using standard enrichment procedures. Subsequently, for all samples where *Salmonella* was detected, the concentration was determined semi-quantitatively by qualitative analysis of ten-fold dilutions of 25 g sample.

Growth rates of Salmonella.

Growth curves of Salmonella were determined in sterile minced pork at regular temperatures from 3.6 to 38°C. The meat was inoculated with a three-strain cocktail and a total of 150 samples were analysed quantitatively for Salmonella by a drop-plating technique using XLD-agar (Hansen et al. 2007a). Each growth curve was fitted to the logistic model (Eq. 1). Fitting was carried out using the method of least squares resulting in estimates of the maximum specific growth rate, μ_{max}. For the description of the effect of temperature on μ_{max}, a square-root-type model was applied (Eq. 4).

Equation 4 $$\sqrt{\mu_{max}} = b \cdot (T - T_{min})$$

where b is a constant, T is the temperature in °C and Tmin is the intercept between the model and the temperature axis.

2.3 Economic model:

The economic model assumes a two-echelon situation of a perishable pork product that is stored in a warehouse and is forwarded, in batches, to the retail store periodically. The calculation of the optimal balance between chilling costs (cooling effort) in the chain and the sojourn time reduction in the chain by choosing smaller lot sizes both in warehouse and/or in the retail store is the intention of the model. Thereby it was aimed at taking into account that microbial growth should not exceed certain prescribed levels for each relevant stage of the supply chain. Therefore the relevant parameters in the chain were measured and characterised (see questionnaire). The microbiological status (N) in every stage of the chain is mainly dependent on temperature (T) and sojourn-time (W). These parameters are as well correlated with the accumulated chilling costs.

A higher value of temperature means reduced chilling costs but higher growth rates of microorganisms. This involves an expended spoilage or rather a higher risk for food caused diseases. A lower sojourn-time in every stage of the chain means lower chilling costs but higher logistical costs. This contribution is intended to provide an informative basis in simultaneous control of time and temperature based control of perishable goods like pork meat.

The first step in the development of the economic model part was the determination of lot sizes (goods flow) at warehouse and retail. In our case we assume the demand as constant. Thereby the time between consecutive replenishments from the warehouse amounts to Q/D Periods. With regarding F as fixed setup costs and h inventory costs the so called economic order quantity is obtained (Eq. 5).

Equation 5 $$EOQ = \sqrt{\frac{2FD}{h}}$$

The derived economic model considers the spoilage of the product in dependence of sojourn time and storage temperature and the raised cooling effort (costs) in an optimization approach to describe an optimal storage and distribution system. Equation 6 describes the optimisation problem. We use, for this example, a simple exponential growth model.

Equation 6 $$\min_{Q,T}\left\{\frac{1}{2}hQ + \frac{FD}{Q} + G(T)\right\}$$ subject to: $N_0\, e^{\mu(T)W} \leqq \mathrm{MAX}$

Thereby is: h = inventory costs, D = demand (constant), μ(T) = spec. growth rate, F = fixed costs, G(T) = costs per period for cooling, N = microorganisms (time t).

This means, this optimisation approach considers the optimal storage temperature bearing in mind low storage costs and minimised microbiological growth. In our case we can substitute W = Q/D because Q/D is the maximum time an item can be in stock. MAX is a parameter to be determined in advance. Equation 6 can be reduced to Equation 7:

Equation 7

$$\min_{T}\left\{\frac{1}{2}h\frac{D}{\mu(T)}\ln\left(\frac{MAX}{N_0}\right)+\frac{F\mu(T)}{\ln\left(\frac{MAX}{N_0}\right)}+G(T)\right\}$$

because in the optimum the inequality will be equality.

3. Results and discussion

Characterisation of the chain

The collected data from the questionnaire allowed a detailed mapping of the different structures of pork chains in Germany, Netherlands, Denmark and Bulgaria. The detailed questionnaire made evident, that the structure of the meat chain is different in the four participant regions. In Germany, there are a few slaughterhouses and cutting plants controlled by large enterprises sharing the market with mainly SME's while wholesalers and retailers are again mostly larger companies. In contrast the Danish and Dutch pork chain are completely dominated by large companies. In Bulgaria the whole supply chain is mainly dominated by SME's.

From the collected questionnaires typical distribution ways concerning storage temperature and sojourn time for different pork products could be derived (Table 1). Additionally the recommended shelf life and packaging aspects are listed. The collected data is the framework for the conduction of laboratory tests and model validation (simulation runs). Table 1 shows exemplarily the results for Germany.

Table 1: Sojourn Time, Temperature and shelf life of the most common pork products in Germany.

Pork product	N =	Shelf life			Temperature (°C)				Sojourn time (d)				
		< 5	5-10	> 10	0	0,1-2	2,1-4	4,1-7	0	1-2	3-4	5-6	>7
Bacon	12	4	5	3	1	5	2	4	-	9	1	2	-
Loins of pork	10	4	4	2	1	2	4	3	-	8	2	-	-
Shoulder	8	4	4	-	1	4	-	3	1	5	1	1	-
Neck	7	1	4	2	1	1	2	3	-	4	2	1	-
Lobe	3	1	2	-	1	1	1	-	1	2	-	-	-
"all"	3	1	-	2	-	2	-	1	1	1	-	-	1

The results show obviously that there is a great difference concerning recommended shelf life, temperature and sojourn time for the different pork products.

The most common methods to determine the quality status of fresh pork were ascertained shows Figure 2. It has been carried out, that the most common method for quality control during incoming inspection is the measurement of product temperature, followed by sensory evaluation and microbiological analysis. While process control, product temperature and environmental temperature are also the most important quality parameters. The temperature measurements are also supplemented by microbiological analysis. This means, that temperature measurements are already the most common method for quality control. Concerning the microbiological analysis mainly TVC and *Salmonella* were monitored.

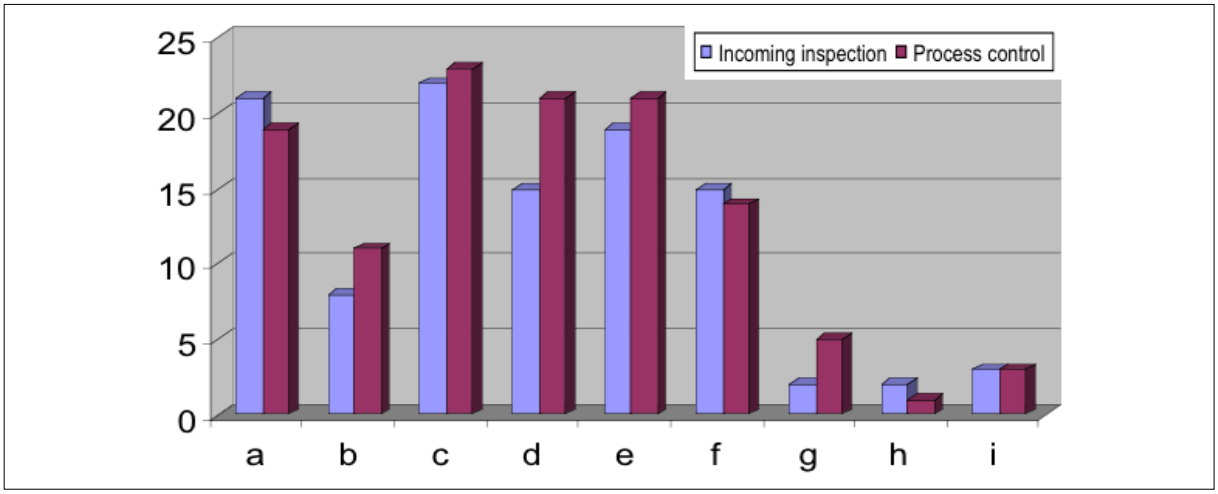


Figure 2: Number of companies using listed methods to determine the quality status of fresh pork (n = 28), where a = sensory evaluation, b = pH-value, c = product temperature, d = ambient temperature, e = microbiology, f = control of shelf life, g = rapid methods, h = other and i = not applicable

Thereby, it is to mention, that the raised results are not accessible to all chain members, but rather for one part of the chain. A comprehensive exchange of quality values is thus not guaranteed. Further on the cooling and storing costs in dependence of operation costs were asked (Figure 3).

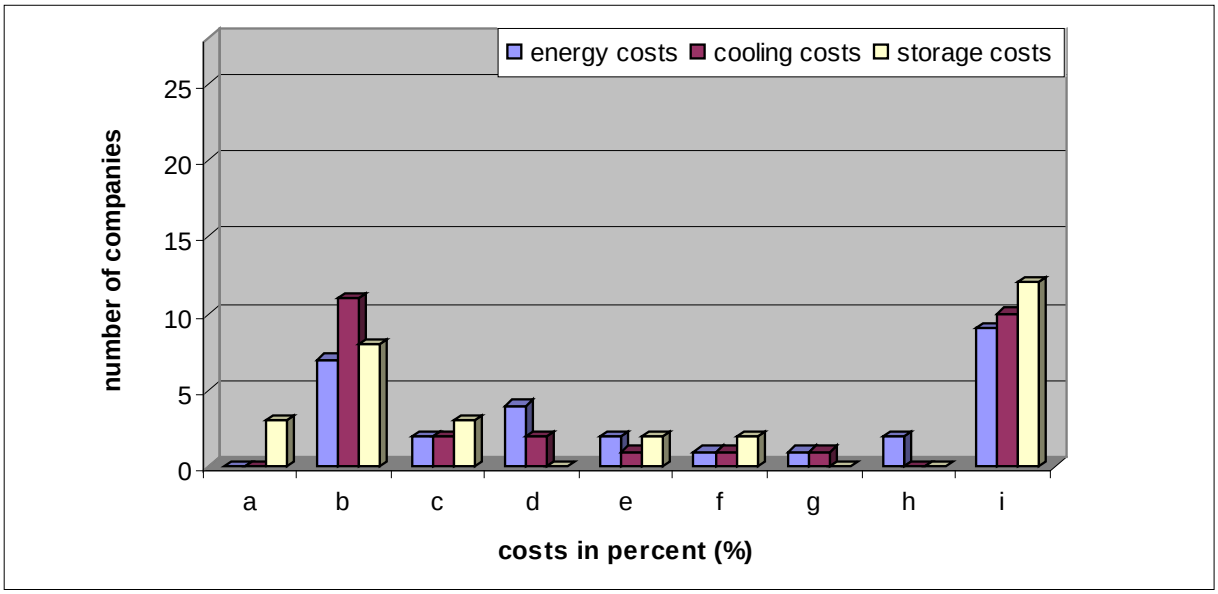


Figure 3: Proportion of energy-, cooling and storage costs (n=28), where a = none, b = 1-5%, c = 6-10%, d = 11-20%, e = 21-30%, f = 31-40%, g = 41-50%, h = ≥ 51% and i = not specified.

In the Netherlands the fraction energy costs are around 10 % while the costs for cooling causes 5 % respectively 7 % for storage. In Bulgaria the enterprises report ca. 30 % each for energy and chilling. The collected data serves as input for the optimisation of the models concerning the aim of the practical approach.

3.1 Shelf life model

Figure 4 shows the measured and fitted growth curves of TVC in minced meat at isothermal temperatures (2-20°C). For all spoilage indicators it becomes evident, that with higher storage temperature the spoilage rate increases.

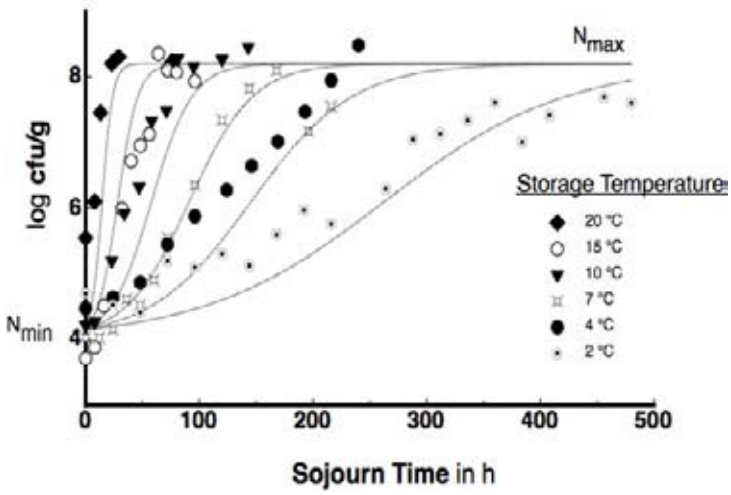


Figure 4:
Growth of Total Viable Counts in minced meat at different temperatures (R2=0,81 (simultaneous fit))

To describe the temperature effect on the development of the relevant spoilage parameters, the Arrhenius approach was used. The characteristic activation energy is determined from the slope of the line. A steeper slope means the reaction is more temperature sensitive. Figure 5 shows the Arrhenius Plot for the growth of TVC in modified packed minced meat.

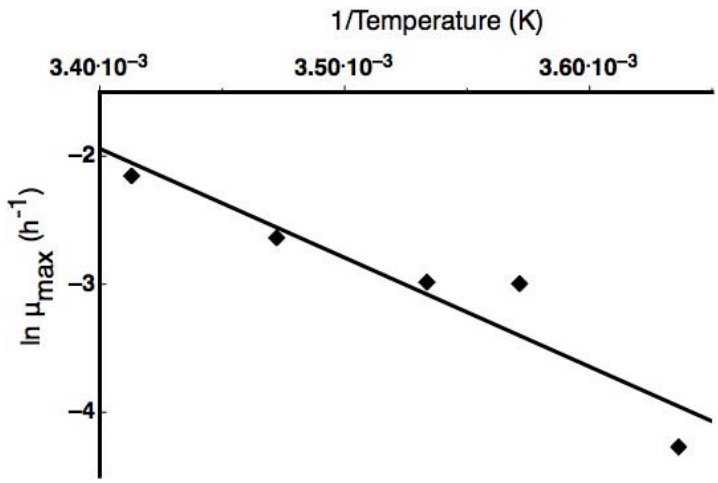


Figure 5:
Arrhenius-Plot for the growth of Total Viable Counts (minced meat)

Table 2 shows the calculated activation energies for the investigated pork products.

Table 2: Calculated activation energies in kJ/mol (to be completed)

Parameter	Product	
	Minced meat	Pork loins
TVC	84,6 kJ/mol	60,0 kJ/mol
Pseudomonas ssp.	122,4 kJ/mol	76,2 kJ/mol
Sensory	70,3 kJ /mol	63,3 kJ/mol

Thus the growth (spoilage) rates for the relevant temperature range are determined and the freshness loss can be calculated for different time-temperature-scenarios. Prerequisite was the validation under non-isohermal conditions. Figure 6 shows the development of TVC and the fitted growth curve in pork loins under dynamic storage conditions.

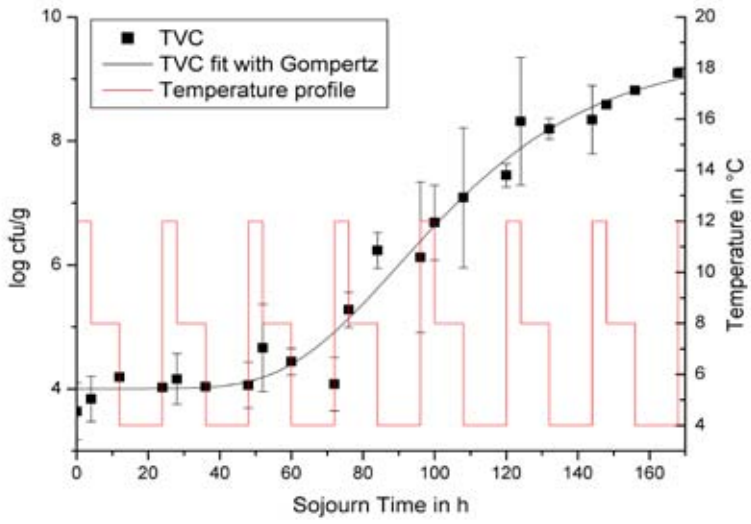
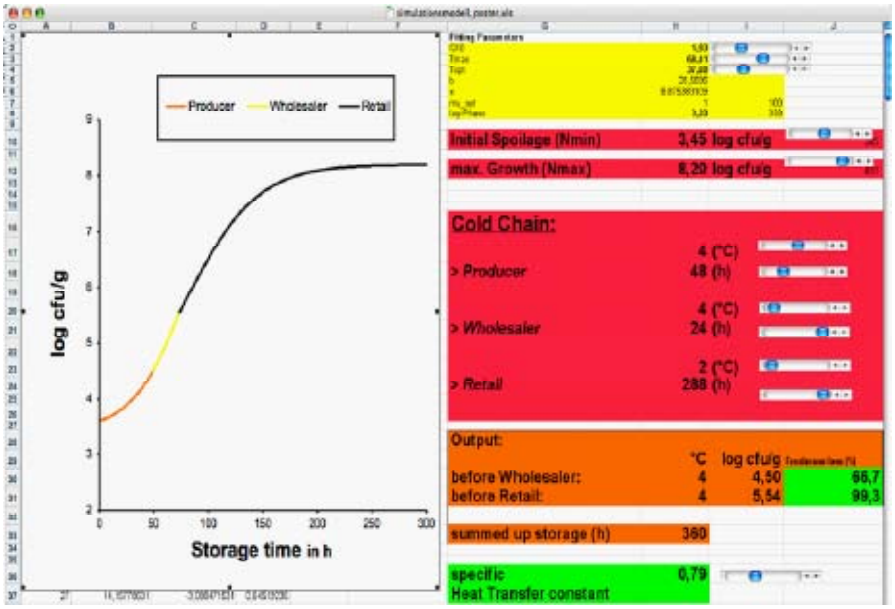


Figure 6: Development of TVC and fitted growth curve under non-isothermal conditions in pork loins

Figure 7 illustrates the derived spoilage model (excel approach) for shelf life prediction. The parameters initial microbiological count, maximum growth rate, specific heat transfer constant (packaging characteristics) as well as temperature and sojourn times in every stage of the chain are adjustable. In combination with temperature monitoring, the determination of shelf life is possible in every stage of the chain.



Variation of:

spoilage bacteria (kinetic of food product)

production planning aspects

packaging characteristics (specific heat transfer constant)

Figure 7: Spoilage model (excel approach) for shelf life prediction

3.2 Risk model

From 4,944 sampled fresh pork cuttings, 57 samples contained *Salmonella*. This corresponded to a prevalence of 1,15%. From 2,172 sampled minced pork packages, 46 samples were contaminated with *Salmonella*. This was equal to a prevalence of 2,10%. For fresh pork cuttings purchased at retail, the cuttings originating from ham were found to have a significantly lower prevalence of *Salmonella* than cuttings from shoulder or mid parts of the carcass, *i.e.* 0.48% (95% C.I.: 0.20-1.00%) as opposed to 1.42% (95% C.I.: 1.05-1.88%). As shown in Figure 8, fresh minced pork meat purchased in butchers' shops had the highest prevalence of *Salmonella*, whereas MA-packaged meat purchased in supermarkets had the lowest (Hansen et al. 2007b). Another factor that was shown to be important to incorporate in the DST was import country (Figure 8).

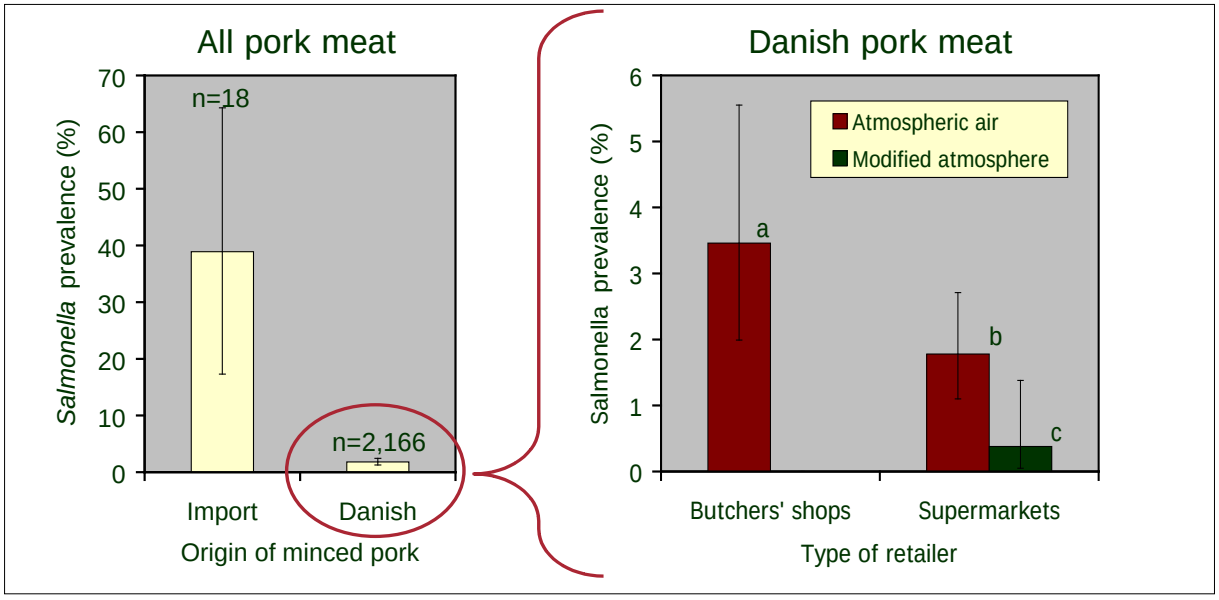


Figure 8: Salmonella prevalence in fresh minced pork meat at retail in Denmark

The observed distributions of Salmonella concentrations in fresh pork cuttings and minced meat, respectively, are shown in Figure 9. These data serve as input to the DST by being secondary models describing the level of Salmonella in pork meat purchased by consumers at retail. To be able to assess the possibility of the Salmonella level to increase in the meat before used for consumption, knowledge on Salmonella's growth capacity at different chilled temperatures was needed. Hence, a secondary model describing the effect of temperature on the growth rate of Salmonella was required.

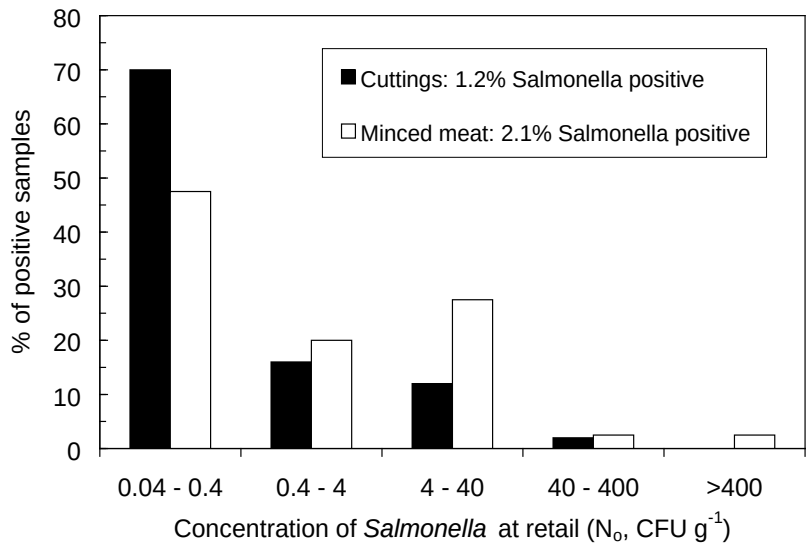


Figure 9: Salmonella concentration in pork cuttings or minced pork harbouring the organism when purchased at retail in Denmark. Secondary model based on 4,944 samples of pork cuttings and 2,272 samples of minced pork.

In order to decide whether it was necessary to develop a new secondary model for this particular purpose, 10 existing models were collected and evaluated (Hansen et al. 2007a). The performance of each model was evaluated by comparing the observed maximum specific growth rates of *Salmonella* in sterile minced pork to predicted values from the models. As shown in Table 3, the models developed by Oscar (1999a) and Oscar (2002) showed exceptionally good performance with more than 85% of the predictions falling in the acceptable zone (pRE > 85%). However, the former model did not cover temperatures below 15°C, therefore, the model developed by Oscar (2002) was preferred. Further graphical evaluation of this model showed systematic deviations in the lower temperature interval from 8 to 19°C (results not shown). To predict growth of *Salmonella* in fresh raw pork it might, therefore, be necessary to develop a new model in order to increase accuracy of predictions in the chilled temperature area.

Table 3: Performance of existing secondary models for predicting μ_{max} of Salmonella in sterile minced pork: prediction bias and accuracy factors.

Reference	Bias factor (for 15 to 30°C) n=7	Bias factor (for model)	Accuracy factor (for model)	pRE[b]
Gibson *et al.* (1988)	1.05	0.79	1.55	36
Davey & Daughtry (1995)[a]	1.18	0.96	1.31	27
Oscar (1999a)	1.21	1.13	1.16	90
Oscar (1999b)	1.19	1.05	1.14	71
Oscar (2002)	1.11	1.01	1.12	86
Oscar (2002)	1.11	0.96	1.18	57
Oscar (2002)	1.10	0.90	1.25	50
Growth Predictor (IFR 2003)	1.07	1.07	1.35	46
Oscar (2005)	0.21	0.21	4.85	0
Juneja *et al.* (2007)	1.29	1.20	1.20	50

[a] Data adopted from Gibson *et al.* (1988).
[b] Proportion (%) of relative errors (RE) in the acceptable prediction zone.

A preliminary secondary square-root-type model was developed using the growth rates determined in the present study (Figure 10). The constant b was estimated to 0.03871 and T_{min} to 3.3991.

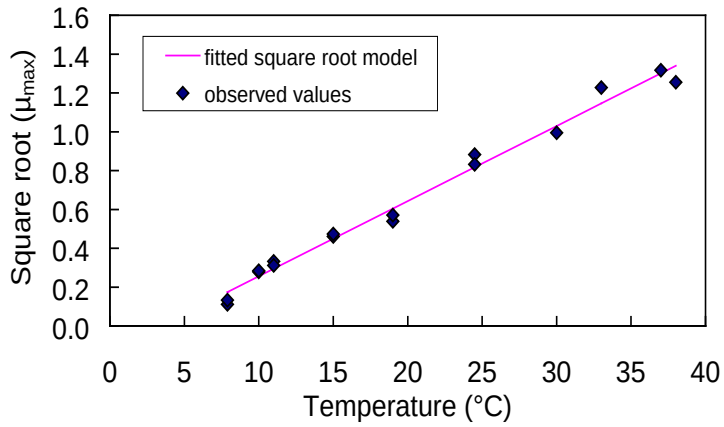


Figure 10: Preliminary secondary model for the effect of temperature on growth rate of Salmonella in sterile minced pork meat. Bias factor = 1.00, accuracy factor = 1.19 and pRE = 87%.

With the purpose of predicting the concentration of *Salmonella* in pork meat at the time of preparation of a meal a preliminary tertiary model has been constructed in the following way. A primary exponential growth model and the secondary model describing the influence of temperature on maximum specific growth rate as well as the secondary model describing the initial concentration of *Salmonella*, were combined in a computer spreadsheet (Microsoft Excel) to form the tertiary model. The tertiary model uses predicted values from the two secondary models in the primary model to predict the concentration of *Salmonella* as a function of temperatures and times experienced during transport from retailer to the point of preparation by consumer.

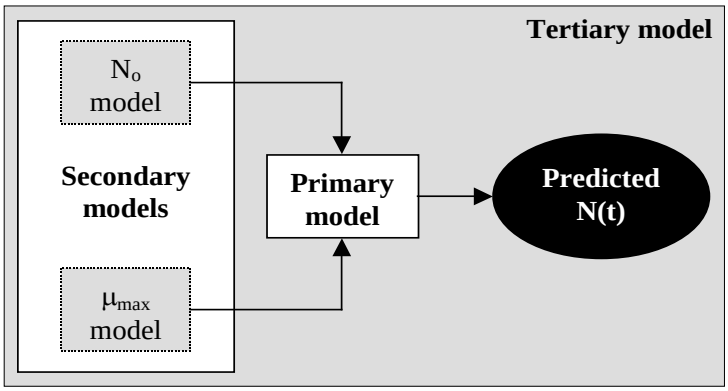


Figure 11: Relationship between secondary models and primary model in the construction of a tertiary model for prediction of concentration, N(t), of Salmonella in pork meat at time t. N_o, initial Salmonella concentration; μ_{max}, maximum specific growth rate.

The preliminary tertiary model needs yet to be validated at conditions of non-isothermal temperatures.

3.3 Economic model

By comparing the solution of the optimisation problem (Eq. 5) with *Q = EOQ* with the solution of (Eq. 6) one can obtain insight into the difference of simultaneous control (in *Q and T*) and "traditional" control based on *Q = EOQ* and T. The optimisation problem can be expanded to a multi-echelon situation illustrated in Figure 12 (in this example we choose a two-echelon equation).

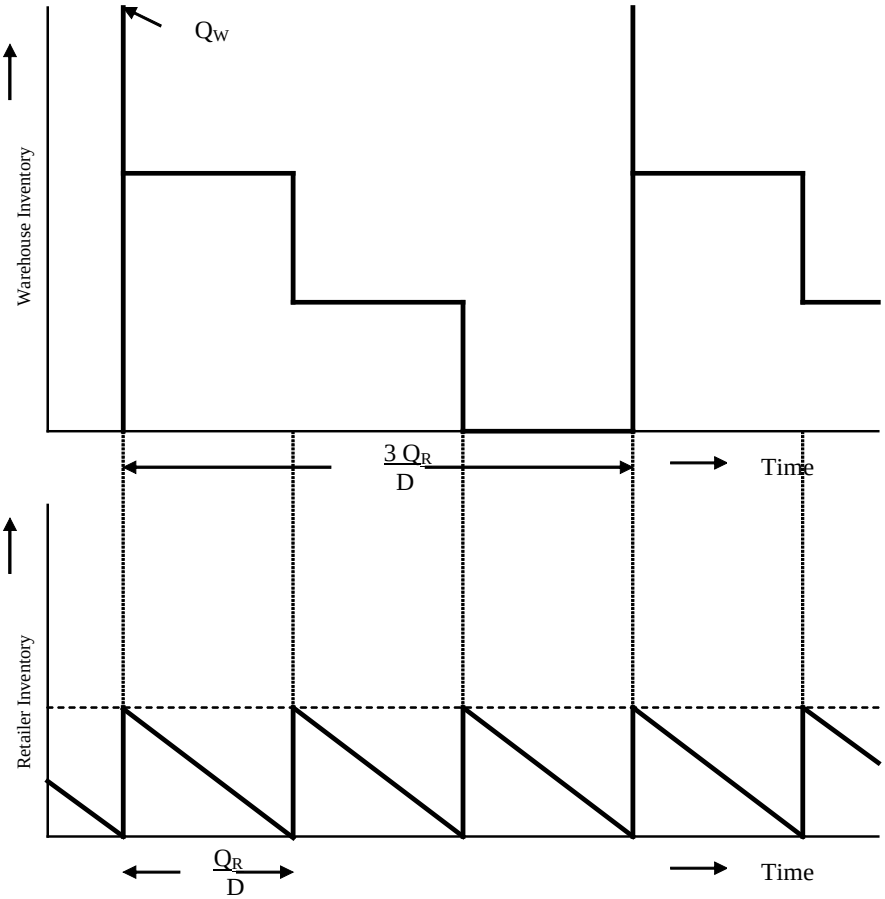


Figure 12: Inventory at the retailer store and at the warehouse site.

From this figure you can conclude that the maximum sojourn time of the product is:

Equation 8 $$\frac{Q_R}{D} + (n-1)\frac{Q_R}{D} = n\frac{Q_R}{D}$$

According to Equation 6 the two-echelon optimization model can be drawn up.

Equation 9 $$\min\left\{\frac{F_R D}{Q_R} + \frac{1}{2}h_R Q_R + G_R(T_R) + \frac{F_W D}{nQ_R} + \frac{1}{2}h_W(n-1)Q_R + G_W(T_W)\right\}$$

Subject to: $$N_0 e^{\frac{\mu(T_W)Q_R(n-1)}{D} + \frac{\mu(T_R)Q_R}{D}} \leq MAX$$

Leads to: $$N_0 e^{\mu(T_W)Q_R(n-1)/D + \mu(T_R)Q_R/D} \leq MAX$$

Thus the Optimisation approach considers shelf life decisions in combination with production planning aspects. Relevant literature in this field: LÜTKE-ENTRUP (2005), SILVER (1998)

Combination of Models

The development of a DST will be used to balance chilling costs related to sojourn time. The integrative character of the DST with respect to shelf life and economic aspects will support activities in fresh food supply chains by considering shelf life as an instrument to generate more added value and food safety while keeping total cost as low as possible.

Table 4 shows the assumptions for three different simulation runs concerning storage temperature and sojourn time derived from the collected questionnaire results.

Table 4: Assumptions for simulation runs

Description of the chain	Scenario Nr.:	Stage 1		Stage 2		Stage 3	
		°C	Sojourn Time (h)	°C	Sojourn Time (h)	°C	Sojourn Time (h)
ideal cold chain (reference)	1	2	12	2	36	2	200
Interrupted in stage 3	2	2	24	2	24	4	200
Interrupted In all stages	3	4	24	5	24	7	200

Assumptions:

The batch size is 10000 units. The size of the cooling area is approx. 175 m2 in each stage. The fraction of cooling costs represent 30 % of the total energy costs in fact 0,90 € per hour (at 2 °C) (ECH 2001). The costs are correlated with temperature. Figure 13 shows the assumed cost function. The price for a kWh is 0,14 € (average). The recommended shelf life for minced meat is 190 h.

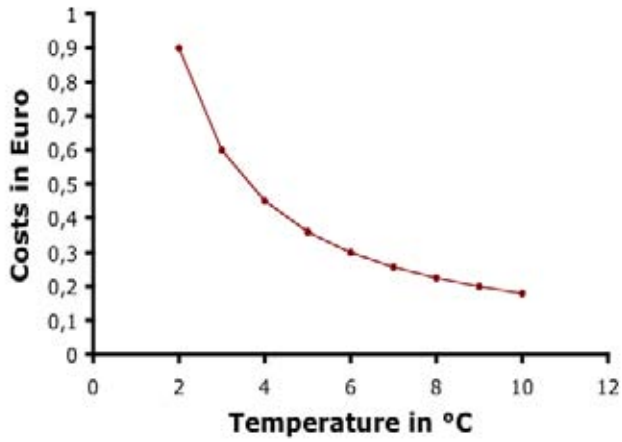


Figure 13: Assumed G (T) cost function (ECH 2001)

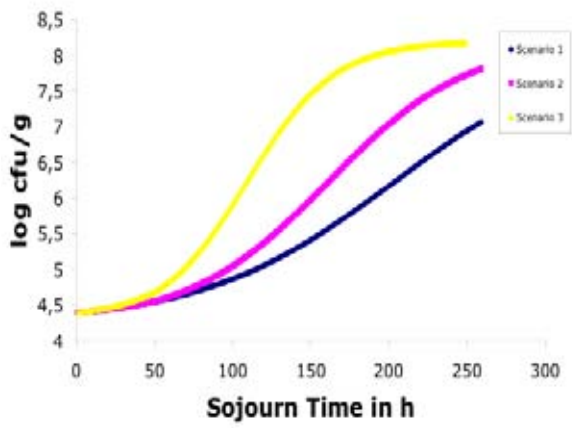


Figure 14: Simulated growth curves

With increasing storage temperature the costs for cooling decreases. Figure 14 shows the simulated growth curves representing the freshness loss. The end of shelf life is set to log 6 cfu/g.

Table 5 shows the results of the simulation runs for the assumed scenarios in Table 1.

Table 5: Overview results simulation runs

Scenario	Shelf life in h	Expected increase of *Salmonella* numbers	Shelf life loss in %	total cooling costs	cooling costs per unit	cost reduction in %
1 (reference)	190	No increase	---	223 €	0,022 €	----
2	152	No increase	- 20	133 €	0,013 €	- 41
3	103	53-fold increase	- 46	70 €	0,007 €	- 69

The conducted simulation runs make evident that the cost can be reduced up to 69 % at the same time with a shelf life loss of 46 %.

The next step in the development of the “DST” will be an improvement of the combination of the three model parts concerning most realistic input variables. Therefore more detailed information regarding cooling and logistic costs as well as the influence of the batch size in each part of the chain are needed. At the moment the costs are assumed as constant over the whole chain, whereas every chain participant possesses different cost structures. In the next step the three models will be combined in a comprehensive software tool. Also the aspects of decision making for the enterprises will be integrated in the software tool.

5. Conclusions

Within this EU-Project, the establishment of a research network to improve food safety and quality has been successful implemented. The group met several times during the running time of the project and discussed the results also with experts and SMEs. The INQAS project was present at several conferences with oral presentations and poster presentations. The four project partners have been in close collaboration, which included exchange of PhD’s students and common research applications for future investigations. Moreover, training courses took place for the dissemination of results and providing the knowledge of the distribution network from slaughter to retail. The group will meet in beginning of February to discuss about further activities in the described thematic.

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Guidelines for regional food authorities to establish science based food safety programmes

Hansen, T.B.[1*], Aabo, S.[1], Rosenquist, H.[1], Christensen, B.B.[1], Nielsen, N.L.[2], Bondt, N.[3], van Wagenberg, C.[3], Petersen, B.[4]

[1] The National Food Institute, Technical University of Denmark, Mørkhøj Bygade 19, DK- 2860 Søborg, Denmark

[2] The Danish Veterinary and Food Administration, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark

[3] Agricultural Economics Research Institute (LEI), Burgemeester Patijnlaan 19, P.O. Box 29703, NL-2502 LS The Hague, The Netherlands

[4] Institute of Animal Science, University of Bonn, Katzenburgweg 7-9, 53115 Bonn, Germany

*Corresponding author, E-mail: tibha@food.dtu.dk

Keywords: Microbiological food control, risk management, data collection, food safety programmes

Abstract

Current methods of data collection in the field of microbial food safety have been compared. Two questionnaires were prepared and sent to each of the participating regions: Gelderland (in the Netherlands), North Rhine Westphalia (NRW, in Germany) and Hovedstads (HUR, in Denmark). The first questionnaire was used to acquire a general overview of the structural organisation of the public food safety organisations in the regions. Together with a workshop in 2006 the first questionnaire was used to design a second questionnaire, which aimed at gathering information about how microbial food safety data are collected in the regions. This information was subsequently discussed at a workshop involving representatives from the food authorities, industries and research environments in the participating regions. All together the knowledge acquired formed the basis for common best-practice guidelines of public data collection in the field of microbial food safety in European regions.

Best-practice guidelines must include: 1) a highly structured organisation, 2) a clear understanding of the responsibility at all levels, and 3) data must be accessible for all involved parties (common database). At a more detailed level the obtained results showed that sampling and analysis could be a weak point of the guideline if these are not done strictly in accordance with the protocol. In addition, the industry involvement needs clarification as e.g. outsourcing of analyses to private laboratories has been shown to influence the data flow negatively, while on the other hand, the food industries, where samples are taken, may contribute positively to the planning of data collection.

1. Introduction

During the past 20 years a significant increase in the number of human illnesses caused by food borne pathogens has been registered throughout Europe. In the same period an increase in the trade of food on the international market has facilitated an increased flow of food borne pathogens across borders. This has brought focus on the importance of improved methods for prevention, control and monitoring of food borne hazards. There is worldwide a basic understanding that food safety has a global impact, but that it must be dealt with at a local level. In order to obtain a common understanding of local and global food safety, it is important that collection and interpretation of data on food safety issues follow a uniform pattern accepted by the involved food safety authorities. The European Food Safety Authority (EFSA) has e.g. expressed this in relation to the elaboration of their annual Zoonosis report. In this specific case, the comparison between European countries has been impeded, as a result of different methodologies, sampling and reporting systems in the different countries.

A structured approach to risk-based food safety investigations developed in Denmark and named “Centrally Coordinated Laboratory (CCL) Projects” has been the inspiration as well as starting point to investigate and compare systems for public data collection in the field of microbial food safety at the EU regional level.

1.1 The Danish experience

In 2000 the Danish government decided to change their strategy on microbiological testing and considered whether the resources could be used more efficiently on a risk-based approach. Subsequently, the local food control units were moved from municipal to governmental rule and at the same time reduced considerably in numbers (Nielsen, 2006a). This reorganisation elapsed until 2005 and currently the Danish Veterinary and Food Administration (DVFA) consists of a central headquarter with three local regional veterinary and food administration centres (www.foedevarestyrelsen.dk). Part of the reorganisation also meant a division of risk management and risk assessment responsibilities. This resulted in the separation of the research institute, Danish Institute for Food and Veterinary Research (DFVF), from DVFA in 2001. The latest development in the structural organisation has been a fusion between DFVF and the Technical University of Denmark (DTU; www.dtu.dk). As of the beginning of 2007, DFVF has been split and reorganized as two separate/independent institutes, the National Food Institute (www.food.dtu.dk) and the National Veterinary Institute (www.vet.dtu.dk), within the organization of DTU.

Thus, In Denmark, from the mid 2000, the focus on food control has changed from random sampling to targeted sampling in problem areas followed by an evaluation in each case. Consequently, sampling at the retail level has been reduced considerably and resources have instead been allocated to surveillance of pathogens at the national level (Nielsen, 2006b; Andersen et al. 2007). Today, Danish microbiological food control is coordinated both at the central as well as the local regional level of administration. The local regional level is responsible for the control carried out within its own region and the central level is responsible for regulation, control strategies and surveillance at the national level (Anonymous, 2006). In practice the control is carried out as 1) Locally Coordinated Laboratory activities (LCL) and 2) Centrally Coordinated activities organized as Laboratory projects (CCL).

The main purposes of the LCL activities are to verify that own-check programmes implemented at food establishments are effective and to verify compliance with microbiological criteria laid down in the legislation (Anonymous, 2006). The CCL activities are carried out as national surveys or projects and are more in the nature of data collection. The purpose of this data collection in the form of CCL projects is to:

- Reveal emerging microbiological problem areas
- Survey for microbiological hazards in foods
- Collect data for preparation of risk assessments and risk profiles to support microbial risk management
- Monitor the effect of established risk management options and evaluating whether these have provided the desired results

(Andersen et al., 2007; Anonymous, 2006).

The financial backbone in this system is the allocation of approximately 30% of DVFA's yearly budget for testing particularly for CCL projects. This percentage is expected to increase over the next years (Nielsen, 2006b). In 2004, a total of 11.000 microbiological samples were allocated for 13 CCL projects (Christensen et al., 2007). In 2006, this number had increased to approximately 14.000 samples distributed on 15 projects as shown in Table 1 (Anonymous, 2006).

Table 1: Centrally coordinated microbiological studies conducted in Denmark in 2006 (Anonymous, 2006)

Main objective of project	Title of project	Agents analysis per sample (regional laboratories)	No. of samples
Surveillance	Salmonella Typhimurium DT104 multiresistent in imported meat	*Salmonella*	3,428[1)]
Surveillance	Intensified control for Salmonella and Campylobacter in fresh Danish meat	*Salmonella, Campylobacter (quantitative)*	792[2)]
Surveillance	Intensified control for Salmonella and Campylobacter in fresh imported meat	*Salmonella, Campylobacter (quantitative)*	1,692[3)]
Surveillance	VTEC in fresh imported beef	*E. coli O26, O103, O111, O145, O157*	330
Surveillance	Campylobacter and antimicrobial resistance in fresh, chilled Danish chicken meat	*Campylobacter, Salmonella, E. coli, Enterococcus*	1,000
Surveillance	Campylobacter and antimicrobial resistance in fresh chilled and frozen imported chicken meat and frozen Danish chicken meat	*Campylobacter, Salmonella, E. coli, Enterococcus*	1,800
Monitoring	Campylobacter and antimicrobial resistance in fresh chilled imported turkey meat	*Campylobacter, Salmonella, E. coli, Enterococcus*	600
Monitoring	Salmonella and Yersinia enterocolitica O3 in cuts of fresh chilled pork from the retail sector	*Salmonella (semi-quantitative), Yersinia enterocolitica O3*	1,000
Monitoring	VTEC in cattle	*VTEC*	700
Control	Microbiological classification of the production areas for bivalve molluscs	E. coli, Salmonella	100
Control	Salmonella in minced meat	*Salmonella*	700
Control	Salmonella, Campylobacter and E. coli in frozen imported berries	*Salmonella, Campylobacter, E. coli*	500
Control	Salmonella and Campylobacter in imported herbs from South-East Asia	*Salmonella, Campylobacter*	500
Control	Salmonella and Campylobacter in lettuce	*Salmonella, Campylobacter*	500
Control	Microbiological control of the production of Danish sausages	Aerobic colony count, *Lactobacillae*	150

[1)] No. of samples representing 687 batches
[2)] No. of analyses representing 49 batches
[3)] No. of analyses representing 89 batches

Over the past 2 to 3 years there have been a continuous development and optimisation of the structure and decision-making processes behind the concept of CCL projects in Denmark. The purpose of the PromSTAP sub-project „SafeFood Guide“ was to develop best-practice guidelines based on input from the project partners. The guidelines can potentially be used within EU regions by the food authorities to implement and operate CCL investigations of microbiological food safety issues.

2. Materials and Methods

Current methods of data collection in the field of microbial food safety have been compared through questionnaires and workshop discussions involving the participating regions Gelderland (the Netherlands), North Rhine Westphalia (NRW; Germany) and Hovedstads (HUR; Denmark) as well as representative from authorities and industry. Results were used for developing a best practice guideline to con-

duct and communicate authority driven CCL projects. Two generic examples of guideline implementation were carried out in the Danish region HUR.

2.1 Questionnaires and workshops

Two questionnaires were prepared and sent to each of the participating regions: Gelderland, NRW and HUR. The first questionnaire was used for acquiring a general overview of the structural organisation of the public food safety organisations in the regions. Together with a workshop in 2006 the first questionnaire formed the basis for designing a second questionnaire, which aimed at gathering more detailed information about how microbial food safety data are collected at the regional level in the participating regions. This information has subsequently been analysed and discussed at internal meetings at HUR and at a workshop in 2007 involving participants from the food authorities, industries and research environments from the participating regions.

All together the knowledge acquired from the workshops and questionnaires formed the basis for a common best-practice guideline of public data collection in the field of microbial food safety in European regions.

2.2 Guideline implementation

Two CCL projects were selected to serve as generic examples of guideline implementation. The projects should provide information on the practicability of using such guidelines. Both projects were described, planned and initiated in accordance with the suggested guideline and the issues of the projects were selected to illustrate different types of data collection. The first example was a surveillance project on Campylobacter that collected exposure data for risk profiling/risk assessment. The prevalence and numbers of thermotolerant Campylobacter were measured in 1,792 samples of fresh chilled and frozen chicken meat produced in Denmark or other countries (import). Samples were collected nationwide from retail stores (butchers' shops and supermarkets) by local food authorities who also analysed the samples semi-quantitatively and quantitatively in accordance with a preliminary version of NMKL No. 119 3rd Ed. (Anonymous, 2007).

The second example was a project that measured the effectiveness of an intervention procedure, implemented to reduce consumer exposure to a food borne pathogen. The intervention was a voluntary slaughterhouse initiative, which channeled Campylobacter positive broiler flocks to frozen production to the extend possible. This was one of the interventions introduced in Denmark in 2003 to control Campylobacter in broilers. In order to determine the proportion of products contaminated with Campylobacter released to the market using voluntary channeling, the prevalence and numbers of thermotolerant Campylobacter were measured in 959 samples of fresh chilled chicken meat (whole chickens, breast filets, legs, etc.). These were collected regularly over the year at the two largest broiler-processing plants in Denmark. The local food authorities carried out sampling according to NMKL No. 91 2nd Ed. (Anonymous, 1988) and semi-quantitatively as well as quantitatively determination according to a preliminary version of NMKL No. 119 3rd Ed. (Anonymous, 2007).

3. Results and Discussion

3.1 Organisational structure of microbiological food control in the regions

Initial insight in the organisational structure of public food control in the three participating regions was established through a questionnaire followed by a discussion-workshop, which addressed i) routines for food safety laboratory investigations, managed by regional authorities, including data transmission and database systems and ii) interactions between public, private and research laboratory facilities involved in public food safety investigations.

The main result was that the food safety control was organised at national level in Gelderland and HUR and operated at a regional level, whereas the control system in NRW was organised and operated both at national (federal) as well as regional (state) level. The overall organisational set-up of the food safety control systems in HUR and Gelderland at country level compared to the one of NRW at the regional level. In conclusion, Gelderland and NRW had a structural organization, which would allow them to develop a CCL project structure similar to the Danish.

3.2 Sampling and data collection in the regions

In regard to sampling and data collection, the first questionnaire and workshop indicated many differences between the regions at the operating level. These included differences in responsibility, management and coordination as well as involvement of cooperative partners, identification of food safety issues, operation of databases, etc. In addition, a key problem encountered was that the definitions and terms related to food safety data collection were different in the participating regions, which complicated the comparison between them. These differences needed also to be taken into account in the final guideline suggestion.

A second questionnaire was elaborated to allow for more detailed comparisons of the observed differences between the regions. More specifically the questionnaire was used for collecting information to describe how activities related to public data collection in the field of microbiological food safety were structured in various EU-regions. It was sent to project partners in Gelderland, NRW and HUR in October 2006. In particular, CCL activities that were carried out as projects with the purpose of supporting public risk management were to be addressed. In December 2006 the responses were received and they gave a clear picture of the organisation of the data collection coordinated at central level in the participating regions. All three participating regions performed CCL projects or similar data collection coordinated at central level on a yearly basis. In NRW, CCL activities were defined at state level, which corresponds to the EU-regional level, whereas in Gelderland and HUR, these activities were driven as national programmes. Therefore, country designations will be used in the cases of Gelderland and HUR. The authorities involved in the different regions are listed in Table 2.

Table 2: Authorities responsible for the different phases of data collection coordinated at central level in the three EU-regions

Phase	The Netherlands[a]	NRW[b]	Denmark[c]
Coordination	VWA (central)	MUNLV	DVFA (central)
Management	VWA (central)	BezRegs	DVFA (central)
Planning	VWA (central)	BezRegs/SVAU	DVFA (central)
Sampling	VWA regional (5 regional centres/services)	KOB	DVFA regional (3 regional centres)
Analysing	VWA regional (5 regional centres/services)	SVAU	DVFA regional (3 regional centres)
Reporting	Regional project leader	SVAU	Project leader (central or research)
Communication	VWA (central)	?	DVFA (central)
Publication	Regional project leader	MUNLV	DVFA (central) & project leader

[a] VWA: Food and Consumer Safety Authority, the Netherlands.

[b] MUNLV: Ministry of the Environment, Conservation, Agriculture and Comsumer Protection of the State of North Rhine-Westphalia, Germany; BezRegs: District Governments; SVAU: State (official) Veterinary Laboratory; KOB: Local competent authorities (in districts and cities); LANUV: State Agency for Protection of Nature, Environment and Consumer.

[c] DVFA: Danish Veterinary and Food Administration.

In Denmark the CCL investigations were carried out at national level. This was also the case for the Netherlands, whereas NRW ran these activities as programmes dedicated one laboratory and the corresponding local authority in this area. In NRW, authorities carried out all the CCL activities (Figure 1a)

whereas both the Netherlands as well as Denmark described involvement of research institutions at several stages in the process (Figure 1b).

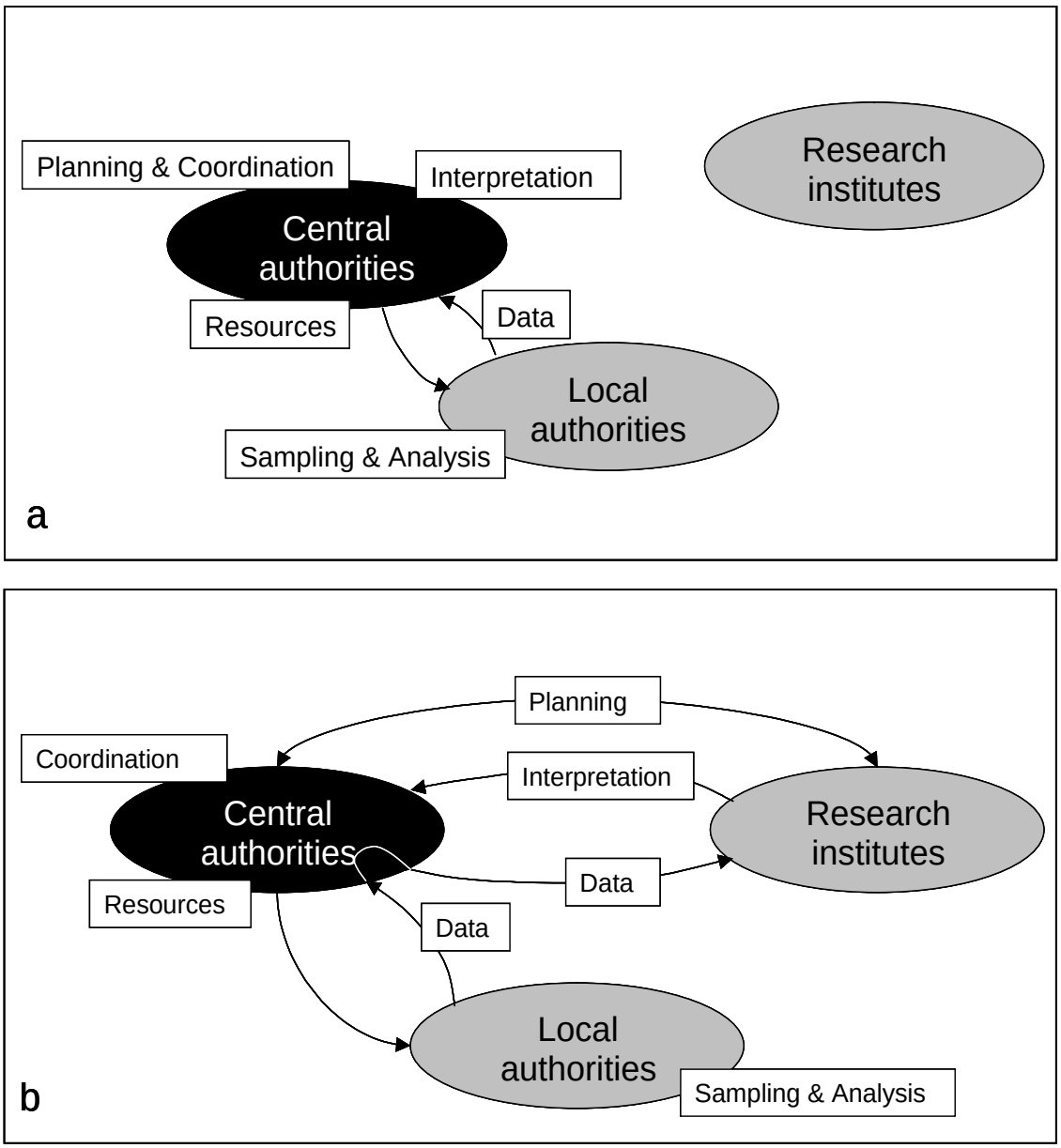

Figure 1: Outline of responsibilities, communication and data flow in authority driven microbiological data collection in a) North Rhine Westphalia and b) the Netherlands and Denmark. Black background indicates overall management responsibility.

In conclusion, the Netherlands and Denmark described a relatively structured way of identifying food safety problem areas and how to support knowledge accumulation by conducting CCL projects. For NRW this approach was not yet established, but they planned to establish a more systematic, risk-based approach with the constitution of the State Agency for Protection of Nature, Environment and Consumer (LANUV) in 2007.

3.3 Best practice guidelines

The Danish experiences as well as responses from the questionnaire were used as the platform for suggesting best practice guidelines for conducting and communicating authority driven CCL projects to support public risk management of food-borne hazards. Overall results showed that such guidelines should include information on how to

- define and share responsibilities between project partners
- communicate between project partners
- define food safety issues to be investigated
- describe issues and priorities
- prepare laboratory protocols
- prepare laboratory databases and data reporting
- communicate results

We suggest that the central food safety authority establishes a CCL management group in their organization. This management group shall have representatives from various sides of the food safety area, i.e. veterinary/animal, food and agricultural/feed aspects taking a “stable-to-table” approach. The group should be responsible for the overall management as well as coordination of the CCL projects. However, for CCL projects to be effective, Danish as well as Dutch experience have demonstrated that interaction between the central offices, the local regional centres and laboratories, research institutions and private companies, also is essential for a smooth conduction of the project. This requires tight planning of the projects and well-organized communication. Therefore, a structured risk-based approach, having the four phases i) selection, ii) planning, iii) running and iv) closing CCL projects, has been suggested as outlined in Figure 2.

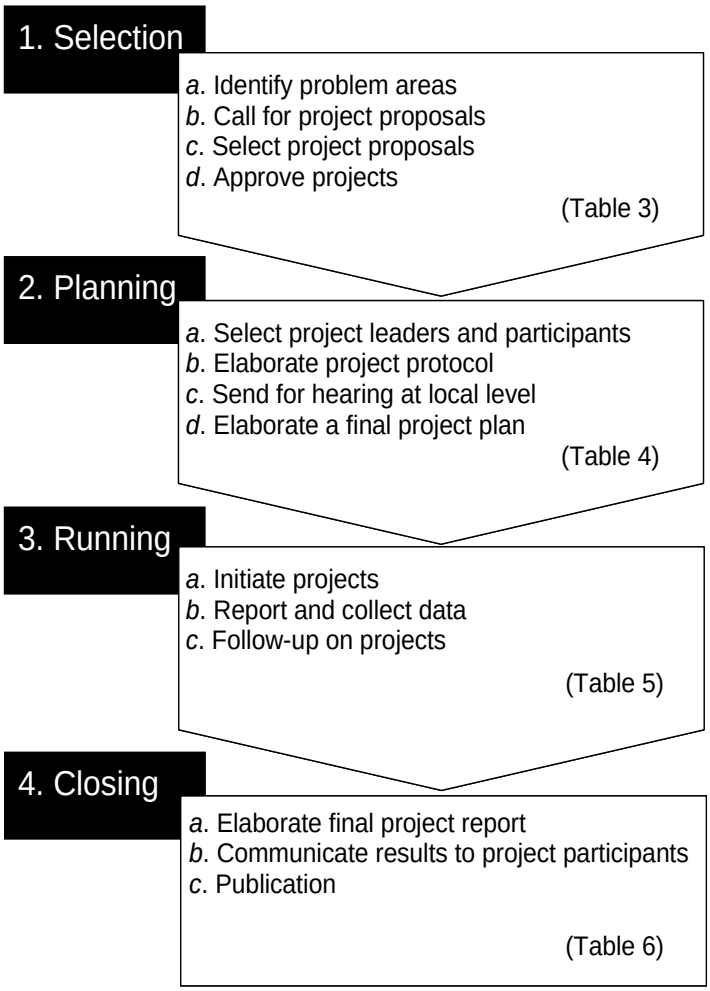

Figure 2:
Structure and content of the suggested best practice guidelines for conducting and communicating authority driven data collection in a risk-based context.

This guideline proposal was presented and discussed with representatives from food authorities, research and industry from the participating regions at a workshop (Christensen, 2007). The concept was generally positively received. A main concern was how and when to involve private industry in these CCL projects. In Denmark e.g. outsourcing of microbiological analyses to private laboratories had been shown to influence the data flow and quality negatively. On the other hand, representatives from the food industries, where samples are taken, pointed out that they could contribute positively to the pl-

anning of data collection (Hansen et al., 2007). Hence, it seems that the industry's involvement in CCL projects needs further clarification and may be decided from case to case.

3.3.1 Selection

As indicated in Figure 2, the selection phase CCL projects has four main tasks a) identification of problem areas, b) call for project proposals, c) selection of project proposals and d) approval of projects. A detailed description of each task is presented in Table 3.

Table 3: Project plan – management of authority driven Centrally Coordinated Laboratory projects

Activity	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1. Identification of problem areas												
2. Call for proposals				01.04 Deadline 20.04								
3. Evaluation of proposals					20.04 - 01.05							
4. Ranking within subject areas??						Deadline 01.06						
5. Ranking between subject areas?							Deadline 01.07					
6. Decision on effectuation								Board: 15.08	Answer: 01.09			
7. Selection of project leaders									15.09			
8. Elaboration of project protocol										Draft: 15.10	Final: 15.11	
9. Elaboration of plan for distribution of samples between local authorities												Local authorities' answers: 01.12 Plan: 20.12
10. Final plan for distribution published												20.12

As the central authority has both the demand for data, specifically targeted risk management problems, as well as the necessary resources, it may not be surprising that the selection phase mainly involves players from the central authorities. However, contributions from research institutions and local authorities are welcomed, and in Denmark also formally asked, to give input for the identification of food safety problems that need to be addressed.

3.3.2 Planning

As shown in Figure 2, the planning phase has four main tasks a) selection of project leaders and participants, b) elaboration of a project protocol, c) hearing at local level and d) elaboration of a final project plan. A detailed description of each task is presented in Table 4.

Table 4: Best practice for food authorities' selection of authority driven Centrally Coordinated Laboratory projects

Tasks	Description of process
Identify problem areas	The central authority identifies risk management problems that demand support through data collection and categorizes these as surveillance, monitoring or control needs. Identification is recommended to be based on - Input from research institutions - Follow-up on prior projects - Acute problems - Emerging problems
Call for project proposals	The central authority calls in project proposals from relevant proposers, i.e. risk assessors (research institutions) and risk managers (central authority). A proposal should include information that enables ranking such as - Objective - Motivation - What to investigate - How to investigate - Number of samples required
Select project proposals	The central authority evaluates, selects, and ranks project proposals. This could be done in collaboration with research institutions, but is not a prerequisite. Things to be considered are - Relevance - Price - Laboratory capacities - Sampling capacities - Practicability
Approve projects	Whether a final project approval is required will be dependent on the organization. For example, there might be a requirement for a central approval if money is granted centrally. Also the central authority could have the overall responsibility for the activities in the laboratories of the local (regional) authorities.

Coordination of projects, including budgets, is the responsibility of the central authority whereas the more detailed planning, i.e. elaboration of project descriptions and laboratory protocols, usually is the responsibility of research institutions. Local authorities are also involved in the planning phase as all plans and protocols are sent for hearing at this level before elaboration of the final list of projects for the current year.

3.3.3 Running

As Figure 2 indicates, the running phase has three main tasks a) initiation of project, b) reporting and collecting data and c) follow-up on projects. A detailed description of each task is presented in Table 5.

Table 5: Best practice for food authorities' planning of authority driven Centrally Coordinated Laboratory projects

Tasks	Description of process
Select project leaders and participants	The central authority appoints project leaders. Project leaders may be selected from the central authority, research institutions or local regional authority dependent on competence and project tasks.
Elaborate project protocol	The appointed project leader elaborates a detailed project protocol. The central authority provides a fixed format ensuring that all relevant information is included. As a minimum, the protocol should include - Title - Objective - Background - Short description of project - Number of samples - Sampling method - Distribution of sampling places - Project period - Analyses To achieve consistency in projects it is important that methods are comparable. It is strongly recommended that the whole project set up is evaluated statistically as well as epidemiologically.
Send for hearing at local level	The central authority collects the individual project protocols and prepares a plan for the total load of sampling and analyses for each laboratory. The material is sent for hearing at local regional level. Things to consider are - Coordination with other tasks - Decision of task priority - Outsourcing of tasks
Elaborate a final project plan	Based on responses from the hearing at the local regional level the central authority elaborates a final distribution plan for sampling and analyses. To make sure that all project tasks can be met by the local regional level a final approval of the project protocol by the head of the central authority is recommended. The final project plan is sent to project leaders and participants.

Most often, the involved research institutions initiate the projects whereas the local authorities are the main players during the running phase as they are responsible for sampling and microbiological analysis. Local authorities also have the responsibility of reporting their findings into a database on a regular basis, e.g. by the quarter. The central authority plays a minor role in this phase. They assess the progress of the projects and take action if any problem occurs.

3.3.4 Closing

As Figure 2 shows, the closing phase has three main tasks a) elaboration of final project report, b) communication of results to project participants and c) publication. A detailed description of each task is presented in Table 6.

Table 6: Best practice for food authorities' running of authority driven Centrally Coordinated Laboratory projects

Tasks	Description of process
Initiate project	The project leader initiates the project by arranging a kick-off meeting with representatives from the participating local regional authorities and, if convenient, a central authority representative. Things to clarify in order to reach a common understanding are - Details in the project protocol - Structure for data reporting - Communication of results - Sharing of tasks
Report and collect data	The local regional authorities report project activities to the central authority on a regular basis, e.g. by the quarter. Data are collected in a common database, where all project participants have access to their own projects. Things to ensure are - Consistency in data structure - Merging keys to other databases - Traceability
Follow-up on projects	On a regular basis, e.g. quarterly, the project leader elaborates project progress reports, including a financial status. The central authority performs the report assessment and, if necessary, take action on encountered problems. Whether running follow-up meetings are necessary dependents on the complexity of the project.

Data analysis and interpretation of results are responsibilities of the research institutions, which also elaborate final project reports. The central authority is responsible for defining data rights and deadlines in a publication policy.

3.3.5 Timetable

The Danish experience has also shown that it pays to establish a formalized system that operates within a certain timetable where also responsible actors and deadlines may be stated. The timetable typically covers a long-termed sequence of 1 to 2 years in order to be in agreement with the working plan for the involved public laboratories (Table 7).

Table 7: Best practice for food authorities' closing of authority driven Centrally Coordinated Laboratory projects

Tasks	Description of process
Elaborate final project report	The project leader elaborates a final project report. A clear agreement between authority and project leader on which structure and scientific level the report needs to have will give the best result.
Communication of results to project participants	In order to recognize the contribution of the participating laboratories, it is a good idea to have a final project meeting where project results are presented.
Publication	A publication policy should exist. It should describe agreements on data rights and deadlines for publication from authorities and researchers, respectively. Any possible restrictions of publication will have to be agreed upon from case to case, as this will be dependent on the specific project. Private companies involved in projects will need a warning in due time before publication as they might have to establish corrective actions before release.

3.4 Generic implementation of guidelines

In order to provide information on how workable these suggested guidelines are, two generic examples of implementation were conducted. The projects were selected, planned, run and closed in accordance with Figure 2, i.e. the process was as follows:

1. Selection:

a) Campylobacter has been recognized and highly prioritized as food safety problem in Denmark by the central food authorities (DVFA) since 2000, where surveillance in various foods began
b) DVFA invited risk managers and researchers to a meeting
c) DVFA in co-operation with researchers at the National Food Institute (NFI) defined the main frames of the projects (issue and number of samples to be tested)
d) DVFA selected and approved the projects

2. Planning:

a) DVFA pointed out a project leader, Hanne Rosenquist, at NFI due to her competence and experience on Campylobacter
b) NFI elaborated detailed project descriptions and protocols covering the issues listed in Table 4.
c) With regard to commenting on project details, the descriptions were sent to the local food authorities that were to collect and analyse the samples
d) The descriptions were revised accordingly by NFI and DVFA elaborated a final overview of all CCL projects to be run in 2006 (Table 1 shows a list of all microbiological CCL projects that ran in 2006)

3. Running:

a) The projects were initiated by the local food authorities according to the project descriptions
b) The results of the microbiological analyses were compiled every third month by the local food authorities in a database also accessible to DVFA and NFI
c) No systematic follow-up on the projects were conducted

4. Closing:

a) Data analysis and final reporting were carried out by NFI
b) Final reports were delivered to the DVFA
c) NFI holds the publication rights, but the results have not yet been published

Carrying through CCL projects following the suggested guideline showed to be a systematic and structured process, where the partners involved were acquainted with their tasks due to the detailed project description and protocol. The guideline worked for data collection both in relation to surveillance/monitoring of exposure data, as well as for monitoring the effectiveness of an intervention. It should, however, be emphasized that sampling and analysis should be done strictly in accordance with the project protocol to ensure consistency and to be able to extract, compare and evaluate the results. Also correct reporting of the sample information requested, for example country of origin, meat type, chilled/frozen, etc, should be carefully reported. In summary, the generic guideline implementation showed that CCL projects were a good way to provide consistent and systematic data nationwide. The CCL projects were, therefore, considered a valuable tool for the food authorities as part of their obligations to establish risk-based food safety programmes.

4. Conclusion

The worldwide acceptance that food safety has a global impact, but must be dealt with at a national or regional level has encouraged us to look for ways to establish a common understanding of local and

global food safety. This has brought focus on the importance of improved methods for prevention, control and monitoring of food borne hazards.Derived from EFSA's concern that comparison of food safety between European countries may be impeded, as a result of applying different methodologies, sampling and reporting systems, we have addressed the aspect of the increased data demand that risk-based management has led to.

A questionnaire was used for collecting information to describe how activities related to public data collection in the field of microbiological food safety were structured in the participating EU-regions, Gelderland in the Netherlands, NRW and HUR in Denmark. Based on this information best practices were identified. The responses gave a clear picture of the organisation of the microbiological data collection coordinated at central level, CCL, in the participating regions. All three regions performed CCL projects or similar activities on a yearly basis. Differences were encountered in the degree of involvement of external partners such as research institutions and private companies. The Netherlands and Denmark described a relatively structured way of identifying food safety problem areas and dealing with these as national studies in the form of CCL projects. For NRW this was not yet the case, but they planned to establish a more systematic, risk-based approach with the constitution of LANUV in 2007.

It was concluded that a best-practice guideline for authority driven collection of data on food safety issues should follow a uniform pattern accepted by the involved food safety authorities and must include:

1. a highly structured organisation
2. a clear understanding of the responsibilities at all levels
3. data must be accessible for all involved parties (common database).

We have used the Danish CCL-template as starting point for our suggestion of best practice guidelines for conducting and communicating authority driven CCL projects with specific focus on supporting public risk management of food-borne hazards. We took a structured risk-based approach, that had four phases i) selection, ii) planning, iii) running and iv) closing of CCL projects, and conducted a generic guideline implementation for two examples in Denmark. The first example was a surveillance project generating exposure data for risk assessment. The second example was a project monitoring the effect of an established risk management option. In summary, the generic implementation showed that CCL projects were a good way to provide consistent and systematic data nationwide. However, at a more detailed level the obtained results showed that sampling and analysis could be a weak point if these are not done strictly in accordance with the protocol. Also the reporting of the data concerning sample information appeared as a crucial step, which had to be addressed specifically in the guideline.

In addition, workshop discussions between food authorities, research institutions and representatives from the industry pointed out that the involvement of private companies in CCL projects needed further clarification. On one hand, outsourcing of analyses to private laboratories had been shown to influence the data flow negatively. On the other hand the food industries, where samples are taken, might contribute positively in the planning phase of the data collection.

All together, the concept of CCL projects was found to be a valuable tool for the food authorities as part of their obligations to establish risk-based food safety programmes.

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Promotion of Codex approved microbiological food safety management tools

Petersen, R.F., Andersen J.K., Hansen, T.B., Boysen, L., Christensen, B.B.*

The National Food Institute, Technical University of Denmark, Mørkhøj Bygade 26, DK-2860 Søborg, Denmark, E-mail: bbc@food.dtu.dk

Keywords: Risk based food safety management; ALOP, FSO, PO, PC

Abstract

For many years food authorities have set limits or criteria for microbiological contaminations in foods. The Microbiological Criteria (MC) have been set based upon experience and expert opinions according to recommendations from Codex Alimentarius and ICMSF definitions. However, in practice many MC were not in accordance with these definitions and may not provide the best means to ensure safe food.

A new set of risk management tools has been introduced by Codex: Appropriate Level of Protection (ALOP), Food Safety Objective (FSO), Performance Objective (PO) and Performance Criterion (PC). These definitions promote a systematic approach for the risk managers to set up microbiological control measures wherever needed in the food chain. The objectives should be scientifically justifiable and based on a quantitative or qualitative risk assessment.

The aim of the project was to promote and discuss how the Codex risk management tools can be implemented in different regions in Europe. The major tasks in the project were: 1) to provide a common understanding among the project participants on the new Codex approved risk management parameters, 2) to discuss problems and benefits of the management tools and 3) to provide suggestions for their implementation.

The tasks were achieved through different working components. We succeeded in bringing together the authorities, science and industry and to reach a common platform of understanding as well as pointing out problems and benefits of the management tools. Practical initiatives are currently being discussed for the implementation of risk management in the food safety area.

1. Introduction

The terms microbiological criteria, standards, specifications and guidelines have been used in different ways in the past and their usefulness has been subject for much discussion. A system suggested by the Codex Alimentarius Commission (CAC) and the International Commission on Microbiological Specifications for Foods (ICMSF) has been widely used (CAC 1997). According to this concept a microbiological criterion (MC) should, among other things, include a statement of the microorganism of concern, the analytical method for detection and/or quantification, a plan defining the number of field samples to be taken, the microbial limits acceptable at that particular point in the food chain, etc.

For many years the authorities have set limits or criteria for microbiological contaminations in foods without using the exact concept suggested by CAC and ICMSF. The criteria have been set based upon experience and expert opinions on what was considered achievable in relation to good hygienic practice on one hand, and what was necessary to ensure food safety on the other. In addition, MC have often been set for raw or for finished processed products. In practice many MC have been set without being in accordance with the defined principles and often without estimating its effect on reducing the risk of foodborne disease.

New risk-based concepts like Appropriate Level of Protection (ALOP), Food Safety Objective (FSO), Performance Objectives (PO) and Performance Criterion (PC) have been developed and introduced by Codex (ICMSF, 2006) (see Figure 1) in order to link the requirements of food safety programs with their

expected public health impact. These new tools can be used to communicate food safety requirements to industry, trade partners, consumers and other countries. They are meant to serve in combination with existing food safety practices, not as replacements. However, exactly how these concepts are supposed to be used in Risk Assessment and Risk Management is not known. Unlike microbiological criteria, FSO, PO, PC are targets and it remains to be explained how they should be verified and which actions that should be taken if they are not met. This is an additional source of confusion between risk assessors and risk managers.

Before attempting to promote and eventually implement the new Codex concepts at the regional level in Europe, it was necessary to obtain information on food safety management within the involved regions. Increased information about the organisation of and interactions between food authorities (risk managers), industry and risk assessors in the different regions and the problems and/or advantages these new definitions may encounter for these organisations are crucial for their usefulness, implementation and acceptance. In addition, it was important to understand how the different stakeholders (authorities, industry, etc) interact and respond in order to achieve a certain criterion e.g. through the introduction of a new intervention or a new microbiological test.

The PromSTAP project has played a central role in this process. In this sub project, regions from Vidin (Bulgaria), Gelderland (the Netherlands), North-Rhine Westphalia (Germany) and Hovedstads (Denmark) participated. In each of these regions, the regional structure and interactions between food authorities (risk managers), industry and risk assessors are significantly different. Also the food production systems are different. Therefore, the concerns, problems and potential benefits of integrating the new food safety management tool were expected to be significantly different. It was expected that through better understanding of the regional differences, the sub project "Microbiosafe" would improve the understanding and potential implementation of these new risk management tools.

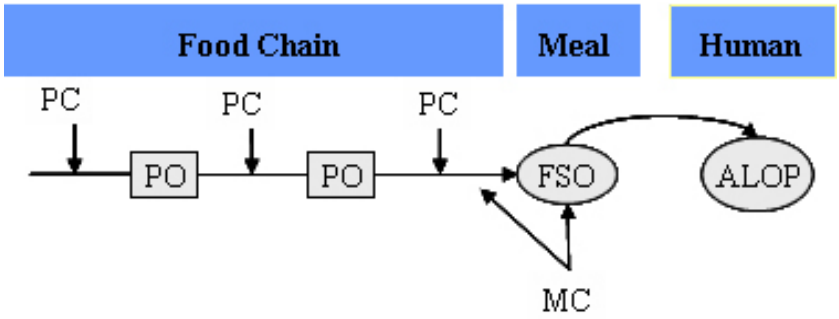

Figure 1: The definition of the Codex approved food safety management tools and their position in a model food chain.

Appropriate Level of Protection (ALOP): The level of protection deemed appropriate by the country establishing a sanitary or phytosanitary measure to protect human, animal and plant life or health within its territory (WTO, 1995).

Food Safety Objective (FSO): The maximum frequency and/or concentration of a hazard in a food at the time of consumption that provides or contributes to the appropriate level of protection (ALOP) (CAC, 2004).

Performance objective (PO): The maximum frequency and/or concentration of a hazard in a food at a specified step in the food chain before the time of consumption that provides or contributes to an FSO or ALOP, as applicable (CAC, 2004). Performance objectives are in principle the same as food safety objectives and differ only by the fact that they are used at/in different points in the food chain.

Performance criterion (PC): The effect on frequency and/or concentration of a hazard in a food that must be achieved by the application of one or more control measures to provide or contribute to a PO or an FSO (CAC, 2004).

2. Materials and Methods

The tasks were achieved through different working components. One approach was through workshops and questionnaires where experts from authorities, science, and industry were invited to discuss and answer different questions related to the Codex management tools. In order to link the requirements of food safety programs with their expected public health impact, approved risk analysis concepts and risk management tools. The second approach was a practical investigation on how the risk management parameters could be implemented in relation to control of *Campylobacter* in broilers.

Questionnaire. In order to give an overview of the structure of the food control in the participating regions (Gelderland, North-Rhine Westphalia (NRW) and Hovedstads) a questionnaire was used. The questionnaire had a total of 17 questions within six main areas, 1) responsibilities in the food control, 2) role of laboratories in the food control, 3) implementation of Codex approved risk analysis in public food control, 4) risk assessment in public food control, 5) risk management in public food control and 6) food safety investigations in public food control.

Workshops. In order to discuss the feasibility of introducing and implementing new risk based management tools in the national as well as international food control, two national workshops were arranged with 1) the Danish food authorities and 2) the Danish food industry. Present at the first meeting (Danish food authorities) were 8 participants from the Danish Food Safety Authority (risk managers) and 8 participants from the scientific environment (risk assessors). Present at the second meeting (Danish food industry) were 4 from the industry, 2 from the Danish Food Authorities and 8 from the University . The aim of these meetings was primarily to get insight into the understanding and the extent of use of the concepts of Codex Food Safety management tools.

Two Inter-regional Workshops were held during the project. The first workshop involved the PromSTAP projects, MicrobioSafe and SafeFood Guide. The focus of the workshop was to discuss and identify barriers for the practical implementation of the Codex approved risk management parameters. The participating regions were encouraged to invite experts on microbiological risk management in their region. In total 12 experts attended the workshop. Gelderland and NRW each participated with two, and Hovedstads with eight. At the workshop the concepts ALOP, FSO, PO, PC and MC were introduced, followed by a plenum discussion of the level of regional compliance. The second workshop, “Science meets policy”, involving PromSTAP projects, MicrobioSafe, SafeFood Guide and Control-of-Control, was held in Hilversum, the Netherlands. In total 51 from the industry, policy and science participated in the meeting: 26 from the Netherlands, 16 from Denmark, 3 from Germany and 6 from Bulgaria. This included invited speakers, guests and PromSTAP personnel.

Practical investigation. In order to study the feasibility of introducing the Codex approved risk management parameters, a practical investigation has been initiated. Specifically, the problems/benefits of introducing performance criteria (PC) to control *Campylobacter* in the poultry production was investigated. Initially, an inventory of possible interventions was prepared, based on either literature or laboratory tests. Interventions were ranged according to their *Campylobacter* reducing capacity, costs of implementation and practical feasibility.

3. Results and Discussion

3.1 Questionnaire

The main output from the questionnaire was that the principles of risk assessment and risk management are generally accepted at country level in the three participating regions. Risk management and risk assessment has been separated as recommended by Codex. Also, quantitative microbial risk assessments have been performed in all three countries. However, only in Denmark the outcome has been used in risk management decision-making and only to a limited degree.

3.2 Workshop

1st interregional workshop:

The discussion at the workshop underlined that the Codex approved risk management parameters (ALOP, FSO, PO etc), are not well understood in any of the participating regions, and their practical applicability in food control is not yet clear. It was generally accepted that it is going to take time, and education of food safety managers and assessors, before the different regions will be able to implement these concepts. It was, however, also agreed that the risk management parameters are beneficial concepts because they provide a common language between risk assessors and risk managers, as well as a more harmonised system for setting food safety criteria in the European countries and internationally.

Thus, in theory these new risk management tools make sense, however, in practise they are difficult to implement. Some of the barriers, which were raised at the workshop, were that:

1. It may be difficult to set an ALOP because the relative contribution to disease for a given pathogenic organism in a given food chain is difficult to establish. In addition this is a political decision, which may not be popular for the politicians to put forward.
2. Calculating an FSO and/or a PO, based on an ALOP is technically difficult.
3. Making a quantitative risk assessment is costly and time consuming.
4. After having established a PO or an FSO this should be followed by setting a criterion on how to achieve this PO or FSO. At present, there has been no explanation on how these criteria should be verified and which actions should be taken if they are not met.
5. The structural organisation and interactions between food authorities (risk managers), food industry and risk assessors, in e.g. different European regions, make it difficult to provide general guidelines that can be used by all stake holders through all countries.
6. There is some conflict between what the risk assessors can deliver and the risk managers' requests.
7. The concept of the parameters and their definitions is not easily understood.

In general the workshop participants seemed sceptical about the use of quantitative risk assessments in the process of setting FSOs or POs, because it is simply too complicated and expensive for many regions. Therefore, it should be considered whether there could be alternatives. It was suggested that this could be an issue for discussion at future meetings.

National workshop: The Danish Food Authorities.

Presentation of the purpose of the PromSTAP project as well as the definitions of the microbiological risk management tools served as introduction to the meeting. This was followed by a status from the Danish food authorities on the current strategy for Campylobacter reduction in food. The strategy was compared to the risk management approach in order to see how well the current food safety strategy could be converted into a risk-based approach. This exercise proved that the current approach could very well be broken down to distinct "goals" that in the future may be converted into the Codex suggested procedure. It was emphasized that goals/targets set in the current approach is based on relative numbers (relative distribution) as a contrast to fixed numbers coming from risk-analyses. The following issues were debated during the meeting:

- How will ALOP be defined/set (for one contamination source or for all)? Does ALOP provide a relevant basis for the setting of targets/objectives? Is there coherence between the food authorities and the food industry interest in using ALOP as a starting point?
- To what extent do the authorities expect to use FSO, PO and PC etc.?

The Danish Food Authorities welcome the new management tools. With the increased concern in the Danish population and among politicians there is much attention on the Food authorities to provide better food safety and to use more transparent methods. The risk-management approach provides, from their point of view, a more systematic method that allows a well-defined, goal-oriented intervention;

the risk based approach pinpoints precise interventions points with a measurable outcome. This must be understood in contrast to the current situation, where the concept of "food safety" is not anchored to a known outcome; thus, initiatives may be taken without a precise knowledge on the effect and the result of the initiative.

Important to the food authority is that any new approach taken must include only what is feasible on a practical level as well as within the available economical limits. Thus, it is important to approach the risk management tools in a pragmatic way. The PO and FSO must be flexible tools and must be tied up to both ALOP and a "public health goal". It is important that PO/FSO are so flexible that they can be used broadly and in many situations. The question was raised whether the terms ALOP and FSO can be seen only in the national setting or it can be related to internationally set targets.

Using *Campylobacter* as an example we discussed the fact that sources of contamination are numerous, and that we must take this into account when calculating FSO, PO and PC. The food authorities stated that risk based modelling is an obvious method to implement in the milk and cheese industry, but that the situation is much more complicated when it comes to fresh, raw meat products. Thus, the Danish food authorities are in general open to incorporate a risk based strategy within the current food safety initiatives, however more experience as well as development of these metrics is needed.

National workshop: The Danish Food industry.

The aim of this meeting was to introduce and discuss the new Codex concepts while focusing on the industry point of view - will these new concepts become a burden or an advantage for the food industry? The following issues were discussed at the meeting:

- What are the considerations of the food industry in respect to the introduction of risk based management? How do the industry see the setting of targets/objectives as FSO, PO and PC?
- Where and when must the public food authority set targets/objectives and when should the food industry and food producers act? What are the roles of the food authority and the food industry?

Three different industries were presented at the meeting; the Dairy sector, the meat sector and the retail sector. Generally, the food producing industries were positive towards risk based food safety management and were, to different degrees, already using quantitative approaches to assure food safety in their food production. In contrast, the retail sector could not easily see how risk based food safety management could be applied in their sector. The situation for the retail sector is different from the other industries. The retail sector is for the main part involved in handling products that are already prepared and available for the consumer. The most important food safety issue within the retail sector is to store food products under appropriate conditions.

The food producing industry sees itself as a natural and important partner in assuring safe food products, and recommend well defined roles and responsibilities within the field of food safety: Risk assessment performed by the scientists, risk-management performed by the authorities and hazard management performed by the industry. For this purpose the quantitative risk assessment approach is welcomed and received as a method that allows the suggested division of responsibility, as well as change the concept of food safety from "**Is the food safe**" (qualitative approach) to "**How safe must the food be**" (Quantitative approach)?

The industry considers ALOP and FSO to be the responsibility of the public authorities, whereas the industry should be responsible for determining PO and PC. However, it is important that an FSO also takes production experience into account.

The industry point out various obstacles and challenges involved in implementing quantitative risk assessment. First of all there is a lack of quantitative microbiological tools, general knowledge, and usable simulation programs and risk assessment models to predict bacterial growth/death. Secondly, the FSO/PO are complicated tools that may be difficult to implement and use while at the same time "keep the

business running". The change of food safety strategy must be done in a cost-effective manner. The industry suggests a dual approach with a traditional qualitative food safety strategy running along the implementation of quantitative risk models. This is important because not all food products and industries are ready/prepared for a change in strategy. The milk/cheese industry is much better suited for using risk-management parameters than for example the fresh meat industry. It was emphasized that this is a long ongoing process that must be started now instead of waiting for a "Rolls Royce model" (scientifically perfect system). The industry sees the risk management tools also as a communication tool, especially important in the communication with the public and the press. Well defined risk management tools agreed on by the official food authority and the industry can provide a barrier to the media driven political decisions on food related topics.

The general conclusions that came out of the meeting with the industry were:

1. The industry welcomes a quantitative approach within food safety
2. Emphasis on the importance of well defined division of responsibility between risk managers (authorities), risk assessors and the industry within food safety
3. PO/PC must be set by the industry
4. The change to a risk-management strategy within national food safety must start now.

The 2nd Inter-regional Workshop: "Science meets policy"

The meeting was a joint workshop between PromSTAP projects "Microbiosafe", "SafeFood Guide" and "Contol of Control". Present at the meeting were the major stakeholders within food safety management: The food industry, food authorities and scientists from the involved PromSTAP regions (NRW, Gelderland, Hovedstads, Vidin). Key speakers, Steve Hathaway from the New Zealand Food Safety Authority and Arie H. Havelaar from the National Institute for Public Health and the Environment (RIVM) in the Netherlands were invited. Day one of the meeting was devoted to issues concerning Microbiological Food Safety Management of today. The aim of the meeting for the "Microbiosafe" project was to promote and discuss the implementation of the Codex approved food safety management parameters (ALOP, FSO, PO and PC) at the regional level in Europe.

Steve Hathaway has been deeply involved in the work on defining and developing the food safety management tools performed within the Codex Commission. According to Steve Hathaway the theoretical benefit of a risk-based approach to food safety is clear: "Where risk assessments or risk information is available, control measures can be based on specific knowledge of the likely levels of consumer protection that will result. In the ideal situation, stakeholder input to a proposed food safety programme should encompass all relevant components of the hazard exposure pathway and ensuring standards should be set where they will be the most effective and efficient in reducing risks" (Hathaway, 2007).

In reality, the practical realisation of a risk-based approach has proven difficult. Properly taking risk into account in a scientifically robust and transparent manner when setting regulatory standards remains somewhat elusive for microbiological hazards. In a paper prepared for the workshop (Hathaway, 2007), Steve Hathaway discusses a number of the factors that provide obstacles for the implementation of food control measures that ideally should be based on systematic risk assessment and risk management processes.

- The estimation of the level of consumer protection is a significant challenge. In spite of increased resources to human health surveillance and food source attribution modelling to establish the existing level of consumer protection, robust estimates remain elusive.

- The FSO and "targets" derived from it (performance objective (PO), performance criterion (PC)) are already defined and are intuitively attractive, however, their practical application is still the subject of much debate.

The discussion at the "Science meets policy" workshop addressed the benefits and obstacles involved in implementation of risk bases food safety management. The main outcome of the discussion is summarized below:

- A lot of work on the risk-based management tools is still needed
- Good examples of use of the risk-based management tools are still missing
- Definitions may be set in Codex prematurely. Working with these parameters in practice has proven to be difficult, as the definitions have shown to be very stringent, with no flexibility.
    - The PO (Performance Objective) definition is not suitable. The setting of a single value does not fit the situation, when the distribution of microorganisms in foods is taken into consideration. The definition states that the "maximum frequency and /or concentration" must always be met, making it practically impossible to deal with real life situations.
    - ALOP (Appropriate Level Of Protection) is not always actually "Appropriate" but rather merely "current".
    - Another view is that if the definitions were not set, we would not have started using them, and thereby harvested the experience, and reached the present knowledge.
- A more flexible parameter, "the Food Safety Target" has been suggested for use where conditions have proven unfit for the use of the very stringent PO. A "Food Safety Target" may be defined according to the circumstances, enabling some latitude as compared to the PO, to provide a flexible and transparent opportunity to set targets that are fit for the purpose.
- Food safety metrics are not applicable in every situation. In cases where immediate action is called for, and the knowledge necessary for deciding on actions to be taken is available, we must rely on qualitative risk assessment/expert opinions.
- We should not try to fit these parameters to every situation, but rather seek the scenarios where they are suitable. We should use them and in this way try and explore their further evolution, - and usefulness.
- Use of the concepts needs time. As they must be quantitatively linked to risk, a quantitative Risk assessment is a necessary prerequisite. Time is needed in order to perform a QMRA so that the parameters best can be linked quantitatively to an outcome/ALOP or FSO (Risk-based approach is defined as being linked quantitatively to risk).
- We need to continue moving towards making risk management decisions risk-based. Therefore, the concept of food safety metrics should be further evolved, as it presently offers the only way. It is important that work on a probabilistic approach, with a set of metrics, which may be modelled to an ALOP, is continued.
- At the same time it is important that work towards a risk based food management is continued, while the food safety metrics PO, FSO and ALOP, are being further developed. The use of "food safety targets" could be a possible solution.

By the end of the meeting the workshop participants prepared: "Statements on recommendations to improve Food Safety". A part of the statements concerned the current view and status of the risk based microbiological food safety management. These statements are summarized below:

1. It was agreed that the role and the responsibilities of the parties involved in national/international food safety should be clearly defined. This is crucial in a risk based food safety approach. Also this was considered a fundamental prerequisite to avoid future setbacks in case of food scandals.
2. All involved parties must give priority to establish bridges between the industry, the policy and science. This interaction must build on mutual trust and a common language and should lead to an open dialogue between stakeholders.

3. Implementation of risk based food management cannot wait for the “Rolls-Royce model” of science. It is important that we continue the process that have already begun and that we in this process focus on a practical level of understanding and formulate practical targets.
4. To reach a common path and useful solution for the industry and policy, the industry and policy must be involved in and take initiatives to influence the research agenda through active involvement meetings where views are exchanged.
5. During the process of developing the ground for risk based food management the workshop participants recommend that:
   - science makes more use of case based approaches (more examples from practical solutions are needed); that science specify and develop more “simple” and user friendly risk based systems; that science look into existing quality assurance systems, and finally, that science advice industry on how to improve these systems and to give the systems a sound scientific basis.
   - industry opens up and share information and data in the field of public food safety with science and possibly policy makers.
   - food safety risk managers act according to the real life fact that zero risk is an illusion.
6. To involve more countries and relevant institutions (including the Commission) in the work towards a common risk based food management.
7. It is important to establish targets or objectives, preferably at the EU level, in order to communicate official acceptable levels with which the industry has to comply. These targets or objectives need not necessarily to be in accordance with Codex legislation. A fundamental prerequisite is the establishment of baseline studies at the EU level. The information obtained through such studies will establish the current level of food safety and will enable the setting of realistic targets and objectives.

Practical investigation: Control of Campylobacter in broilers.

In the present project we used an approach that in principle do not follow the formal suggestions on how to establish an FSO or PO as suggested by Codex. Instead we attempted to work backwards by suggesting methods to set performance criteria (PC). The reason for this was that the actual output from the Danish risk assessment established on *Campylobacter* in broilers in 2001 (Rosenquist et al., 2003) did not operate on a numeric scale but rather on a relative scale. E.g. saying that a reduction of the *Campylobacter* concentration on broiler meat by a factor of 100 would potentially reduce the probability of getting ill from *Campylobacter* in chicken meat by a factor of 25. Furthermore a reduction of the percentage of positive flocks by a factor of 10 would potentially reduce the probability of getting ill from *Campylobacter* in broilers 10-fold. Therefore, as a part of the practical investigation, a large-scale study was performed. Through this study, we examined the problems/benefits of introducing a performance criterion (PC) in the poultry production.

Initially, we looked at different interventions for reduction of the number of *Campylobacter* on chicken meat. An inventory of more than 22 possible interventions was prepared. The interventions were ranged according to their costs of implementation, practical feasibility, and expected reducing capacity. Two methods that were assumed to have low implementation costs and to be relatively easy to study in full scale were selected for further investigation. The first study focused on improved evisceration. This study examined the effect of channelling carcasses with visual faecal contamination due to viscera rupture for an extra washing procedure. The second intervention studied was the effect of an improved air-chilling system, where the chilling time has been extended, the ventilation increased and the temperature reduced. In addition, a third method, steam combined with ultrasound (SonoSteam®), was also investigated. The SonoSteam® equipment was an off-line prototype placed along side the slaughter line. All investigations were conducted in a Danish broiler slaughter plant.

Channelling of broilers with visible faecal contamination seems to be a feasible intervention method. However, the contamination on the visible contaminated carcasses was only approximately 1 log unit higher compared to non-contaminated carcasses, thus this method should not be a stand-alone intervention method. The second study on optimized air chilling resulted in only a small reduction of 0.4 log units on the carcasses. On the other hand, the SonoSteam® treatment proved to be an efficient method with a reduction of 2-3 log units which is an even more efficient intervention method than freezing (Boysen and Rosenquist, 2007). However, this was prototype equipment and further development and in-line trials should be performed to evaluate true effect of the technique.

The output from these studies was used in the discussion on how to implement the risk management parameters. Especially, in discussions of whether alternative approaches are available to specify risk management parameters that provide the same standard as currently suggested by the Codex Commission.

4. Conclusion

The implementation of Codex approved management tools is still in its infancy in Denmark as well as the other EU regions involved in the PromSTAP project "Microbiosafe". In general, the local food authorities and the food industries have been open towards a risk-based approach and welcome the risk management tools within food safety. Both stakeholders view the risk-based approach as a mean to provide food safety and consumer protection on a scientific basis with food safety initiatives linked to a well-known outcome. In addition, the Codex approved risk management tools allow a clear division of responsibility between the authorities and the industry.

During the project period we have accomplished to spread the knowledge on the Food Safety parameters within the participating regions. As a result of the discussion between policy, science and industry we have been able to provide "feed-back" to the developers of these parameters; thus the project has paved the way for the use of these tools and contributed to further development of the concepts. A lot of work is still necessary to convert these rather theoretical definitions that only in rare cases may be applied in food safety programmes, into more flexible and practical applicable tools.

A major conclusion drawn from the project is that more emphasis must be put forward from national governments / Codex to introduce the risk management tools in European regions and countries. As of now Food safety authorities are only to a limited degree prepared to take in these new tools.

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Monitoring strategies in food supply chains

Bruckner, S.*[1], Gymnich, S. [1], Petersen, B.[1], Schmitz, T.[2], van der Roest, J. [3], Kägi, A. [4], Crespo, P. [4], Bertschinger, L.[4]

[1] Institute of Animal Science, Katzenburgweg 7-9, 53115 Bonn, Germany, E-mail: bruckner@uni-bonn.de

[2] Plato AG, Emil-Figge-Straße 76-80, 44227 Dortmund, Germany

[3] RIKILT – Institute of Food Safety, P.O. Box 230, 6700 AE Wageningen, The Netherlands

[4] Forschungsanstalt Agroscope Changins-Wädenswil ACW, P.O. Box 185, 8820 Wädenswil, Switzerland

Keywords: Broiler chicken, carrot, *Chalara*, pig production, *Salmonella*

Abstract

The overall objective of the PromSTAP subproject MonStratFood was the exchange of know-how of different approaches from selected food chains to improve food quality and safety during the food chain between the participating regions. The individual subprojects of the partners are quite divers because the regions focus on different food supply chains: pig production chain (DE), carrot production chain (CH), broiler chicken production chain (NL) and milk production chain (BG)*. In North Rhine Westphalia (DE) a knowledge database based on the Software SCIO™ FMEA of the PLATO AG was developed, evaluated and implicated in the pig production chain for all stages. In Switzerland (CH) a documentation of the fork to farm carrot production chain as well as the identification of critical control points for carrot quality has been conducted. The monitoring of the carrot chain has been focused on one major, actually very pressing quality problem: the infection with fungi of the Genus *Chalara*. The management of the *Chalara* problem at these control points was looked at in the context of PromSTAP's subproject QualiTools and InnoFruit. In Gelderland (NL) an inventory study of national legislation and the subsequent application of monitoring systems in different countries has resulted in an overview of monitoring activities and interpretations at regional level, as well as the actual results of control programs. In order to combine and compare the individual results of the different regional projects on monitoring strategies in food supply chains a kind of synthesis was suggested.

* Due to financial complications the partner from Vidin was not able to participate in the project

1. Introduction

EU-regulations (178/2002, 825/2004, 853/2004, 854/2004, 882/2004) as well as standards of the trade and chain-oriented quality control programs demand the introduction of self-control systems from enterprises of the agrarian and food production in all European regions. This means that also the farm level has to be included in the assessment of hazards and risk regarding food quality and food safety. Thereby the focus should be on process analyses in the chain and the identification of potential hazards. Especially for SMEs it is important to have innovative systems that monitor the quality and safety of the products during the whole chain to adapt more efficiently to market and consumers' demands.

The agro-food sector in **North-Rhine Westphalia** consists of a variety of network and supply chain structures, which are forming different net chains with a broad diversity of inter-enterprise relationships between its mostly legally independent links. Because of that the pork production chain is organised under very heterogeneous contractual arrangements. Zoonoses especially salmonella are a special category of risk factors for the consumer with regard to food safety in the pig production chain. Thus the abatement of Salmonella and other zoonoses causing organisms already on the farm level is very important.(Gymnich et al. 2005) Therefore the objective of the North-Rhine Westphalian study is to examine to what extent the theoretical and methodical approach of the failure mode and effects analysis (FMEA) as well as the hazard analysis and critical control point concept (HACCP) can represent a basis

for setting up a software-based knowledge data base for advisors in pig production chains especially in the field of salmonella monitoring.

The fresh and processing carrot chain in **Switzerland** is characterised at the production level by many small structured vegetable farms organized in one national association and also in regional organisations. The storage and processing sector is structured in several SMEs. At the public authority level, food security is organised mainly at regional level while food quality is controlled by national vegetable branch dependent offices and/or also wholesalers' dependent offices. In consequence it is essential to safeguard the potential occurrence of hazards in the different food supply chains and the effect on public health. So the aim of the Swiss project was the documentation of the fork to farm carrot production chain as well as the identification of critical control points for carrot quality, whereby the monitoring was focused on the infection with the fungi *Chalara*. The management of the *Chalara* problem at these control points was looked at in the context of PromSTAP's subproject QualiTools, while for MonStratFood, more conceptual aspects of the problem were looked at.

Agricultural products are produced and marketed by a great number of (international) companies before they reach the consumer. Therefore food safety risks are divided over numerous different organisations within the supply chain. In the light of these two observations it is essential to safeguard the potential occurrence of microbiological and chemical hazards in the different links of the supply chain and the effect on public health. An effective and efficient monitoring and measuring strategy is of great importance.

In order to comply with the intentions of Interreg IIIc projects in general, the **Dutch** sub-project focused on international aspects of legislation in different EU regions. Besides EU legislation on food safety in general, additional requirements as well as the application of monitoring programs in particular are specific to each country. The research mainly focused on practices in The Netherlands, Denmark and EU in general. Consumers in various countries demand higher food safety standards and guarantees. One of the aspects is the efficiency and efficacy of monitoring and measuring strategies. So the objective of this subproject was to compare national legislation and the subsequent application of monitoring systems in different countries (The Netherlands and Denmark). The target groups within this project were envisaged within the supply chain of meat products i.e. farmers, processors, wholesalers and retailers. As it can be seen the individual regional subprojects of the partners within the MonStratFood project are quite divers. The projects focused on different food supply chains. In order to combine the individual results of the regional projects on monitoring strategies in food supply chains a kind of synthesis was suggested.

2. Material and methods

In **North-Rhine Westphalia** the software SCIO™ FMEA of the PLATO AG (Lübeck, Germany) was used as basis for a knowledge data base. It supports structural analysis, hazard and failure analysis, risk evaluation and risk treatment. Expert knowledge was collected by literature research and expert interviews and than put into the FMEA forms. Risk evaluation was conducted by the valuation criteria severity (S), occurrence (O) - and detection (D) probability and the calculation of the risk priority number (RPN = O x S x D). Additionally there was the possibility to identify critical control points (CCP's), hygiene control points (HCP's) and quality control points (QCP's).

In **Switzerland** (CH) the fork to farm carrot production chain was studied on individual farms, 6 packing houses and some shops of wholesalers. 3

The monitoring of the carrot chain has been focused on one major, actually very pressing quality problem: the infection with fungi of the Genus *Chalara*. The management of the *Chalara* problem at these control points was looked at in the context of PromSTAP's subproject QualiTools.

The inventory research of the participant **Gelderland** has been performed by reviewing literature. Key items addressed in this literature study were EU directives and regulations on monitoring and control of zoonoses with specific emphasis on *Salmonella* in broiler chickens production chain. The inventory study has resulted in an overview of monitoring activities and interpretations at regional level, as well as the actual results of control programs.

The benefits of this project will foresee in a monitoring and measuring strategy that is both effective and efficient in its approach to food safety hazard in the supply chain. The results will be beneficial to companies in Europe, who will be able to produce at a safer and more cost effective level. Integration and harmonisation of monitoring and measuring systems between the project partners will be an additional benefit. In order to formulate an overall result of the MonStratFood project, the partners looked at the all regional projects with regards to the existence of synergy between the partners and synthesis of the individual project results. Therefore the terms "synergy", "synthesis" and "supply chain" were defined. Than a set of criteria for the synthesis of the regional subprojects approach and results in MonStratFood was defined to be able to assess a comparable outcome.

3. Results and discussion

3.1 Results of the German project

The result of the region north-Rhine Westphalia is an existing database for the pig production chain which includes all stages from breeding, rearing and fattening to slaughter and processing. The database includes the already existing knowledge of failure types and categories for the prevention of Salmonella at farm level as well as specific causes and measures for trouble shooting. It can be extended at any time. So the data base is in a constant extension and continuous improvement process. As an example the function tree in the SCIO™ FMEA software for the green side in the pig production chain (breeding, rearing, fattening).is shown in Figure 1.

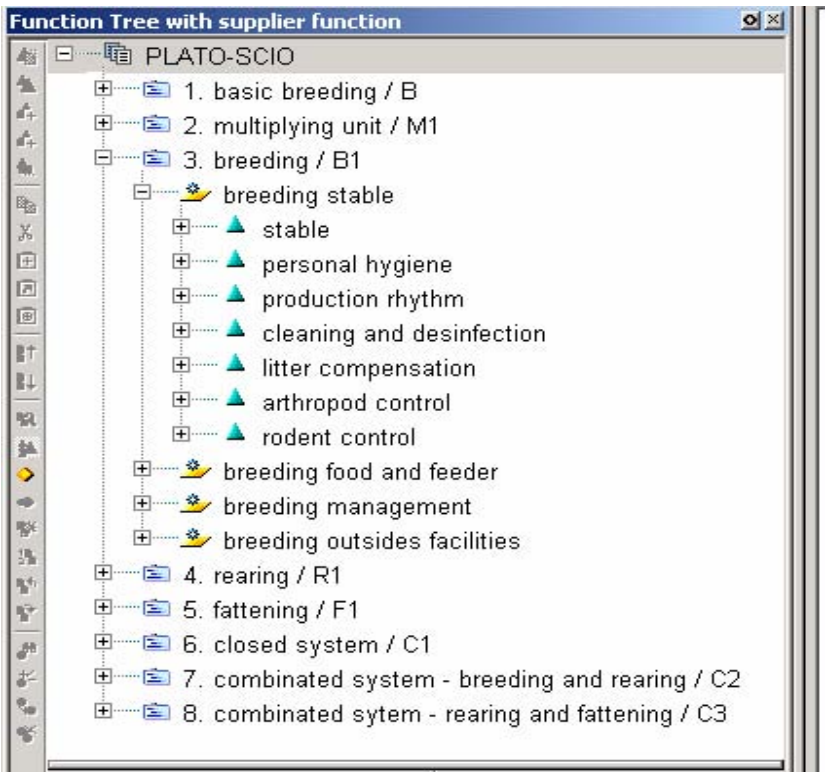

Figure 1:
Function tree in the SCIOTM FMEA software for the green side in the pig production chain (breeding, rearing, fattening)

With the database in the software SCIO™ FMEA it is possible to define specific risk factors at every stage and carry out a risk evaluation (O, S, D, RPN) for each hazard. Furthermore problem solutions for each production stage can be compiled which lead to appropriate control points (CCP´s, HCP´s) and self-control measures (preventive, inspection and monitoring measures). In addition animal-health measures can be adjusted with measures of the food hygiene in order to minimize the cross contamination and to improve the hygiene status in all stages. In Figure 2 an example for a weak point analysis in the step 'rearing' for the process 'climate' is shown.

Process Analysis	Potential Failure	Control Point	Potential Effect	Cause(s)	P/D	Current Action	O	S	D	RPN	P/D	Recommended Action
climate	Immune depression winter	QS HCP	Salmonella infection	poor temperature conditions	State: 27.09.2006						State: 27.09.2006	
					P	???	0	0	0	0	P	heating 3 days before housing with a minimum floor temperature of 28°C
					D	???						
	Immune depression summer		Salmonella infection	poor air condition	State: 28.09.2006						State: 28.09.2006	
					P	???	0	0	0	0	P	minimum air rate
					D	???						

Figure 2: Example for the process climate of the weak point analysis rearing

3.2 Results of the Swiss project

Five control points in the carrot chain have been identified. Carrot production in with *Chalara* contaminated fields, the storage where cooling time and storage conditions have a major influence on the carrot quality, the washing because of the cross-contamination risk with washing water and the often occurring injuries of the product in this processing step, the waste disposal where fields can be contaminated by *Chalara* contaminated wastes again and the distribution step where high temperatures favour the development of *Chalara*. The management of the *Chalara* problem at these control points was looked at in the context of PromSTAP's subproject QualiTools and InnoFruit, while for MonStratFood, more conceptual aspects of the problem were looked at. The washing and the temperature management at and after harvest have been identified as the chain points of major, most critical impact on the *Chalara* problem. This control point was therefore conceptually looked at in more detail. Methods for a quantitative monitoring and controlling of *Chalara sp.* contamination and prevalent environmental conditions along the chain have also been looked at in the context of QualiTools and InnoFruit. Solutions were found to keep the *Chalara sp*. contamination with washing and temperature management at acceptable market levels. A good management at other critical points than washing and temperature management can significantly alleviate the problem also as studies in the context of sub projects QualiTools, InnoFruit and other initiatives showed:

- The washing with fresh, uncontaminated water, at best under high pressure, is crucial for achieving an acceptable quality.
- A rapid cooling after harvest and a storage temperature of 0-1°C avoids that Chalara sp. create quality problems.
- Keeping temperatures below 8°C prevents from black rot for 10 days.
- During storage high humidity is a requirement for efficient carrot storage and maintenance of quality.
- Use of plastic liner in wooden bins is still recommended in most of the cases depends on the technique.
- Concerning the wide range of host plants by *Chalara sp.*, the rotation gap between carrots and other host plants of *Chalara sp*. like bush bean, peas, cucumber, clover and alfalfa should be at least 4 years. Hairy vetch does not get infected by *Chalara sp*. and should be preferred as intercrop. Crops like wheat, corn or rye are not infected either.

MonStratFood helped to look at the problem from a conceptual level which made reflection easier about specific solutions and how to deal with quality problems along a plant food chain.

3.3 Results of the Dutch project

In The Netherlands poultry products obtained from retail stores were investigated on the presence of *Salmonella spp*. in the year 2004. In that year *Salmonella spp.* were present in 7.4% of the samples, compared to 2003 this is a decrease for *Salmonella*, being statistically significant. *Salmonella* enteritidis was present in only 0.4% of the products. Concerning the retail channels, real butchers, regular poulterers, market poulterers and supermarkets, it appeared that products from butchers had the highest contamination level concerning Salmonella (10.6%).

Most frequently isolated serotype was *Salmonella* paratyphi B being 52.8% of all isolates. The isolates of *Salmonella spp.* in 2004 showed a statistically significant increase in antibiotic resistance for cefotaxim, trimethoprim and trimethoprim/sulpha (VWA, 2005).

In 2005 no rearing breeding or adult breeding flocks were positive for *Salmonella*, as the annual prevalence was 2.1% in Denmark. However this was an increase compared to 2004 (1.5%). The mandatory examination of enc-products was carried out through sampling of batches of chicken cuts shortly prior to packaging. A batch is defined as the amount of meat from animals slaughtered between two cleanings and disinfections of processing equipment. *Salmonella* was detected in 2.3 % of these batches, which is also an increase compared to 2004 (1.6%). From the middle of the year 2005, the two main producers of poultry meat were approve to market *Salmonella*-free poultry meat. As a part of this approval they were allowed to take verification samples for *Salmonella* once a week instead of each day, as required by the legislative control program (Anonymus, 2006).

In the years 2005 and 2006 a European Union-wide baseline survey in all EU Member States and Norway was carried out to determine the prevalence of Salmonella in commercial flocks of broilers with at least 5,000 birds. The objective was to provide scientific basis for setting of EU target for reduction of prevalence of Salmonella in broiler flocks. A total of 6,325 holdings responded, corresponding to 7,440 flocks with validated results to be included in the survey analyses.

The Community observed prevalence of *Salmonella*-positive flocks was 23.7%. However the Salmonella prevalence varied widely amongst the Member States, from 0% to 68.2%. A total of 11% of the broiler flocks was estimated to be positive for *Salmonella* enteriditis and/or *Salmonella typhimurium*, the two most common serovars found in Salmonella infection cases in humans. The variation between the Member States observed of flock prevalence of these two Salmonella spp. varied also greatly, from 0% to 39%.

Salmonella positive broiler flocks contribute in a consequent contamination of broiler meat and is an important source of human *Salmonella* infections in EU. The risk for human health arises from accidental under-cooking of the meat of cross-contamination to other foods. While the Community reduction target will most likely be set for a transitional period only for *S. enteriditis* and *S. thyphimurium*, it is recommended that Member States would address in their national *Salmonella* control programmes also other serovars when these serovars are of public health importance in their country (Anonymous, 2007)

3.4 Results of the whole project

At first the terms "synergy" and "synthesis" were defined. Synergy, in the human synergy context, relates to the interacting of persons. Synergy usually arises when two persons with different complementary skills cooperate. The fundamental example is cooperation of men and women in a couple. In business, cooperation of people with organizational and technical skills happens very often. In general, the most common reason why people cooperate is that it brings a synergy. On the other hand, people tend to specialize just to be able to form groups with high synergy (teamwork).

With regard to synergy the partners within the project have interacted in the project meetings on an individual level on contents and cooperation within the MonStratFood project. At the annual meetings of the PromSTAP project the partners of the MonStratFood project interacted with participants of other subprojects of all four components. Within each subproject of the MonStratFood project the partners interacted also with other public or private organisations in order to exchange views of monitoring strategies within the food supply chains.

Synthesis, in relation to analysis, means 'to put together' and 'to loosen up' respectively. These terms are used within most modern scientific disciplines to denote similar investigative procedures. In general, analysis is defined as the procedure by which we break down an intellectual or substantial whole into parts or components. Synthesis is defined as the opposite procedure: to combine separate elements or components in order to form a coherent whole (Ritchey, 1996).

To be able to assess a comparable outcome of this combination of project approach and results a set of criteria was defined. But first a definition of a supply chain is described.

A supply chain is a coordinated system of organizations, people, activities, information and resources involved in moving a product or service in physical or vitual manner from supplier to customer. Supply chain activities transform raw materials and components into a finished product that is delivered to the end customer.

Today, the ever increasing technical complexity of standard consumer goods, combined with the ever increasing size and depth of the global market has meant that the link between consumer and vendor is usually only the final link in a long and complex chain or network of exchanges.

This supply chain begins with the extraction of raw material and includes several production links, for instance; component construction, assembly and merging before moving onto several layers of storage facilities of ever decreasing size and ever more remote geographical locations, and finally reaching the consumer. Although many companies and corporations today are of importance not just on national or regional but also on global scale, none are of a size that enables them to control the entire supply chain, since no existing company controls every link from raw material extraction to consumer. Many of the exchanges encountered in the supply chain will therefore be between different companies who will all generally seek to maximize company revenue within their sphere of interest but will have little or no basic knowledge or interest in the remaining players in the supply chain except those to which it is directly linked. Figure 3 shows the schedule of a supply chain defined by the project partners.

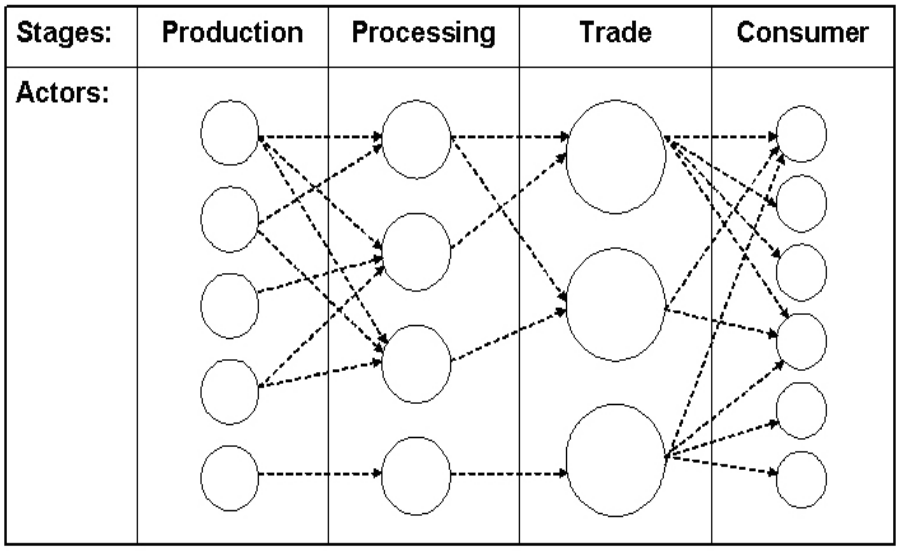

Figure 3:
Schedule of a supply chain

In table 1 a description and a subdivision (level) of the criteria is given.

Table 1: Description and subdivision (level) of criteria for synthesis of subprojects approach and results in MonStratFood

No.	Criterion	Description	Level
C1	Stages	Number of stages in chain considered by sub-project case study	1-4
C2	Horizontal integration	Level of intensity of exchanges between the stages by the actors	Low: only product, several ownerships
			Middle: product, information, several ownerships
			High: product & information under one single ownership
C3	IT	Horizontal and vertical use of IT-tools by chain actors	None
			Independent use by some actors
			Coordinated between actors and/or stages
C4	Advise, inspection and audit	Public vs. private, at any stage	Public
			Private
			Public & private
C5	Complexity	Number of relationships between actors of the different stages	(near to) linear
			Linear and multiple combined over the stages
			Multiple at all stages
C6	Food safety	Impact of the sub-project result on food safety issues	Low: no or little impact
			Middle: indirect impact
			High: direct health effect on the consumer
C7	Food quality	Impact of the sub-project result on food quality issues	Low: no or little impact
			Middle: impact at one stage
			High: impact on the whole chain
C8	Output	Establishment of standards parameter or procedures (SOP) as a result of the subproject	Recommendation
			Guideline/directives
			Implementation

The characterization of each criterion in the subsequent subproject on regional level is given table 2.

Table 2: Regional characterization of criteria for synthesis of subprojects MonStratFood

Criterion	Level Gelderland	Level Zürich	Level NRW
C1: Stages	3	3	4-6
C2: Horizontal integration	low	middle	middle
C3: IT	independent	independent	independent
C4: Advice, inspection and audit	public & private	public & private	public & private
C5: Complexity	linear and multiple	linear and multiple	linear and multiple
C6: Food safety	middle	low	high
C7: Food quality	middle	high	high
C8: Output	recommendation	recommendation	recommendation

4. Conclusions

The project in North-Rhine Westphalia showed that *Salmonella* monitoring is only successful in connection with a coherent control strategy to minimise weak points in the enterprises. The developed software-supported model of a knowledge database is the basis for an efficient standardized consulting for pig producing farms.

The results from the Dutch project part revealed that an effective and efficient monitoring and measuring strategy of microbiological hazards in the broiler chicken production chain is of great importance. Therefore an inventory study has been carried out and resulted in an overview of monitoring activities and interpretations at regional level, as well as the actual results of control programs.

- The directives on EU level are very specific on monitoring aspects of zoonoses and regulations mentioned are quite specific with regards to *Salmonella* and broiler production. European Community legislation foresees the setting of *Salmonella* reduction targets for animal population including broiler flocks.
- In the Netherlands EU directive 92/117/EEC is implemented through a number of regulations and decisions of the Product Board Poultry and Eggs. The regulations and decisions aim at reducing food borne diseases, specifically caused by *Salmonella spp.* The prevalence of *Salmonella* in broiler chickens or chicken cuts has decreased over the years, but the level is still above 5%.
- In Denmark the number rise of human *Salmonella* infections led to a targeted national control program for broiler production in 1989. The initial aim of the program was that < 5% of broiler flocks would be infected with *Salmonella*. In 2003 the Danish Poultry Council undertakes responsibility for the surveillance program. Since 2000 the prevalence of *Salmonella* in broiler chickens has been indeed below 5%, which is largely attributed to large scale national efforts aimed at reducing the occurrence of *Salmonella* in broilers in this country.
- On EU level the baseline survey shows that a great difference exists in the prevalence of *Salmonella* between the individual Member States ranging from 0% to 68%. Broiler meat is an important source of human salmonellosis in EU. Thorough cooking of broiler meat and strict kitchen hygiene would prevent or reduce the risk posed by *Salmonella* contaminated broiler meat.
- It is recommended that all Member States address *Salmonella* in their national control programs and introduce consumer education campaigns about good hygiene practices.

The results of the Swiss study showed that 5 principal points can be identified in the fork to farm chain of carrots that are critical for carrot quality (mainly endangered at the moment in Switzerland by *Chalara* fungi causing black rot) at the point of consumption. MonStratFood helped to conceptualise the carrot food production chain which in turn contributed to develop in the context of sub projects QualiTools, InnoFruit and other initiatives sound, feasible solutions to prevent from the critical black rot problem in Switzerland.

According to the overall aim of PromSTAP and INTERREG III C the partners within the MonStratFood project have formed a network of experts in their field by sharing and exchanging information across borders. Synergies between the different regional projects have been identified and used in a constructive way. The partners have also interacted with participants of other PromSTAP subprojects of all four components and with public or private organisations in order to exchange views of monitoring strategies within the food supply chains.

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Geoquality - Part I
Chain models as a tool to quantify the relation between soil, crop quality and human exposure

Römkens, P.[1], Franz, E.[2], van der Fels-Klerx, I., van Raamsdonk, L.[2], Jaeger, F.[3], Thielen, M.[3], Bosshammer, K.[4], Leisner-Saaber, J.[5], Rath, C.[5], Hamer, M.[6]

[1] ALTERRA, Dep. of Soil Science, PO box 47, 6700 AA Wageningen, The Netherlands

[2] RIKILT - Institute for Food Safety, PO Box 230, 6700 AE Wageningen, The Netherlands

[3] Ministery of the Environment and Conservation, Agriculture and Consumer Protection of the State of North-Rhine Westphalia, Germany

[4] LANUV NRW - state agency for nature, environment and consumer protection North Rhine-Westphalia, Germany

[5] LDS NRW - State agency for data processing and statistics North Rhine-Westphalia, Germany

[6] GIQS e.V. c/o University of Bonn, Germany

1. Introduction

Awareness has grown that soil is an important factor in the chain leading to the production of food and feedstuff. Whether dealing with home-grown or industrially processed vegetables, animal food or grassland; the transfer of contaminants from soil to a specific product is of importance regarding the quality of food.

At present there is genuine concern about the increased level of contaminants in soil and its adverse effect on human and animal health. Metals like cadmium, copper, zinc and lead have increased due to both agricultural and industrial processes and are both intentionally and unintentionally added to the soil. Atmospheric deposition of lead for example is mostly due to the emission by cars and industry and less related to management of arable land. On the other hand, products like manure, compost, sludge, and even fertilizers contain considerable amounts of metals but are added to the soil because of beneficial effects of both organic and inorganic soil amendments.

Aside from uptake from soil, also farm management has a direct impact on the quality of products. The use of pesticides, herbicides and other chemicals to reduce pests, weeds etc. can affect the quality of a product. In this case, the role of soil is limited since the product is brought in contact with the product directly. Examples of this include the use of copper sulphate in wine growing and the extensive use of pesticides in growing different kinds of fruits. Obviously, chemicals used can enter the plant through the root system after being applied to the plant or on the soil but usually this uptake route is of lower importance. Pesticides will degrade after some time, and uptake of persistent chemicals (which are now mostly banned anyway) by plants is very low due to their high sorption onto soil organic matter.

Nevertheless, the pathway through which a chemical is introduced into or onto the soil is of importance considering the product quality. Within the scope of the project Geoquality the goal was to describe and quantify such pathways. This then allows to design specific measures to reduce the transfer of chemicals in the food chain. Ideally these chains can be used in different areas throughout Europe by adapting specific parts of such chains. In this Interreg IIIC subproject two major pathways or chains have been identified and studied by different partners:

1. Application of chemicals directly onto the plant or the soil. In this case the application of a copper based pesticide to control fungal pathogens in olive trees. The major objective of this study was to assess the impact of the use of pesticides on the quality of olives. This part of the project was more or less conducted independent from the other project parts. The end-point of interest here is the quality of the olive oil which has to meet the -not yet official- quality criteria of 100 µg kg^{-1}. The approach is based on the direct measurement of copper in soils and olive oil. This part of the project was coordinated by the Centro Regionale di Sperimentazione e Assistenza Agricola in Alberga (It).

2. The soil – crop – animal – human exposure pathway. Once a chemical is in the soil, uptake by plants followed by consumption by both animals and human beings forms a major pathway through which both animals and human beings are exposed to harmful substances. The degree to which the 'soil-plant' route is of importance obviously depends on many factors including the chemical availability in soil, the transfer from soil (solution) to crops and the amounts of crops consumed by animals or human beings. As an example of such a chain partners from Germany (NRW) and the Netherlands (Alterra and Rikilt, both part of Wageningen UR) studied the transfer of cadmium from soil to crops, animals and ultimately human beings. Important 'end-points' in this chain are the quality of fodder (regulated by EU directives, ao EU 32/20002), the quality of arable crops (regulated by EU directive 466/2001) and obviously the human exposure (considering the maximum tolerable intake of 0.5 µg Cd kg-1 bw day^{-1}.

In contrast to the cadmium 'chain' the problem of copper applications in olive trees is not so much an example of a chain that allows for the design of management options. Obviously, reducing the use of copper-based pesticides lowers the impact on the quality. As such the sub-project will deliver useful insight in the relation between the use of pesticides, the quality of soil and the product. At present information relating the use of pesticides to the quality of products is scarce and this study can be seen as a first reconnaissance of this potential problem. It is doubtful however whether copper is taken up by olive trees and transferred into olives. It is more likely that the quality of the olives is directly related to the use of the pesticide. However, no data were collected on the amounts of pesticides used, which hampers a clear evaluation of the impact of the use on the quality of the soil and that of the olive oil. Furthermore, although the soil was included in the study and copper levels in soil were measured, it remained unclear what caused the differences between locations. In certain areas elevated copper levels were present in soil but these differences may not be related to the use of pesticides alone. The fact that elevated copper levels in soil were found also in areas with low application rates already suggests that copper in these soils (and hence in the plants and plant products) are controlled by factors not included in the study. This obviously hampers a clear chain analysis.

In this report we therefore focus mainly on the second chain since this chain can be divided in to several separate parts that each can be evaluated in terms of potential management options (soil management, crop management, feeding strategies, food patterns). Results of the olive oil project are presented in a separate annex attached to this report.

As explained previously, the soil is an important part of the management chain and the use of specific soil amendments can be steered to such an extent that the supply of contaminants to soil is reduced. Both national and regional policy measures can be taken to reduce inputs to soil. In the Netherlands for example, concern about the potential long term effects of sewage sludge application has resulted in a total ban of the use of sludge in agriculture. In North Rhine-Westphalia as well its application to farmland was considerably restrained during the last years. Also the use of compost is restricted to compost with a quality label which indicates that this type of compost meets the criteria for heavy metals.

In many cases, however, long term atmospheric deposition, the (ongoing) use of manure and phosphate fertilizer still results in the accumulation of especially copper, cadmium and zinc.

To assess whether this ongoing accumulation, or even the current soil quality, eventually leads to excess uptake of contaminants in soil, instruments are needed, that are able to predict the level of contaminants in food crops and animal products. Based on acceptable levels in food and feed stuff, acceptable levels in soils can be defined using process models that describe the transfer of contaminants in the chain from soil to products. The aim of this project is:

1. to describe the relevant chains for contaminants from soil to food and feed stuff that may cause a risk of harmful impacts on human health
2. to evaluate whether current data are of sufficient quality and detail and comparable for the attending regions and to assess whether analytical procedures currently used in the partner regions are equivalent.

3. to develop a conceptual model that characterizes all main processes but permits individual adaptations in detail. This concept therefore has to comprise principal modules that can be filled with mathematical models taking regional conditions into account if needed.
4. to check this coordinated concept by way of example for two regions based on available data and model concepts.
5. to evaluate whether the current soil quality is sufficient to ensure the production of safe food. Two project areas were determined in the Netherlands (Kempen area) and North Rhine-Westphalia (Rheinisch-Bergischer Kreis/Leverkusen/Oberbergischer Kreis). Ideally data from the project areas will be used. However, if insufficient data are available, data from other regions can be used as well to illustrate the possibilities and restrictions of the approach developed.
6. to make the start of communicating risks and possible measures via development of an internet-based information system. The main objective of this system will be to illustrate spatial structures in contamination for administrative purposes and to give farmers a hand in reducing local risks.

Food chain modeling involves determination or estimation of contaminant concentration at various points of the chain. The feed and food production chain-concept used in the project is presented in figure 1. Emphasis is given to the goal of the project Geoquality: the steps are presented in terms of simulation models, calculated results and input data (contamination levels and parameters). The production chain as foreseen for the project consists of four main steps where the contaminant (cadmium) is transferred from one matrix to another: transfer from soil to crop (whether for animal or human consumption), composed animal exposure from different sources, transfer from feed to animal product, and composed human exposure from different sources. Some blocks are of special interest. Certain calculated data can be compared to actually measured contamination levels. The levels in plants, either in fodder or in vegetables, and in animal products are available in databases and can be used to calibrate the calculation models.

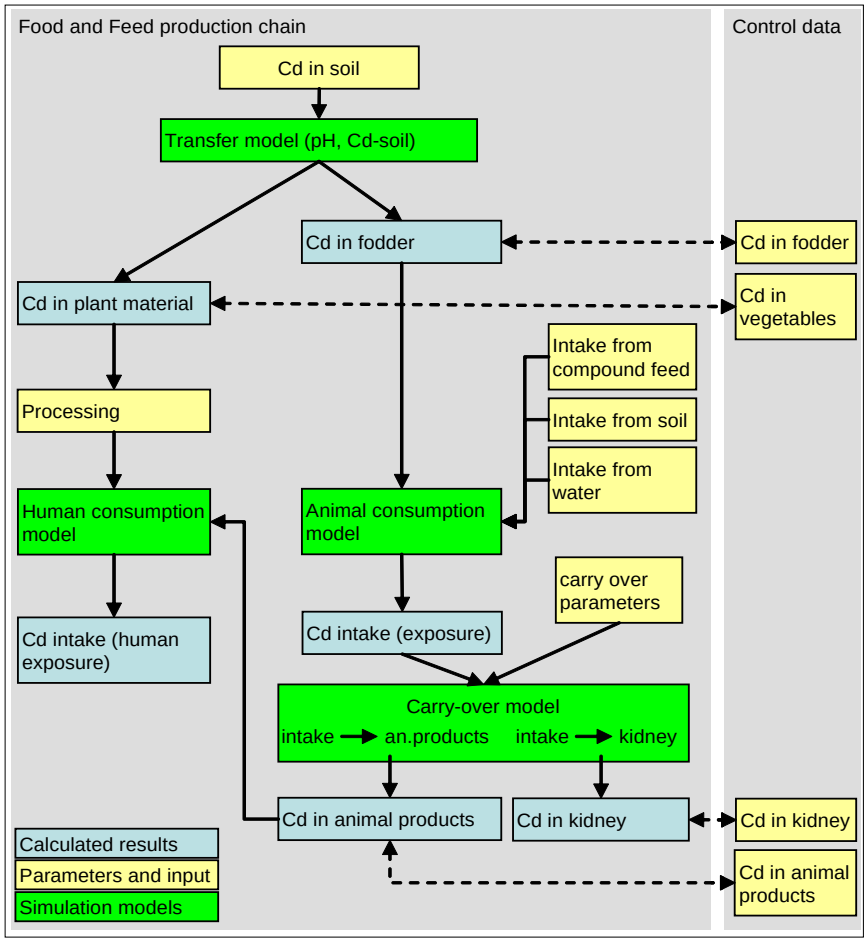

Figure 1: Flow chart of the chain model to estimate human exposure to Cd from animal and plant products, based on soil Cd levels and soil quality parameters.

Every block in the production chain will be presented and discussed in more detail. In this way the procedure for simulating the entire production chain will be documented, and gaps in data and knowledge can be identified.

Data on model-constants (calculation of cadmium in grass and maize) and pollution levels for soils (as well as generic soil properties like pH, organic matter and clay content) and water are available from Alterra and LANUV. Data on contamination levels in a wide range of material for food and feed are collected in a Dutch database called KAP, managed by RIKILT. Data from this database can be used as input or control data in several steps of the process.

2. Methods and Concepts

2.1 Geographical schematization used

In this project results are presented on a grid basis. Depending on data density, the extent of the area and the scale of visualisation different dimensions of grid cells are appropriate to use (e.g. 25 x 25 m, 50 x 50 m, 100 x 100 m). Subsequent calculations are based on estimated or mapped soil properties for each grid cell unit. This means that the results are not representative (as such) for entire farms; they merely indicate what the transfer of cadmium through the food chain for a soil unit with specified characteristics (acidity, cadmium level etc) would be. In order to apply quantitative models for heavy metal transfer from soil to plant, spatial information on soil properties are necessary. Both in the Netherlands and in North Rhine-Westphalia they exist or can be derived on a scale of 1:50.000.

2.2 Cadmium in soil

Based on existing data on heavy metals in topsoils concentration maps can be constructed using different interpolation techniques. Two of these known methods are well put into practice in the Netherlands and in North Rhine-Westphalia (Brus et al., 2005; LANUV, 2000). As it could be shown in a previous project (http://www.lanuv.nrw.de/boden/boschu-lua/d_n_belastkarte.htm), it can be expected, that results concerning estimated contents in soil are similar for both methods applied in this project. To each gridcell within the project areas, a value of cadmium in the soil has been assigned that way and serves as an input for the model. Data included to derive the maps are based on Aqua Regia destructions (in mg kg^{-1}).

2.3 Transfer model soil-plant

Contaminant uptake of plants from soil is a rather complex process which is affected by different factors. Its amount is mainly determined by the contaminant itself, the plant species and the soil characteristics. A harmonised model for predicting the uptake as a function of all coefficients is not available, but in Germany as well as in the Netherlands statistical methods on the basis of regression analyses are established to describe the relationship between contaminants in soil and plants. These approaches require sampling of crops relevant for this study (such as grass and maize, but also wheat, potato, scorzonera, carrot etc.) that were taken together with soil samples from the immediate vicinity of the crop.

A convention has to be achieved how to tackle with soiling – that means external deposition of soil material onto foliage of feeding crops. Considerable amounts of soil material are regularly attached to raw feeding crops and therefore ingested by cattle. If the specific procedures of plant sampling lead to unusually clean samples, this has to be taken into account by adding a certain percentage of soils concentration to plants concentration before calculating the regression parameters. Alternatively it is possible to add this effect as a separate source of intake when calculating animals' consumption.

During the period 2004 – 2006 field research has been conducted to investigate the cadmium content in soil and crops in the Kempen area (Rietra et al., 2005, 2006, 2007). In North Rhine-Westphalia similar

studies have been conducted between 1980 and 2000. Soil parameters including pH and organic matter were determined to derive a rather robust soil – plant transfer relationship. For both grass and maize (the quality of the entire above ground plant was measured) the general relationship between soil composition and plant cadmium is shown in equation 1:

$$^{10}\log[\text{Plant-cadmium}] = \text{Constant} + a*pH_{CaCl2} + b*^{10}\log[\text{organic matter}] + c*^{10}\log[\text{Soil-cadmium}] \quad [1]$$

With plant-cadmium and soil-cadmium in mg kg^{-1} (dry matter), organic matter in % and pH $CaCl_2$ as measured in a 1:10 soil-solution extract.

Outlining the results from the Kempen area in table 1 the values for the model coefficients are listed for cadmium (Römkens et al., 2007). It should be stressed that this empirical model has been derived for soils from a sandy region. Most soils in the Kempen area are podzols, with a low (2 – 5%) clay content and low (2 – 6%) organic matter content. The cadmium content in the database from which the model was derived ranges between 0.1 and approx. 2 mg kg^{-1} which means that the model has a limited validity for heavily polluted soils.

Table 1: Model coefficients for the calculation of the cadmium content in grass and maize derived from data of the NL project-area

	Model coefficients					
Crop	Constant	org. mat.	pH-$CaCl_2$	Cd-soil	R^2	se(Y-est)
		a	b	c		
Grass (n=15)	1.57	-	-0.38	1.22	0.63	0.23
Maize (whole plant), n=22)	1.04	-0.26	-0.23	0.85	0.58	0.24

For grass the contribution of organic matter appeared not significant and was left out in the equation.

The preconditions for calculating models for the NRW-project area differed from those stated before for some items. Systematic sampling didn't take place in this area but, because a lot of corresponding studies have been conducted all over the states area and over a long period of time, these samples were used as a basis for calculation. Therefore input-parameters are much more numerous but even more heterogeneous. Ranges are wider for every included component. Nevertheless, the resulting transfer functions, which are summarized in Table 2, turned out to be rather similar.

Table 2: Model coefficients for the calculation of the cadmium content in grass and maize (mg/kg DM) derived from data of the NRW project-area

	Model coefficients				
Crop	Constant	org. mat.	pH-$CaCl_2$	Cd-soil	R^2
		a	b	c	
Grass (n=1056)	0.070	-	-0.125	0.407	0.38
Maize (whole plant), n=101)	0.118	-	-0.121	0.578	0.32

2.4 Cadmium in fodder

Data on concentrations of cadmium in fodder was obtained from the KAP (Quality of Agricultural Products) database of the RIKILT, where the results of monitoring programs for chemical compounds in food are gathered in a national database (http://www2.rikilt.dlo.nl/kap/index.html).

2.5 Cadmium in animal products

2.5.1 Intake from compound feed

The compound feeds on the Dutch market have, on average, relatively low Cd levels (Table 3). For the specific situation in the Kempen area it is assumed that the compound feeds are obtained from nationally operating manufacturers, which produce their compound feeds predominantly form imported feed ingredients. Normal background levels can be applied.

Table 3: Cadmium levels in compound feed (mg/kg), based on the standard moisture content of 12%

	2003				2004				2005			
	n	min	max	med.	n	min	max	med.	n	min	max	med.
cattle additional feed, general	33	<0.02	1.200	0.069	0	-	-	-	14	<0.02	0.160	0.043
cattle additional feed, dairy cattle	8	0.028	0.061	0.052	6	0.025	0.200	0.062	5	0.037	0.890	0.043
cattle additional feed, beef cattle	3	0.068	0.100	0.082	3	0.044	0.058	0.048	5	0.048	0.100	0.052
cattle feed, general	1	-	-	0.074	3	<0.02	0.300	0.046	2	0.051	0.063	0.057
mineral premix, ruminant	11	0.030	1.600	0.110	18	0.041	1.600	0.220	29	<0.02	1.100	0.180
pig feed, general	11	<0.02	0.200	0.046	3	0.040	0.074	0.060	8	0.033	0.100	0.053
pig feed, meat pigs, final	11	<0.02	0.082	0.050	7	<0.02	0.110	0.044	7	0.055	0.076	0.068
horse feed	0	-	-	-	0	-	-	-	3	0.067	0.270	0.240

2.5.2 Intake from soil

In the model calculations a percentage of soil attached to the raw feed (grass and maize) was included based on data from the literature. For the summer period the amount of soil attached to plants was assumed to be 4% of the mass of food consumed whereas in the winter period (stable) this was 2% (Römkens et al., 2007). Provided soiling was not included in the soil-plant transfer model this results in a daily intake of soil ranging from 65 gram day-1 for young animals to 500 gram day-1 for older cows. Based on the cadmium level in the soil the resulting intake from soil was calculated as the product of the mass consumed and the level in the soil.

2.5.3 Intake from water

The amount of water consumed by cows strongly depends on age and whether or not a cow is lactating. For lactating cows the daily consumption of water can be as high as 150 L cow^{-1} day^{-1} (including the amount of water consumed by fodder). In the regional calculations the intake of water ranged from 7 (young calves) to 80 liters of water per day. To account for the variation in the level of cadmium (concentration) three scenarios were evaluated. Cadmium in the water ranged from 0.3 $\mu g\ L^{-1}$ (low exposure) to 3 $\mu g\ L^{-1}$ (high regionally averaged exposure) and to 20$\mu g\ L^{-1}$ (local extreme exposure). These values were derived from monitoring wells.

2.5.4 Animal consumption model

The daily intake *CONS* is the arithmetic average of the contamination levels in the feed ingredients *vg* and in the fodder adjusted to the relative shares *va* of every ingredient *i*, multiplied with the amount of the total consumption *co*:

$$CONS = \sum_{i=1}^{n} \left(va_i / 100 * vg_i \right) * co \qquad [2]$$

The amount *CONS* which is consumed daily of the contaminant, is usually not fully absorbed through the intestine wall into the physiological system of the animal. The absorbed amount (*up*take) can be calculated from the intake when the parameter for biological availability F_{abs} is known. When the parameters for the combination target-contaminant / target-animal does not include information on the biological availability, them it is assumed that the parameter for the carry-over rate includes the biological availability. The parameter F_{abs} is fixed to the value 1 (or 100%) in such cases

2.5.5 Cd intake (animal exposure)

The animal intake is the arithmetic average from different shares of the feed ingredients (Table 4). An average daily exposure in the Kempen area to cadmium is approx. 12.5 mg/day. Average exposure in other areas of the Netherlands is below 3 mg/day.

Table 4: Daily amounts and contamination levels per source for cattle

source	amount (kg dm)	Cd level (mg/kg)
grass/hay/silage (fodder)	15	0,8
soil	0,24	1,5
compound feed	3	0,05
water	80	0,003

In the Kempen study (Römkens et al., 2007) more detailed information on consumption patterns were used. A distinction in age classes (0 – 1, 1 – 2 and > 2 years) as well as a distinction between lactating and non lactating cows was used. Specific data on consumption patterns of raw food, and additional feeding materials can be found in the report.

2.5.6 Carry-over parameters

The parameters for the behavior of a contaminant (accumulation, metabolization and elimination) depends on the contaminant, the target animal and the target organ. For cadmium extensive desk studies are conducted. The results are published in Dutch reports. In summary the following ranges and choices for the relevant parameters for cadmium transfer to kidneys in cattle are listed in table 5:

Table 5: Overview of parameters used to calculate cadmium transfer into animal organs

parameter	symbol	range	final choice
biological availability	F_{abs}	low to 100 %	20 %
carry over rate	COR_o	0.07 tot 0.55 %	0.12 %
half life time	$T_{1/2}$	40 days (mice) to infinite (cattle)	900 days

Notes:
There is a phytate complex available in grass that binds to cadmium, lowering the biological availability. In calve feeds (milk replacers) this complex is absent and usually a biological availability of up to 100 % applies in those cases. Several studies present a carry-over rate. A worse case scenario would be based on the upper limit reported (0.55 %). A reconstruction of the Kempen data (1984) revealed that an average carry-over rate of 0.12 % is optimal.
Some studies, either experimental or surveys, present data that can be explained by assuming a linear relationship between period of exposure and resulting level of cadmium in kidneys. Other studies indicate the possibility of a slight elimination, finally resulting in a steady state situation. There is also a correlation between animal weight and half life time, with the shortest period in mice (40 days). The mentioned reconstruction of the data from the Kempen area revealed that a linear relationship can be applied for animals between 2 and 5 years in age, but an exponential relationship is more appropriate for covering the entire life span of the cattle (approx. 1 to 10 years). A half life time for cadmium of 900 days suits.

2.5.7 Carry-over animal model

For the animal transfer of chemical contaminants an exponential equation will be used based on a growth factor containing the duration of the period and the half-life time (exponential function) multiplied with the level at start (t=0) and the level in an assumed steady state situation, where uptake equals elimination (van Raamsdonk et al., 2006).

There are two principal routes for the transfer of a contaminant through the target animal: Accumulation in organs of the animal, or elimination. In both cases the accumulation or elimination can apply to metabolized products of the original contaminant. In the case of cadmium the original contaminant (ion) remains the sole target throughout the chain. As the concentration in the organs approaches the equilibrium level (concentration at steady state, C_{SS}), the part of the total amount that accumulates becomes smaller and the part that is eliminated increases. The period in time that is needed to reach the steady state in a target organ depends on half-life time $T_{1/2}$.

The building up of a level in a tissue or organ differs from the way in which contamination levels are reached in matrices that are meant for elimination (urine, milk, egg). In an organ (especially liver and kidney) the amount of a chemical contaminant accumulates from day *t* to day *t*+1. The product involved in an elimination route is extracted from the system once or several times a day, and the "accumulation" starts all over for the next portion to be eliminated. There is only a mathematic relationship between the level in the portion(s) of day *t* and of day *t*+1, depending on the accumulation rate. The parameters weight *W* and the building up of C_{SS} have to be interpreted differently. In a steady state situation the total amount of the contaminant that is eliminated equals the total amount consumed (*D*). This amount that is eliminated in steady state situation is not a continuously present depot, but a total portion per day with a weight *W* newly build up every next day, containing the contaminant. From a mathematical point of view, the final level upon elimination can be described as a steady state concentration (C_{SS}).

For all routes (accumulation and elimination) the concentration at day *t* can be described as:

$$C_t = C_0 \cdot e^{-\lambda t} + C_{SS} \cdot (1 - e^{-\lambda t}) \qquad [3]$$

For which applies:

$$C_{SS} = BTF \cdot D \qquad [4]$$

with:

C_t:	concentration of contaminant (mg/kg) at day *t* ,
C_0:	concentration of contaminant (mg/kg) at day 0; start level of the simulated period of time,
C_{SS}:	steady state concentration (mg/kg),
λ:	elimination time constant (day^{-1}), tob e calculated from the half life time; $\lambda = \ln(2) / T_{1/2}$,
BTF:	biotransformation factor,
D:	daily total uptake (mg/dg); $D = CONS * F_{abs}$.

De *BTF* in (4) is defined as the constant to calculate the steady state concentration (mg/kg) from the uptake (mg/day), en has therefore the unit day/kg. The biotransformation factor *BTF* will be calculated differently in the process of accumulation in an organ or in an elimination route:

organ: $$BTF_o = \frac{CDR_o}{W_o \cdot \lambda} \qquad [5a]$$

elimination: $$BTF_e = \frac{CDR_e}{W_e} \qquad [5b]$$

with:

BTF_o of BTF_e :	biotransformation factor for an organ or at elimination (day/kg),
COR_o of COR_e :	Carry-Over Rate to the target organ or the matrix for elimination) (no dimension),
W_o of W_e :	weight of the organ (kg) or of the matrix for elimination (kg/day),
λ :	elimination time constant (day^{-1}); see previous definition.

2.5.8 Cd in kidney

In Table 6, parameters used to calculate the expected average level of cadmium contamination in kidneys of cattle are listed (Van Raamsdonk et al., 2006):

Table 6: Overview of parameters used to calculate Cadmium in kidneys

Parameters	value	unit
total consumption	18	kg
total intake (CONS)	12.51	mg/day
body weight	600	kg
kidney fresh weight	1.75	kg
biological availability	20	%
COR kidney	0.12	%
half life time	900	day
total uptake (D)	2.502	mg/day
simulated period	1825	days

3. Results

3.1 Cadmium in kidneys

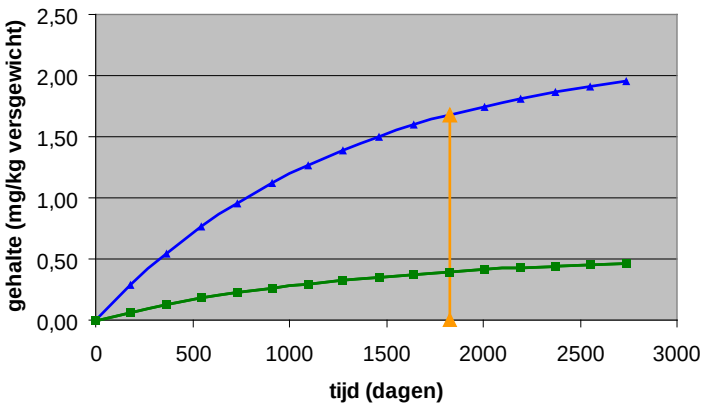

Figure 2:
Predicted increase in the cadmium level of kidneys based on assumptions listed in table 6.
Triangle line: building up curve of the contamination level.
Square Line: background exposure (3 mg/day)

After 5 years (1825 days) the cadmium level in the kidney has increased to 1.68 mg kg^{-1} fw. At steady state the cadmium levels reaches a level of 2.2 mg kg^{-1} fw.

From several studies the average level of the cadmium contamination in kidneys from cattle grown in the Kempen area is known (table 7). These data have been used to validate the models. The calculated results mentioned previously and shown in figure 2 are comparable to the data from these surveys. The legal limit is 1 mg/ kg kidney (fresh weight). Even the background level in the 2004 study for Belgium (1.54 mg/kg) exceeds this limit.

Table 7: Measured Cd levels in kidneys of cattle.

study	Kempen (mg/kg)	NL/BE (mg/kg)
1984 NL	2.04 ± 0.15	0.83 ± 0.10
2004 NL	1.52 ± 0.27	0.47 ± 0.05
2004 BE	2.90	1.54

The KAP database contains data for 194 kidney samples of cattle from zero to ten years in age for the total area of the Netherlands. The mean level of cadmium in these samples was 0.75 mg/kg. This is higher than the 2004 data in table 7, and comparable to the 1984 data. The average in the 1984 NL study might be biased, since these samples were collected in areas adjacent to the Kempen. The KAP data includes a relatively high share of samples with a level exceeding the legal limit (approx. 13 %). This might indicate that a part of these data have been collected after targeted sampling additional to at random sampling.

In the framework of the mentioned Dutch study (Römkens et al., 2007) 12 scenarios were calculated based on three different soil contamination levels (0.8, 1.5 and 2.5 mg/kg) and four different feeding strategies (feeding locally produced fodder all year [high content] vs. import in winter of low content hay and two scenarios for milk and meat cows respectively). Using a linear relationship between period of exposure (i.e. age) and the resulting kidney contamination level the 1984 dataset from the Kempen area can be explained for animals between 2 and 5 years. An exponential relationship covers the data from animals at higher ages as well (see figure 3).

Within the report of Römkens *et al.* 2007, the estimated Cd levels in cattle kidneys were plotted per GIS-cell of the Kempen area to obtain a risk map.

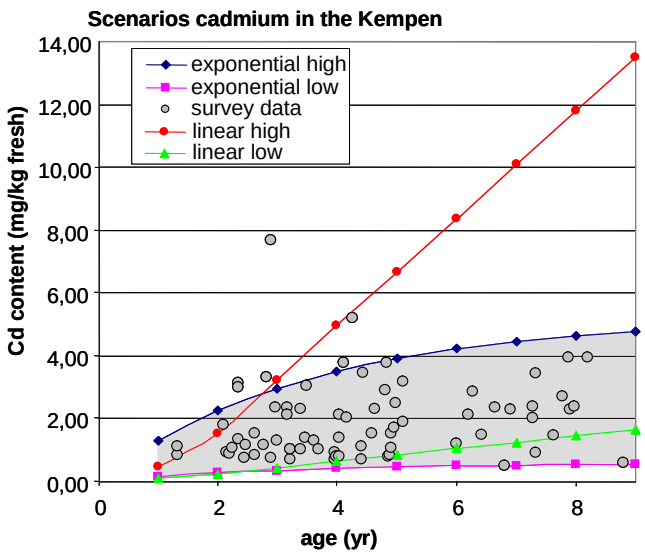

Figure 3:
Measured versus predicted levels of cadmium in kidneys in samples from the Kempen area. Both the linear accumulation model as well as the non-linear model were applied to the same data

3.2 Cadmium in muscle tissue

The carry over to muscle tissue of cattle is low (approx. 0,07 %). This is not substantially lower than that for kidney, but muscle tissue contributes at a much higher share to the body weight of cattle. Assuming 45 % of the body weight for muscle tissue, resulting in an organ weight of 270 kg, the expected level of cadmium calculated by the model is between 0.01 and 0.02 mg/kg (legal limit is 0.05 mg/kg fresh weight except for horse meat where it is 0.2; EU Commission Regulation 466/2001). It can be concluded that the main factor influencing the low contamination level is the dilution by the high amount of muscle mass.

The KAP database does not contain data on cadmium content of cattle muscle. Data on horse muscle tissue (0.08 mg/kg) and swine muscle tissue (0.003 mg/kg) indicate large differences between animal species, but generally low levels.

3.3. Cadmium in vegetables

In 2001 the EU introduced food quality standards for Cd levels in crops. These are implemented to protect human beings from an unacceptable exposure to cadmium as a result of intake of food. In non-polluted soils, the level of cadmium in crops is usually well below the food quality standard although sensitive crops including several types of vegetables, rice and wheat are known to accumulate cadmium. In case of soil pollution with cadmium (in either agricultural areas and/or private gardens), there is a real risk that the Cd concentration of crops will exceed these standards. In table 8 an overview of present food quality standards are listed based on fresh weight except for feed which is expressed as a product that contains 12% moisture.

Table 8: Cd food quality standards for food crops and animal fodder (EU 466/2001 and EG 32/2002)

Crop	Quality Standard (mg Cd/kg fresh weight)
Beans, cucumber, tomato, cabbage, peas, onion, asparagus	0.05
Carrots, celery, leek, potatoes, scorzonera	0.1
Celeriac, endive, lettuce, spinach	0.2
Feed	1.1

In the Kempen area, soil cadmium concentrations are relatively high (0.5 to 100 mg/kg, compared to other regions in the Netherlands (average is below 0.3 to 0.5 in non-affected areas). The main reason for the elevated cadmium (as well as lead and zinc) levels in soil is the presence of a zinc smelter near Budel Dorplein. The cadmium content in the soil depends on the distance from the factory and decreases in a north easterly direction due to prevailing winds. Close to the factory levels vary between 1 and 5 mg kg^{-1} whereas levels reach background levels (< 0.3 mg kg^{-1} in sandy soils) at a distance of approximately 30 to 40 km from the factory. Although the levels of cadmium in the soil are not extremely high and well below the level at which further investigation is required (Intervention value, ranging from 7 to 17 mg kg^{-1} in soil depending on the soil type) the soils are mostly acidic with pH levels below 5.5. At these pH levels, the availability of cadmium in soil is high which can lead to high uptake despite the rather low total cadmium content in the soil. In order to determine whether the elevated levels of cadmium in the soil indeed lead to unacceptable levels in food crops and animal fodder, a field-survey was conducted. In both arable soils and private gardens the cadmium content of soil and vegetables was determined, as well as soil characteristics (Römkens *et al.* 2004 and 2005). These data were used to develop predictive models for the cadmium concentrations in different vegetables. Interestingly, all vegetables exceeding the norm were grown on soil with pH lower than 5.5 and relatively low Cd levels (0.2-0.6 mg/kg). This confirms the hypothesis that at low pH the risk of cadmium in soil can be high despite a low total metal content. The level of cadmium in crops was predicted using a log-linear relationship considering the pH, clay content, organic matter content and the cadmium content of the soil according to:

$$\mathrm{Log}(crop) = \mathrm{INT} + \alpha \cdot \log(OM) + \beta \cdot \log(clay) + \gamma \cdot \log(pH) + \delta \cdot \log(soil), \qquad [6]$$

Where INT is the intercept of the model (constant), *crop* is the estimated level of Cd in the crop (in log mg Cd kg-1 fresh weight), *OM* is the percentage organic matter in the soil, *clay* is the percentage of clay particles in the soil, *pH* is the pH of the soil and *soil* is the Cd level in the soil (in log mg Cd kg^{-1} soil). An overview of all parameters used here is shown in Table 9.

Table 9: Coefficients for the predictive model for the estimation of cadmium levels in crops (Römkens et al. 2007)

Crop	n	INT	α	β	γ	δ	R^2	dm%
Grass	14	1.45	ns[1]	ns	1.22	-0.38	0.63	88
Maize	39	0.90	ns	-0.32	1.08	-0.21	0.50	88
Potato	60	0.97	-0.41	-0.20	0.81	-0.21	0.78	24
Endive	87	2.35	-0.44	-0.18	0.58	-0.28	0.66	6
Leek	15	2.52	-1.22	-1.00	1.40	-0.24	0.48	10
Lettuce	69	2.55	-0.39	-0.19	0.85	-0.33	0.71	5
Spinach	36	2.19	-0.40	ns	0.77	-0.29	0.49	6
Tomato	40	1.52	-0.75	ns	0.51	-0.21	0.41	5
Carrot	100	1.00	ns	ns	0.29	-0.20	0.43	11
Cucumber	45	-0.86	ns	ns	0.74	ns	0.57	3
French beans	47	0.44	ns	ns	1.08	-0.33	0.69	11
Scorzonera	52	2.25	ns	ns	0.49	-0.44	0.74	23
Celery	103	1.29	ns	ns	0.65	-0.20	0.54	10
Radish	39	1.03	-0.39	-0.20	0.67	-0.11	0.74	8

[1] Not significant

3.4 Human exposure to Cd

3.4.1 Scenario's

Risks of cadmium in soil are related to the degree to which it enters the food chain. Uptake by crops, fodder, animals and ultimately human beings depends on soil properties, plant properties and consumption patterns. To assess to what extend cadmium in soil poses a risk for human health an exposure model is developed that links soil cadmium to cadmium intake by consumers. A schematic overview of the model is given in fig. 1. Different consumption scenarios are evaluated (Table 10).

Table 10: Description of the different consumption scenarios evaluated in the exposure assessment.

Scenario	Description
A	Background exposure total Dutch population
B	Exposure of inhabitants of the Kempen area when all vegetables, cattle organs and cattle meat consumed originated from the Kempen area. All other food products consumed originate from outside the Kempen area.

Consumption scenario B is based on 6 different soil-scenarios, differing in cadmium levels and pH since these are the main factors determining cadmium levels in crops (Table 11).

Table 11: Description of the different soil scenarios evaluated in the exposure assessment.

Scenario	Cadmium level soil (mg kg^{-1})	pH	Description
1	0.5	4.5	Clean – low pH
2	0.5	5.5	Clean – high pH
3	1	4.5	Average – low pH
4	1	5.5	Average – high pH
5	2.5	4.5	Contaminated – low pH
6	2.5	5.5	Contaminated – low pH

Scenario A is calculated based on the KAP-database developed by RIKILT, where results of monitoring programs for chemical compounds in food are gathered in a national database. Scenario B is calculated on basis of cadmium concentrations in crops and animal products as predicted by the models described above (Tables 12 and 13). For model validation, the scenarios are additionally calculated based on available survey data available for food products from the Kempen area.

Human exposure is calculated with the Monte Carlo Risk Assessment (MCRA) program, developed by RIKILT and BIOMETRIS (Reference: http://mcra.rikilt.wur.nl/mcra/mcra.html). This is a stochastic model for dietary intake of chemical compounds. Long-tem (chronic) dietary exposure to cadmium was simulated with MCRA program version 6 (de Boer, 2007). This program simulates the daily consumptions by sampling 100,000 randomly drawn food consumption patterns from the food consumption database and combines these with random samples from the contamination database. The result is a full distribution of short-term intakes rather than a traditional deterministic point estimate of exposure. In a chronic exposure assessment, MCRA calculates the intake as the consumption on each day of each consumer multiplied by the average value of the compound cadmium concentration levels divided by body weight. Compound concentration data were presented as full data (as opposed to the use of mean, percentiles or maxima) and presented by a non-parametric (empirical) distributions. In order to account for heterogeneity of variance (e.g. some individuals are more variable than others with respect to their consumption patterns, the discrete/semi-parametric method (ISUF, Iowa State University Foods) was used to estimate the chronic dietary exposure to cadmium (Dodd, 1996; Nusser et al., 1996) with logarithmic transformation of intake data. The transformation to normality was improved by a spline fit to the transformed intakes. The exposure was modeled for the total population (1-97 years, average of 36 years, n=6250) and for children 1-6 years, average of 4 years, n=530).

For the total Dutch population (1-97 years) the transformed daily intake data showed no significant deviation from normality (Anderson-Darling test value 0.32, p=0.75) (Fig. 4). The day-to-day variability in cadmium intake was equal to the variability between individual consumers. The long term median dietary exposure to cadmium for the total Dutch population, as calculated by the MCRA program using the Nusser method, was 0.16 µg kg bw^{-1} year $^{-1}$. This mean that 50% of the total population had an intake equal or smaller than 0.16 µg kg bw^{-1} year $^{-1}$. The 90th, 95th, 99th, 99.90^{th} and the 99.99^{th} percentile were respectively 0.16, 0.27, 0.32, 0.43, 0.56 and 0.71 µg kg bw^{-1} year $^{-1}$ (fig. 2). The uncertainty bounds around the calculated percentiles were small and not overlapping (not shown). Assuming a Tolerable Daily Intake (TDI) level of 0.5 µg kg bw^{-1} year $^{-1}$ (Baars, 2001), this mean that the TDI is exceeded by less than 0.5% of the total Dutch population (approximately 0.25%). The food groups contributing most to the intake were wheat (45%), potatoes (28%), vegetables (20%). Meat products contributed approximately 4 % (of which beef 2%), fruits 2%, sea food 1% and kidneys/livers only 0.2%.

Also for children (1-6 years) the transformed daily intake data showed no significant deviation from normality (Anderson-Darling test value 0.14, p=0.99). In contrast to the total population, the within individual variability in cadmium intake was 2.33 times larger than the between individual variability. The long term median dietary exposure to cadmium for Dutch children of 1-6 years was 0.36 µg kg bw-1 year -1. The 90th, 95h, 99th, 99.90th and the 99.99th percentile were respectively 0.36, 0.50, 0.55, 0.67, 0.79 and 0.93 µg kg bw-1 year -1 (Fig. 4). The TDI (0.5 µg kg bw-1 year -1) is exceeded by approximately 10% of 1-6 years population). The food groups contributing most to the intake were wheat (47%), potatoes (27%) and vegetables (16%). Within the group of vegetables especially spinach (6.5%), carrot (3.6%) and endive (1.5%) and leek (1.2%) were most contributing. Meat products contributed approximately 2.5% (of which beef 1.6%) and fruits 2.9%.

Table 12: Calculated cadmium levels grass, liver and kidney of six year old cattle for the six defined soil scenarios.

Soil scenario	Cd in maize	Cd in grass	Total Cd intake cow (0-6 years)				Average content	Cadmium in organs	
			Maize	Grass	Compound feed	Soil		Kidney	Liver
	mg kg-1	mg kg^{-1}	g cow^{-1}	g cow^{-1}	g cow^{-1}	g cow^{-1}	mg kg^{-1}	mg kg^{-1} fw	mg kg^{-1} fw
1	0.26	0.21	0.31	4.1	0.5	0.4	0.22	0.66	0.12
2	0.16	0.09	0.19	1.7	0.5	0.4	0.12	0.37	0.07
3	0.56	0.48	0.66	9.5	0.5	0.7	0.47	1.42	0.26
4	0.34	0.20	0.41	4.0	0.5	0.7	0.25	0.75	0.14
5	1.50	1.47	1.77	29.2	0.5	1.9	1.35	4.03	0.75
6	0.92	0.61	1.11	12.2	0.5	1.9	0.69	2.05	0.38

Table 13: Calculated cadmium levels in vegetables for the six different soil scenarios, the maximum tolerated level for each vegetables as set by the European Union and the median of measured cadmium levels in vegetables produced in the Kempen area according the meta-analyses of Smolders et al. (Smolders 2007).

Soil scenario	Cadmium levels in vegetable (in mg kg-1 fresh weight)					
	Potato	Endive	Leek	Lettuce	Spinach	Tomato
Max. level	0.10	0.20	0.10	0.20	0.20	0.05
1	0.06	0.24*	0.09	0.17	0.17	0.05
2	0.04	0.13	0.05	0.08	0.09	0.03
3	0.11*	0.37*	0.24*	0.31*	0.29*	0.07*
4	0.07	0.19	0.14*	0.14	0.15	0.05
5	0.23*	0.62*	0.87*	0.67*	0.59*	0.12*
6	0.14*	0.33*	0.50*	0.31*	0.30*	0.07*
Median measured	0.03	0.06	0.06	0.10	0.14	0.01
	Carrots	Cucumber	French beans	Scorzonera	Celery	radish
Max. level	0.10	0.05	0.05	0.10	0.10	0.10
1	0.11	0.00	0.00	0.31*	0.16*	0.09
2	0.07	0.00	0.00	0.11*	0.10	0.07
3	0.14*	0.00	0.01	0.44*	0.25*	0.14*
4	0.09	0.00	0.00	0.16*	0.15*	0.11*
5	0.18*	0.01	0.03	0.69*	0.45*	0.26*
6	0.12*	0.01	0.01	0.25*	0.28*	0.21*
Median measured	0.08	0.02	0.01	0.18	0.27	

* = calculated value exceeds the maximum tolerated level.

3.4.2 Dietary exposure levels for different soil scenarios.

The dietary exposure to cadmium was calculated for 6 different soil scenarios (differing in soil cadmium levels and pH), using vegetable and organs/meat contamination levels as estimated by the predictive models on soil-plant-cattle transfer characteristics. With respect to the total Dutch population (1-97 years) the transformed daily intake data showed no significant deviation from normality for scenario 1, 2, 3, 4, 5 and 6 (Anderson-Darling test values respectively 0.42, 0.27, 0.24, 0.49, 0.21 and 0.55; p-values respectively 0.42, 0.75, 0.90, 0.25, 0.9 and 0.25). The within individual variation in cadmium intake was for all scenarios higher then the between individual variation (ratio's respectively 2.20, 1.58, 2.57, 1.96, 3.45 and 2.69). Percentiles of the population exposed to a specific level of cadmium are shown in figure 4. Only in the "worst-worst-case scenarios" cadmium exposure can be considered a problem.

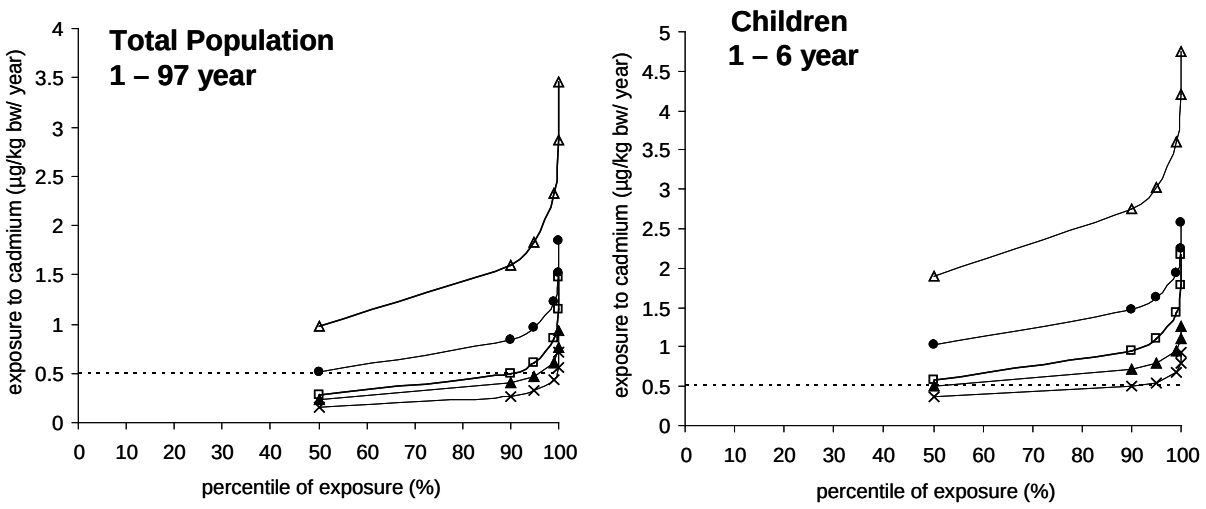

Figure 4: Percentiles of chronic exposure to cadmium in A) the total population (1-97 years, left figure) and B) young children (1-6 years, right figure) for the Dutch background exposure based on national monitoring data (×), exposure of Kempen inhabitants as calculated by soil scenario 2 (lowest exposure of all scenario's) (▲), exposure of Kempen inhabitants based on measured contamination data from Kempen food products (validation) (□),exposure of Kempen inhabitants according to the average calculated scenario values (●) and exposure of Kempen inhabitants as calculated by soil scenario 5 (highest exposure of all scenario's) (Δ).

4. Information system

As described above methods used to analyze transfer behavior of heavy metals from soil to forage crops are rather complex and difficult to communicate to a non-expert audience. Premising that there are different impacts arising from elevated levels of contaminants in soil on different target groups of public, affected farmers on the one hand and surveillance- or advisory-authorities on the other hand should be informed about the degree of risk. Furthermore recommendations how to react should be given. By means of a web-based information system guidelines for regional authorities to undertake risk oriented feed control should be developed. Moreover, this information system should provide support to farmers in finding solutions in regard to prevention and reduction of locally risks.

To achieve these aims technical solutions using a geographic information system (GIS) are required. On the basis of existing digital soil quality maps, reflecting cadmium and lead concentrations in top soils of the NRW project region, the spatial distribution of possible risks that forage crops could exceed maximum permissible values of heavy metal contents will also be mapped. In accordance with the model concept estimated plant-values were calculated by using spatial information on cadmium and lead concentrations as well as pH-values of soil. It is apparent that all of the different steps of calculation involve uncertainty. In general it seems possible to take uncertainty into consideration when finally assessing risks. In this project uncertainty of predictions could not be taken into account.

As a pilot project the evolved transfer functions for grassland were applied to accordant areas. In this process soiling was included with a degree of 3 %. The calculated map was clipped to only grassland areas and results were classified into three classes: 1) Predicted values are below limits of the EU feedstuff ordinance; 2) Predicted values are close to these limits; 3) Predicted values are beyond these limits. Interactive assistance in selecting adapted measures is a major component of the information system. Depending on individual situations concerning soil parameters a variety of recommendations could be established and put into practice (LANUV, 2006). The system supports interactive dialogues which enable farmers to enter e.g. individual measured pH-values that differ from those estimated by interpolation. Calculations of predicted plant concentrations as well as recommendations will be updated in those cases. With respect to matters of data protection the visualization of maps is limited to a scale not bigger than 1:50.000.

The system is based on Internet Map Server technology (ArcIMS) and the GIS-Portal Framework (AED-SICAD). It will be run by the North Rhine-Westphalian state agency for data processing and statistics (LDS NRW).

Screenshot 1: Web-Mapping-Application

Screenshot 2: Recommendation

5. Conclusions

The use of food-chains to emphasize the role of soil as a factor controlling the quality of food, fodder, animal products and human exposure

The results of this study clearly show that soil and soil quality affect the quality of agricultural products. Obviously soil quality in many areas is (still) of good quality and there is little reason for concern. Nevertheless, instruments such as the one described here allow for an analysis that reveals whether or not soil quality has an impact on the quality of products. If so, different options can be evaluated using the same knowledge as used to parameterize the different model blocks described in chapter 3. Options include both soil management (reduction of inputs, management of soil pH) or feeding options (import of clean fodder). Recommendations can include advice for farmers not to grow specific crops in areas with a higher cadmium content and/or low pH.

For both the Kempen are and the NRW are studied here, the amount of cadmium in soil does affect the quality of fodder and certain food products. It can be shown that under conditions where acid soils prevail, cadmium levels in grass and vegetables will exceed current maximum levels set by the EU. However, the levels observed or predicted do not lead (in the Kempen area) to an unacceptable exposure for human beings on a large scale. Only a very small percentage of the population is, under extreme assumptions, prone to an elevated cadmium intake from food products. The results presented here nevertheless have resulted in certain regional measures such as advice for local people with private gardens not to grow vegetable in soils with cadmium levels in soil exceeding 1 to 2 mg kg^{-1} depending on the pH.

The combination with a GIS based environment allows for a regional assessment of the risks of cadmium in soil, or, to approach it from the positive side, in a designation of ‘safe’ areas.

Soil-plant transfer

The attending partners of the “GeoQuality”-project agreed that contaminant transfer via food chain transport is one main factor to take into account when observing human health risks. Looking at the pathways of heavy metals from soil to plant the determination of soil concentration is of major importance. With regard to different contaminants additional characteristics like pH, organic matter, etc. have some influence on the degree of the pathway through plant roots. Different methods to quantify predictable contents in food and feeding plants already exist. Regionally modified approaches based on a single basic concept can be developed by varying specific parameters. This requires further harmonization of among others analytical procedures (what to measure in soil and crops) as well as monitoring protocols. The latter aspect is largely related to the need for combined soil – crop sampling events to reduce the noise in the existing soil to plant transfer functions.

Carry over model soil-crop-animals

Different model concepts exist to describe the transfer of metals from food, fodder and soil to animals. Based on limited data availability both concepts presented here are able to reasonably describe the measured levels of cadmium in kidneys. Transfer of cadmium to meat is likely not to have a large impact on the exposure or humans due to low levels of cadmium in meat. A lack of recent data on cadmium in organ meet (kidney and liver) however, causes a considerable uncertainty about the validity of the models applied.

Information system

Public acceptability of administrative recommendations concerning measures against arising risks has to be improved. There was agreement between the partners that it is feasible to communicate viewpoints in an active and offensive manner by means of web-based information systems. They believe that decision processes in handling existing impacts can be enhanced by promoting information use.

The benefits of technical solutions on basis of geographical information systems (GIS) are obvious. The current implementation in NRW seems to be developable by expansion of the area's extent, enclosing of different types of land use and different contaminants. Moreover, arrangements have to be made how to launch probability or uncertainty analysis in this context.

Knowledge transfer through web-based technology nevertheless should be in line with the user involved. This requires more 'ready-to-digest' information for farmers and advisory officers, like a list of measures and farming techniques versus more regionally oriented information including maps. The latter serves, for example, more policy oriented decision makes who need an overview of the area of interest to assess where measures have to be taken.

Finally, information for the general public is again different in nature. Neither cadmium maps nor farm management advice can be used to give insight in the risk of cadmium (assuming there is a risk!). Fine-tuning of information is essential if different target groups have to be addressed.

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Annex

Handlungsempfehlungen zur Minimierung der Schwermetallbelastung - Cadmium oder Blei - in oder auf Futtermitteln

Diese Handlungsempfehlungen zeigen den Tierhaltern, die Wiederkäuer halten, bei der Grünlandnutzung verschiedene Möglichkeiten auf, um **potenzielle Eintragsquellen** für Cadmium und Blei zu erkennen und durch geeignete **betriebliche Maßnahmen** einen Beitrag zur Minimierung des Eintrags über die Futtermittel in die Lebensmittelkette zu leisten.

Potenzielle Eintragsquellen → Besonders auf folgenden landwirtschaftlich genutzten Flächen können Futtermittel mit überhöhten Gehalten an Cadmium oder Blei vorkommen (Prognostizierte Cd- und Pb-Gehalte in Futtermitteln in Abhängigkeit vom Schwermetallgesamtgehalt und dem Boden-pH-Wert siehe Tab. 1):

- Flächen im Einflussbereich langjähriger Immissionen
- Überschwemmungsgebiete (insb. Senkenlagen, bei Einleitungen aus Erzbergbau, Industrie und Gewerbe, auch historische Einleitungen, geogene Besonderheiten)
- Polder und Böden aus Auensedimenten
- Rieselfelder
- Beaufschlagte Flächen (Klärschlämme, Gewässersedimente)
- Flächen mit Prüf- oder Maßnahmewertüberschreitungen nach Bodenbelastungskarten

Betriebliche Maßnahmen → Optimierung des pH-Wertes (Verringerung der Pflanzenverfügbarkeit)

- regelmäßige Erhaltungskalkung „Kalkversorgungsstufe C“
- Anhebung des pH-Wertes auch über den Optimalbereich bei sehr hohen Cadmiumgehalten

Betriebliche Maßnahmen → Verringerung der Verschmutzung

Bei Futtermitteln sind alle Möglichkeiten zur Reduzierung des Verschmutzungsanteils zu ergreifen.

- Lückige Bestände sind durch ausreichende Narbenpflege oder Abschleppen von Wühlmaus- oder Maulwurfbesatz zu vermeiden
- Schaffung dichter Grasnarben durch häufige Nutzung und Nach- oder Übersaat mit standortangepassten Arten und durch Anpassung der Düngung
- Befahren nur bei ausreichender Tragfähigkeit des Bodens sowie Anpassung der Bereifung
- Vermeidung von verschmutzungsintensiven Ernteverfahren, insbesondere durch zu tief eingestellte Mähgeräte (Schnitthöhe mind. 5 cm, besser 7 cm), Wender, Schwader und Pick-up-Einrichtung des Ladewagens oder zu häufiges Wenden, ggf. Futterentnahme mittels Heu-Reinigungsgerät oder Übergang zu Konservierungsverfahren mit weniger Erdanhang
- Unkrautbekämpfung
- Überfahren des Futters in Fachsilos nicht mit verschmutzten Schlepperreifen
- Keine Zwischenlagerung des Futters auf dem Feld oder auf verschmutzten Bodenplatten
- Keine Futtereinlagerung in Behelfsilos auf schadstoffbelasteten Böden.
- Auszäunen bei Weidenutzung oder Ausgrenzung bei Wiesennutzung der Senkenlagen in Überschwemmungsgebieten
- Keine mechanische Überlastung der Narbe, z.B. durch Befahren oder Viehtritt (insbesondere bei zu nassen Bodenverhältnissen), keine Beweidung bei Regen sowie ggf. Verzicht der Beweidung im zeitigen Frühjahr, Herbst oder im Winter
- Keine Beweidung durch Pferde oder Schafe auf belasteten Böden
- Gefahr zu tiefen Verbisses über Viehbesatz und Standzeiten (rechtzeitiger Weidewechsel) regulieren
- Wechsel des Weidesystems (Mähweide anstelle von Portions- oder Umtriebsweide)

Futtermittelrecht:

In Futtermitteln dürfen Schwermetallhöchstgehalte beim Inverkehrbringen und Verfüttern nicht überschritten werden (siehe Tab. 1, Rot). Ein Verschneiden mit weniger belasteten Futtermitteln ist bei Überschreitung der für pflanzliche Futtermittel festgesetzte Höchstgehalte (Cadmium 1,0 mg/kg 88% TM, Blei 30 mg/kg 88% TM) unzulässig, auch wenn dadurch in der Gesamtration – bezogen auf 1 kg Alleinfuttermittel - der Höchstgehalt unterschritten würde. Die rechtlichen Grundlagen sind im Lebensmittel- und Futtermittelgesetzbuch mit zugehöriger Rechtsverordnung geregelt.

Die Einhaltung der Höchstgehalte bei der Verfütterung ist von jedem Landwirt eigenverantwortlich sicherzustellen.

Tabelle 1: Prognose der Cadmium- oder Bleigehalte in oder auf Futtermitteln bei Grünlandnutzung (Weide- oder Wiesennutzung, z.B. Heu, Grassilage etc. mg/kg bei 88% Trockenmasse) unter Berücksichtigung eines üblichen Verschmutzungsanteils von 3 % in Abhängigkeit vom Cd- bzw. Pb-Gesamtgehalt und dem Boden-pH-Wert - bei mehr als 3 % Verschmutzungsanteil erhöhen sich die Cd- bzw. Pb-Gesamtgehalte deutlich

Cadmium (Cd)												
	pH-Wert	4,6	4,8	5	5,2	5,4	5,6	5,8	6	6,2	6,4	6,6
Cd-Boden [mg/kg]												
3,0		0,54	0,52	0,49	0,47	0,45	0,43	0,41	0,39	0,37	0,36	0,34
3,5		0,59	0,56	0,53	0,51	0,49	0,46	0,44	0,42	0,40	0,39	0,37
4,0		0,63	0,60	0,57	0,55	0,52	0,50	0,48	0,46	0,43	0,42	0,40
4,5		0,67	0,64	0,61	0,58	0,56	0,53	0,51	0,48	0,46	0,44	0,42
5,0		0,71	0,68	0,65	0,62	0,59	0,56	0,54	0,51	0,49	0,47	0,45
5,5		0,74	0,71	0,68	0,65	0,62	0,59	0,56	0,54	0,51	0,49	0,47
6,0		0,78	0,74	0,71	0,68	0,65	0,62	0,59	0,56	0,54	0,51	0,49
6,5		0,81	0,78	0,74	0,71	0,68	0,65	0,62	0,59	0,56	0,54	0,51
7,0		0,85	0,81	0,77	0,74	0,70	0,67	0,64	0,61	0,59	0,56	0,53
7,5		0,88	0,84	0,80	0,76	0,73	0,70	0,67	0,64	0,61	0,58	0,55
8,0		0,91	0,87	0,83	0,79	0,76	0,72	0,69	0,66	0,63	0,60	0,57
8,5		0,94	0,90	0,86	0,82	0,78	0,74	0,71	0,68	0,65	0,62	0,59
9,0		0,97	0,92	0,88	0,84	0,80	0,77	0,73	0,70	0,67	0,64	0,61
9,5		0,99	0,95	0,91	0,87	0,83	0,79	0,75	0,72	0,69	0,66	0,63
10,0		1,02	0,98	0,93	0,89	0,85	0,81	0,78	0,74	0,71	0,68	0,64
10,5		1,05	1,00	0,96	0,91	0,87	0,83	0,80	0,76	0,73	0,69	0,66
11,0		1,08	1,03	0,98	0,94	0,89	0,85	0,82	0,78	0,74	0,71	0,68
11,5		1,10	1,05	1,00	0,96	0,92	0,87	0,84	0,80	0,76	0,73	0,69
12,0		1,13	1,08	1,03	0,98	0,94	0,89	0,85	0,82	0,78	0,74	0,71

Blei (Pb)	
Pb-Boden [mg/kg]	
20	1,10
40	2,02
60	2,87
80	3,69
100	4,48
200	8,20
300	11,68
400	15,01
500	18,24
600	21,38
700	24,46
800	27,48
900	30,45
1000	33,38
1100	36,27
1200	39,13
1300	41,96
1400	44,76
1500	47,54

Grün:

- Es sind keine Überschreitungen der Höchstgehalte für Cadmium oder Blei zu erwarten.

Gelb:

- Der für Kälber, Lämmer oder Ziegenlämmer festgesetzte Höchstgehalt an Cadmium bzw. der für alle Tierarten festgesetzte Höchstgehalt an Blei wird nach der Prognose überschritten, wenn der Pflanzenaufwuchs die alleinige Futterquelle ist.
- Es besteht die Möglichkeit, durch die Zufütterung mit geringer belasteten Futtermitteln eine Verdünnung auf ein erlaubtes Maß zu erreichen (§ 26 Absatz 2 FMV).
- Besonders empfohlen wird eine Probenahme und die Analyse des Cadmium- oder Bleigehaltes des Weideaufwuchses bzw. der auf diesen Flächen erzeugten und getrennt zu lagernden Einzelfuttermittel, um zu ermitteln, wie hoch der Anteil an der Tagesration sein darf.

- Wenn insbesondere bei Weidehaltung eine entsprechende Zufütterung nicht durchgeführt werden kann, dürfen die von diesen Flächen erzeugten Einzelfuttermittel nicht verfüttert bzw. die Weiden nicht genutzt werden.

Rot:

- Der für Cadmium bzw. Blei festgesetzte Höchstgehalt für pflanzliche Einzelfuttermittel wird nach der Prognose überschritten.
- Einzelfuttermittel pflanzlichen Ursprungs, bei denen die Höchstgehalte an Cadmium oder Blei überschritten werden, dürfen nicht verfüttert und nicht zu Verdünnungszwecken mit dem gleichen oder anderen Futtermitteln gemischt werden (§ 23 Absatz 2 FMV).
- Vor einer Verfütterung ist der prognostizierte Cadmium- bzw. Bleigehalt des Weideaufwuchses bzw. der auf diesen Flächen erzeugten und getrennt zu lagernden Einzelfuttermittel durch Probenahme und Analyse des Cadmium- bzw. Bleigehaltes zu überprüfen.
- Sollte die Überschreitung der Höchstgehalte bestätigt werden, dürfen die erzeugten Einzelfuttermittel nicht verfüttert werden, bzw. ist eine Beweidung dieser Flächen auszuschließen.

Sollten die Cadmium- bzw. Bleigehalte oder der pH-Wert des Bodens der Grünlandflächen nicht bekannt sein, wird empfohlen, diese durch entsprechende Untersuchungen zu ermitteln. Informationen sind in dem Merkblatt „Handlungsempfehlungen zu Maßnahmen der Gefahrenabwehr bei schädlichen stofflichen Bodenveränderungen in der Landwirtschaft" (Hinweise zur Durchführung zur Beprobung von Böden (Nr. 8.3) oder Pflanzen (Nr. 8.5) sowie zu möglichen Maßnahmen (Nr. 8.6)) zusammengestellt. (http://www.lanuv.nrw.de/veroeffentlichungen/merkbl/merk55/merk55start.htm)

Geoquality - Part II
Impact of the use of Copper based pesticides on the quality of olives

Rossi, N. [1], Bassi, S.[1], Biondi, L.[1], Sassi, L.[1], Pini, S.[1], Tinivella, F.[2], Minuto, G.[2]

[1] LaboCAAR, Regione Pallodola 19038 Sarzana (SP), Italy

[2] Centro Regionale di Sperimentazione e Assistenza Agricola, Regione Rollo 98, Albenga (SV), Italy

1. Introduction

Copper-based pesticides are of major interest in olive tree cultivation. They are used for the control of fungal pathogens such as *Spilocea oleagina, Mycocentrospora cladosporioides, Glomerella cingulata* and they can also have some effects in the control of the olive fruit fly (*Dacus oleae*). At low concentrations copper is an essential element for plants and animals, while at high concentrations it causes in plants symptoms which are similar to iron chlorosis with the subsequent formation of short, big roots and modified cation exchange capacity while in animals it can cause disturbes of the nervous system, as well as in leaver and kidneys.

The use of copper at high dosage rose awareness about the level of danger and toxicity related to this element in an agricultural context and it is under investigation to what extent its buildup can have an influence on the biological activity in the soil.

1.1 Objectives

- Monitoring of soils for Cu content, pH, clay content and organic matter;
- Set up of an experimental protocol for Cu content assessment in olive oils;
- Georeferring of monitored soils and oils and evaluation of the informations about copper based disease control treatments;
- Map creation about Cu concentration in soils and oils;
- Analysis of collected informations and comparison between Cu content assessed in soils and oils.

2. Materials and methods

2.1 Analysis of soil samples

2.1.1 Law references and principles

Cu content in soils was assessed according to the official national procedure (D.M. 13/09/1999 method XI.1 “Assesment of Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn content through aqua regia extraction” published on the Official Gazzette n° 185 - 21/10/1999). The operative principle foresees the heavy metal extraction in aqua regia after a pretreatment with concentrated hydrogen peroxide.

2.1.2 Analytical procedure

1 g of thin soil (dried and passed through a 2mm sieve) is weighed, 3 ml of concentrated (30% m/m 110 vol) hydrogen peroxide are added and everyhting is let stand for 30 minutes; afterwards 9 ml of HCl (37%) and 3 ml of HNO_3 (65%) are added. Sample is digested in a microwave oven at controlled temperature and pression, after that it is cooled down; volume is brought to 100 ml with H_2O bidest. The extract is filtered and Cu content assessed using an atomic absorption spectrophotometer (Thermo Electron Corporation - M SERIES, 324,8 nm wave length).

2.1.3 Sampling

Samples were collected in all 4 provinces of Liguria Region. Samples coming from olive farms which were already monitored for other purposes were preferred. For these farms data regarding exposition, main variety grown, disease control strategy (distribution, compounds and timing) and harvesting methods were known. Other informations were collected using the data sheet described in Annex 1.

Totally 87 soil samples were collected in 73 farms: 28 samples in Imperia province, 9 samples in Savona province, 22 samples in Genova province and 28 samples in La Spezia province. They were analyzed for Cu content, pH, % of organic matter and clay. Olive farms were georeferred according to 3 different procedures:

- Using the SIMA database belonging to the regional geographic service;
- Analysis of aerial pictures according to the Gauss-Boaga system;
- Direct georeferring through GIS device by sampler technicians.

2.2 Analysis of oil samples

2.2.1 References and principles

Since no official procedures are foreseen for heavy metal assessment in olive oil, a literature research was carried out in order to evaluate the most suitable one. Method IUPAC n° 2.631 – ISO 8294 "Determination of copper, iron and nickel by direct graphite fornace atomic absorption spectrometry" was chosen. It is based on the direct analysis of olive oil using a fornace atomic absorption spectrophotometer (Thermo Electron Corporation - M SERIES).

2.2.2 Analytical procedure

According to the IUPAC method cited above, oil extracted from sunflower was purified and used as a control and to prepare standard Cu solutions for the determination of calibration curve. Besides indications for the set up of the analytical procedure were deduced from Thermo Electron Corporation guidelines. The subsequent protocol was defined:

- Preparation of purified sunflower oil;
- Preparation of the standard Cu solution in purified sunflower oil (2,5 ppm);
- Preparation of the "master standard" Cu solution (50 ppb) in purified n-eptane/oil from which the device obtains, through an automatic dilution, 5, 10 and 25 ppb Cu solutions for the determination of the calibration curve;
- Determination of the calibration curve through the assessment of the control samples;
- Assessment of Cu content in the oil samples previously diluted 5 times in n-eptane.

2.2.3 Sampling

If possible, oils coming from the same farms where soil samples were collected were analyzed. Totally 51 oil samples were collected: 19 from Imperia province, 12 from Savona province, 7 from Genova province, 13 from La Spezia province.

3. Results and discussion

3.1 Soil samples

Values about Cu content, pH, organic matter content (%) and clay (%) of the analyzed soils are presented in Table 1. Geographical distribution of soil samples and relevant risk classes are described in Figure 1. The highest value is 440.2 ppm, the lowest is 14.9 ppm, on the average 104.4 ppm. Cu concentration

in the earth crust is variable, but the main contamination source is represented by Cu salt based pesticide like oxychloride, sulfate and hydroxide. In the soil Cu is not subjected to any chemical, photolytic or metabolic degradation, it reacts with clays and organic matter originating insoluble compounds which build up in the soil and which are removed by rains. In Italy Cu concentration in the soils varies between 2 and 375 ppm. Relevant to croplands law references about Cu content threshold do not exist, but a concentration range which can be defined as "normal" was defined between 10 and 120 ppm according to an extensive survey carried out in at least 10 Italian regions (Barbafieri et al. 1996). Cu values varying in this range do not cause phytotoxicity neither specific environmental concerns. Cu toxicity is related to soil pH: with pH values around 6 troubles can occur when Cu concentration is around 100 ppm, while in soil with pH values around 8 no problems are encountered since Cu is unsolubilized as hydroxid or carbonate.

Table 1: Characteristics of soil samples collected in the different provinces

Province	coordinate N	coordinate E	Cu content (ppm)	pH	organic matter %	clay %
SP	4885490	1540231	182,7	5,8	3,2	10,9
SV			37,4			
SV	4879410	1423453	54,6	8,1	4,5	
GE	4912725	1509891	52,1	8,1	4,4	
GE	4921400	1481860	148,7	6,9	5,1	
GE	4908830	1526842	190,1	7,6	4,0	
SV	4872834	1420262	22,7	7,1	4,2	8,2
GE			67,7	4,5	10,7	
GE			165,3	5,5	5,4	8,4
GE			198,8	6,4	9,7	3,3
SV	4878566	1433316	163,4	7,6	6,1	4,1
SV	4876023	1427503	50,4	8,1	2,5	
SV			65,4	7,7	9,3	
IM	4881060	1418020	70,2	6,8	4,0	14,2
SP	4889786	1574357	71,1	8,1	4,9	
SP	4886899	1577514	116,5	8,5	1,5	22,3
SP	4886899	1582968	90,4	7,3	1,8	15,4
SP	4882364	1544403	83,5	5,9	1,7	
SP	4882551	1584037	54,5	7,1	9,4	
SP	4882377	1584024	88,6	6,1	14,1	
IM	4855676	1392381	36,0	8,4	2,1	17,7
GE	4915670	1524547	84,3	5,5	8,8	6,5
SP	4892527	1572160	81,6	7,2	10,8	
SP	4886213	1571988	215,3	6,9	1,3	5,4
SP	4886550	1572267	161,3	7,9	2,3	20,0
SP	4893187	1572081	92,5	6,3	1,1	21,8
SP	4890354	1573442	89,4	6,4	2,3	
SP	4886627	1578606	90,5	7,7	5,8	
SP	4886508	1578543	133,4	8,3	3,7	17,7
SP	4883808	1420262	93,1	8,4	3,2	
SP	4889703	1575457	93,1	6,7	4,5	9,7
SP	4890365	1573671	46,5	7,2	3,7	25,2
SP	4889639	1575497	195,3	6,3	3,5	15,4
SP	4889666	1575457	174,1	6,6	3,5	12,7
SP	4887587	1570222	243,1	6,4	3,6	16,5
SP	4888943	1552533	95,8	6,8	5,3	16,5
GE	4908650	1523010	92,2	7,9	10,1	19,2

Province	coordinate N	coordinate E	Cu content (ppm)	pH	organic matter %	clay %
GE	4912100	1518450	91,7	7,3	5,0	19,6
GE	4909300	1527250	104,9	6,8	6,4	12,7
GE	4909900	1525900	135,9	6,9	6,7	11,4
GE	4912190	1523030	71,2	8,2	7,2	16,3
GE	4912190	1523030	130,9	6,3	0,9	23,7
GE	4905070	1530825	328,3	5,8	13,8	8,5
IM	4868320	1419700	54,8	7,7	5,5	31,0
IM	4868704	1417590	63,1	8,0	4,4	20,7
SP	4890775	1566706	43,5	6,6	1,6	21,1
SP	4887361	1570606	321,3	6,3	1,5	18,0
SP	4893640	1548906	200,7	7,0	7,1	7,1
SP	4885667	1572396	58,9	6,6	1,8	13,7
SP	4887407	1570051	353,4	7,0	3,6	8,8
SP	4881692	1572582	20,3	7,7	0,8	16,7
SP	4889620	1573508	125,2	7,1	2,7	15,6
GE	4912757	1509346	75,2	8,1	7,9	22,0
GE	4911969	1523352	70,2	7,9	11,8	19,1
GE	4909409	1527239	85,0	8,0	7,0	13,0
GE	4912100	1518450	67,7	8,0	3,9	25,4
GE	4908733	1523003	89,3	7,5	15,3	17,2
GE	4908400	1526830	167,6	7,6	5,3	9,3
GE	4911969	1523352	143,6	5,4	6,6	6,2
GE	4911969	1523352	46,3	6,3	0,7	29,1
IM	4881060	1418020	91,8	7,5	5,5	11,3
IM	4868408	1404300	237,2	7,9	7,7	14,1
IM	4862495	1424844	44,6	8,2	3,6	35,3
IM	4865164	1423423	54,0	8,1	4,9	28,5
IM	4864259	1424642	38,3	8,2	3,9	20,5
IM	4864709	1424735	46,9	7,9	5,6	23,0
IM	4863362	1414707	73,9	7,0	7,8	21,2
IM	4864504	1414453	80,2	7,9	8,3	24,2
IM	4879380	1420950	80,2	8,1	3,3	15,0
IM	4868620	1422366	150,7	8,0	3,6	30,0
IM	4859123	1416136	58,1	8,0	3,7	25,1
IM	4870065	1416148	69,8	6,9	6,2	22,5
IM	4868755	1417618	61,9	8,1	5,3	24,7
IM	4860602	1423931	440,2	8,2	5,0	26,8
IM	4853746	1385967	24,8	7,9	2,1	17,6
IM	4858087	1415685	52,4	8,0	4,5	17,5
IM	4857532	1391844	49,5	7,9	4,2	16,0
IM	4863555	1426261	59,0	8,1	4,1	18,5
IM	4858825	1383258	118,4	8,3	3,4	11,0
IM	4860527	1418241	17,9	8,0	8,4	12,4
IM	4878522	1417531	75,5	7,6	6,0	15,0
SV			19,85	6,7	3,8	20,4
SV			14,9	7,3	3,7	19,1
SV			89,65	7,9	11,7	9,6
SV			56,64	5,1	8,7	9,4
SV			95,79	5,5	8,1	8,1

Province	coordinate N	coordinate E	Cu content (ppm)	pH	organic matter %	clay %
SV			39,99	5,5	8,9	8,8
		Maximum	440,2	8,5	15,3	35,3
		Minimum	14,9	4,5	0,7	3,3
		Average	104,4	7,2	5,4	16,7
		total number	87			

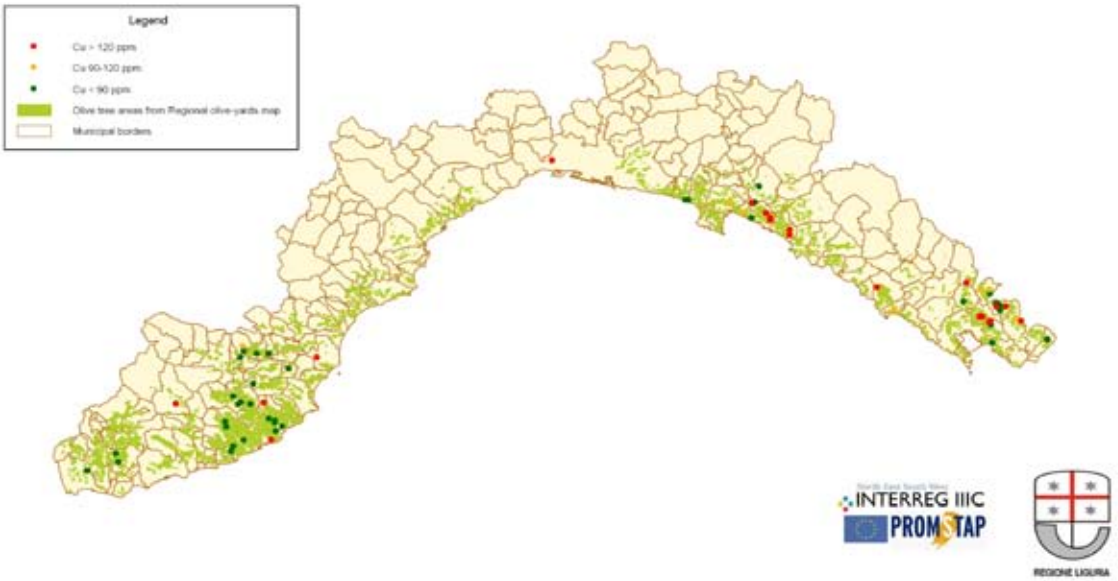

Figure 1: Grographic localization and Cu content in the analyzed soils

Therefore soils at higher risk are those, not so widespread in Italy, with a low pH where metal mobility increases, cation exchange capacity decreases and microbial population is modified. A low content in organic matter as well as in clay may be also related to a higher risk of toxicity by Cu in soil. Cu content assessed in soils coming from olive orchards can be considered safe: 24 samples (29%) are over the safe threshold, but, among them, just in 4 cases pH values are between 5 and 6 and almost all soil samples have a good content in organic matter with low percentage of clay.

Characteristics of soil samples with a Cu content higher than 120 ppm in correlation with pH values, organic matter content (%) and clay content (%) are presented in Table 2.

Table 2: Characteristics of soil samples exceeding 120 ppm of Cu content

Province	Treatments	Treatment period	Cu content (ppm)	pH	organic matter %	clay %
SP	Cu oxychloride	September	182,7	5,8	3,2	10,9
GE	Cu oxychloride	August	148,7	6,9	5,1	
GE	none		190,1	7,6	4,0	
GE			165,3	5,5	5,4	8,4
GE			198,8	6,4	9,7	3,3
SV	Cu oxychloride	May and September	163,4	7,6	6,1	4,1
SP	Cu oxychloride	September	215,3	6,9	1,3	5,4
SP	Cu oxychloride	End of August and end of September	161,3	7,9	2,3	20,0
SP	Cu oxychloride	September and October	133,4	8,3	3,7	17,7
SP			195,3	6,3	3,5	15,4
SP			174,1	6,6	3,5	12,7

Province	Treatments	Treatment period	Cu content (ppm)	pH	organic matter %	clay %
SP	Cu oxychloride	April and September	243,1	6,4	3,6	16,5
GE		October	135,9	6,9	6,7	11,4
GE		September and October	130,9	6,3	0,9	23,7
GE		August and September	328,3	5,8	13,8	8,5
SP	Nitrate + Cu oxychloride	March and September	321,3	6,3	1,5	18,0
SP			200,7	7,0	7,1	7,1
SP	Cu oxychloride	April	353,4	7,0	3,6	8,8
SP			125,2	7,1	2,7	15,6
GE			167,6	7,6	5,3	9,3
GE		August and September	143,6	5,4	6,6	6,2
IM	Cu hydroxide	August, September, November	237,2	7,9	7,7	14,1
IM	Cu oxychloride	September and October	150,7	8,0	3,6	30,0
IM	Cu oxychloride	September and October	440,2	8,2	5,0	26,8

3.2 Oil samples

Data regarding Cu content in oil samples are presented in Table 3. Geographical distribution of oil samples and relevant risk classes are described in Figure 2. The highest value is 582 ppb, the lowest 7.08 ppb, the average 56.23 ppb.

Law reference in force (Reg. CE n. 1881/2006) indicates thresholds just for some metals: Pb, Cd, Hg and Sn and it sets the highest oils and fat matter content at 0,1 ppm of Pb (100 ppb). The maximum threshold for Cu content in oils has not been established yet. Since Pb is much more toxic than Cu, a threshold of 100 ppb can be used as a reference for a critical level of contamination of oils. Among 51 samples only 4 (7,8 %, all in Imperia province) result to be above the threshold while all the other show an average Cu content of 32.49 ppb.

The presence of metals in olive oil depends on different factors such as the olive processing phases or the use of unsuitable vessels during storage. 2 samples out of the 4 with the highest Cu content come from the same olive farm where high Cu content in soil (237.2 ppm), pH 7.9, a high organic matter content (7.7%) and a low clay content (14.1%) were assessed. Several treatments were also carried out with Cu based fungicides. Because of these factors a Cu carry over from the soil to the plant and from the olive to the oil can be assumed. Relevant to the other 2 samples, high Cu concentrations were not determined in the soil so Cu contamination source could be represented by contaminated vessels in which the oil was put.

Table 3: Characteristics of oil samples collected in the different municipalities

Municipality	Province	coordinate N	coordinate E	Cu content (ppb)
CHIUSANICO	IM	4868320	1419700	19,41
GENOVA PRA	GE	4921400	1481860	13,81
RAPALLO	GE	4912100	1518450	14,5
LAVAGNA	GE	4905070	1530825	97,6
SAN COLOMBANO CERTENOLI	GE	4912190	1523030	7,08
SARZANA	SP	4886508	1578543	36,09
LUCINASCO	IM	4868755	1417618	43,62
DIANO ARENTINO	IM	4868620	1422366	40,96
DIANO CASTELLO	IM	4864259	1424642	127,79
SAN LORENZO AL MARE	IM	4859123	1416136	12,69

Municipality	Province	coordinate N	coordinate E	Cu content (ppb)
MOLINI DI TRIORA	IM	4868408	1404300	184,1
RANZO	IM	4879380	1420950	63,87
BORGHETTO D'ARROSCIA	IM	4878522	1417531	18,6
CHIAVARI	GE	4908650	1523010	23,47
CHIAVARI	GE	4909900	1525900	12,69
BOLANO	SP	4892527	1572160	25,05
ORTONOVO	SP	4886899	1582968	31,39
ORTONOVO	SP	4882551	1584037	33,36
SARZANA	SP	4890354	1573442	25,25
LA SPEZIA	SP	4887587	1570222	14,40
IMPERIA	IM	4860527	1418241	452,5
VENTIMIGLIA	IM	4853746	1385967	70,47
VEZZANO LIGURE	SP	4887407	1570051	87,38
LERICI	SP	4881692	1572582	17,21
SARZANA	SP	4892481	1571725	17,94
SARZANA	SP	4878220	1547327	74,9
SARZANA	SP	4886508	1578543	32,58
SANTO STEFANO MAGRA	SP	4889703	1575457	51,79
VENTIMIGLIA	IM			10,02
MOLINI DI TRIORA	IM	4868408	1404300	582
BORGOMARO CANDEASCO	IM	4870065	1416148	30,56
SANTO STEFANO MAGRA	SP	4889620	1573508	13,72
DIANO CASTELLO	IM	4865164	1423423	81,69
PERINALDO	IM	4857532	1391844	50,55
CERVO	IM	4864709	1424735	22,68
GARLENDA	SV	4876349	1427550	16,93
TOVO SAN GIACOMO	SV	4892050	1442650	7,63
VEZZI PORTIO	SV	4896080	1449170	13,1
FINALE LIGURE	SV	4893300	1444974	16,48
FINALE LIGURE	SV	4893210	1451890	66,66
ALBENGA	SV	4892600	1436350	25,4
FINALE LIGURE	SV			16,22
ANDORA	SV	4869900	1430749	49,13
SPOTORNO	SV	4898370	1454040	24,98
CASANOVA LERRONE	SV	4876890	1425040	46,68
PIETRA LIGURE	SV	4888625	1441074	11,49
ARNASCO	SV			29,78
PRELA'	IM	4863362	1414707	33,00
PRELA'	IM	4864504	1414453	30,74
CHIAVARI	GE	4908400	1526830	26,53
BORGHETTO D'ARROSCIA	IM	4881060	1418020	16,78
	Minimum			7,08
	Maximum			582,00
	Average			57,08
	Total number of samples			51

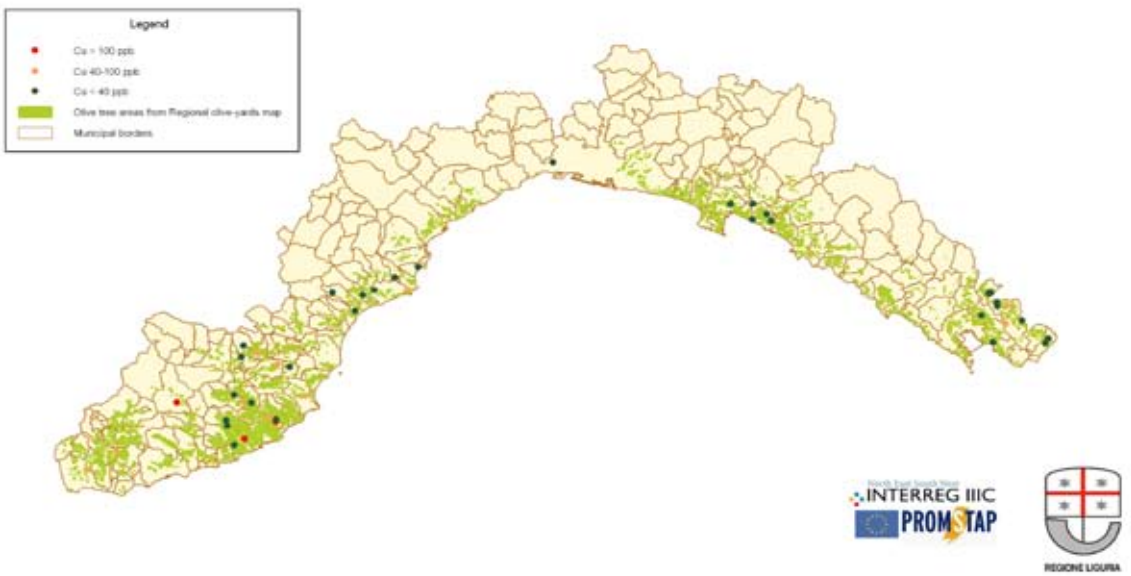

Figure 2: Geographic localization and Cu content in the analyzed oils

4. Conclusions

1. analyzed soil samples show an average Cu content of 104.4 ppm and 29.6% of samples varies in between a safe range. Most of soil samples with high Cu content have relatively high pH values and a good content of organic matter, so that the situation can be considered safe from an environmental point of view;
2. areas with a higher Cu concentration are found in La Spezia and Genova provinces;
3. a relationship between high Cu content in the soil and a higher number of Cu based pesticide applications is not observed;
4. on the whole oil samples result not to be contaminated by Cu;
5. only in 4 cases (7,8%) Cu concentrations result to be higher than 100 ppb;
6. just in one case a relationship between Cu content in the soil and in the oil obtained from olive trees grown in the same farm is observed.

It is possible to conclude that no particular concerns, due to toxicity deriving from Cu build up in the soil, has to be risen about olive growing areas in Liguria Region and about oil safety. In the soils where a higher Cu content was assessed it could be useful to repeat sampling in different moments during the year and to carry out a leaf exam to evaluate the effective Cu carry over and its assimilation at root level. Relevant to oil samples it is possible to conclude that the situation is absolutely under control; very low values were registered (which vary in the average range assessed for italian oils) and just in one case a relationship between Cu accumulation in the soil and in the oil was observed.

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Regione Lombardia : "Analisi del contenuto in rame e altri metalli nei suoli agricoli lombardi" – Quaderni della ricerca n° 61-febbraio 2007.

Annex

Data sheet used in the different olive farms

Name				
Site				
Surface				
Main variety				
Age				
Tree installation scheme				
Growing shape				
Soil type				
Tillage				
Fungicides applied	Date			
	Active ingredient (dose)			
Fertilization	Date			
	Compound			
	Mode			
Harvesting technique				
Olive pressing technique				
Yield				
Geographic coordinates				

Innovative Concepts and Technologies for Supply Chain Quality Management of Fruit and Vegetable and Improvement of monitoring systems

Noga, G.[1], Schulpin, C.[1], van Kooten, O.[2], Schouten, R.[2], Bertschinger, L.[3], Crespo, P.[3]

[1] Bonn University, Institute for Crop Science and Resource Conservation, -Horticultural Science-, Auf dem Hügel 6, 53121 Bonn, Germany, E-mail: NogaG@uni-bonn.de

[2] Wageningen University, Horticultural Production Chains, Marijkeweg 22, 6709 PG, Wageningen, The Netherlands

[3] Agroscope Changins-Wädenswil Research Station ACW, P.O. Box 185, CH – 8820, Wädenswil, Switzerland

Keywords: modelling, product quality, firmness, colour, apples, tomatoes, carrots, *Chalara sp.*

1. Introduction

At the end of the 20th century significant changes have been introduced in food supply systems, which contributed to a better fulfilment of consumers´ demands (Early 2005), as confirmed by enhanced consumer willingness to buy the produce. With reference to perishable food, it defines the acceptance period of the quality of fresh fruits and vegetables (Tijskens 1997 and 2000). In order to determine the acceptance period of a product, appropriate quality attributes for product quality characterization, suitable quality measurement technologies and models for predicting product quality at each point within the supply chain have to be elaborated and combined (Schouten and van Kooten 1998).

Quality management systems in supply and demand chains of fruit and vegetables are currently being developed in several large scale projects in the EU (Snoekx et al. 2005). These projects describe the relative quality decay in relation to environmental constraints during transport in the chain. However, consumers are not interested in relative quality but absolute quality at the moment of purchase.

Therefore the challenge is to determine the actual quality of the product at any time within the chain. This can be achieved if the initial quality of the product at the point of harvest is known and if this information can be used in combination with the environmental parameters within the chain. In order to get an estimate on the initial quality we have to understand how the process of production leads up to a final quality in the growth phase, i.e. an initial quality in the post-harvest phase (Hertog et al. 2004), which can be maintained at a constant level in the ideal case, but more or less will deteriorate in practice. Combining this initial quality with the information obtained from tracking the product in the chain is rather straight-forward.

On the fresh produce sector European supply chains will have to compete more and more with overseas-oriented ones regarding produce like apples, onions, melons and even carrots. In order to assure market share and competitive ability of regional products they must show an advantage in maturity, freshness and shelf life potential, recognizable for the consumer. In order to deliver transparency not only on the safety level but also on the quality level, this effort will make each participant of such supply chains an important member contributing to a consumer-oriented high quality produce.

One item that has been out of focus too much, however, is the need to understand how different regions and different seasons do affect quality and quality behaviour. Differences evoked or caused by different cultivars, growing sites, soil types, climate and weather etc. have to be merged and combined into one description. For that type of understanding and integration a different approach is necessary that incorporates the relevant behaviour of the product, both in the preharvest (food production) as in the postharvest realm (distribution and processing). Traditionally approaches in modelling (mainly statistical and/or empirical models) are unsuitable to accommodate this integration of knowledge (Tijskens et al. 2006). The ultimate goal of modelling is to predict future behaviour of any product, in any circumstance, from any region and grown in any season.

Up to now the quality systems in use in the regions of application do not allow to predict how quality will evolve along the chain towards the consumer. The reason is that the physiological and the phytosanitary status of the product at harvest (initial quality) cannot be measured accurately, so far. A decay of quality up to the point of sale is very often the consequence.

The aim of this project therefore was to overcome this problem by introducing appropriate measurement techniques before/at harvest and fusing the measured data in such a way that a more accurate prediction of product quality can be made. Moreover, a combination of diagnostic and prospective tools that can be applied to estimate the absolute quality including the phytosanitary status of fruits and vegetables was to be exploited. As basis, an already existing model for predicting quality decline during marketing of fruits and vegetables had to be validated first. This model is based on the biological variance of quality and phytosanitary attributes of the product at harvest (Schouten et al. 1997). The variance will be determined, and the obtained results serve as a basis for the prediction of the forthcoming quality status in the running supply chain, e.g. from the farm to the consumer (Tijskens et al. 2005).

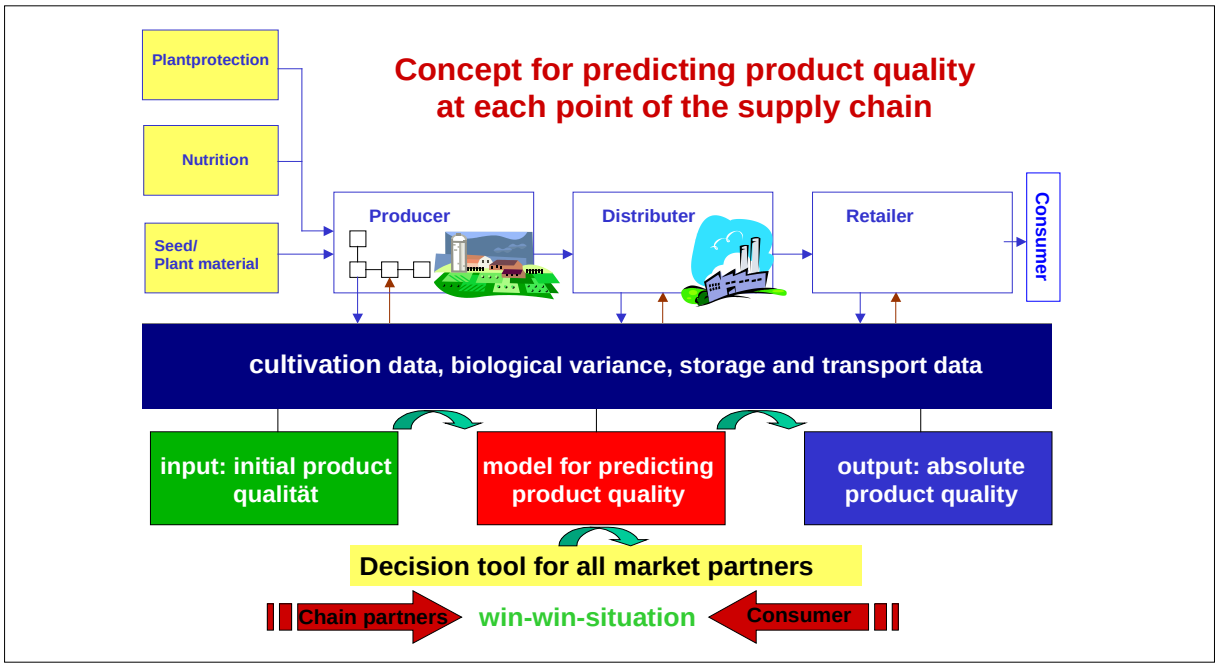


Figure 1: Concept for innovative technologies for supply chain quality management of fruit and vegetables

Therefore, as a result of the project a novel quality assessment tool can be expected, which can be used to predict quality at any point of the supply chain (Fig. 1). Consequently, the decision makers of fresh produce trade in the Euregio will use that system to improve their efforts in supplying the different markets with suitable products. Finally the consumer in the regions will be provided with a higher percentage of high-quality products, which also allow to extend shelf life after the purchase.

For evaluating innovative technologies and approaches to improve supply chain quality management of fruit and vegetable it was of particular interest to assess data on

- quality attributes that characterize the product quality (incl. pathogen contamination grade) most appreciably
- measurement technologies that are applicable, easy to handle and qualified to determine changes in quality attributes of individual products and pathogen contamination grade of fresh products
- parameters with influence on the product quality and pathogen contamination in the pre- and post-harvest phase
- combination of suitable, non-destructive measurement technologies in order to estimate representative quality attributes with specific quality models for prediction of product quality

2. Materials and methods

2.1 Plant material

2.1.1 Apples:

Malus domestica Borkh. cvs. “Braeburn”, “Golden Delicious” and “Jonagold” cultivated under commercial growing conditions at the Research Station Klein-Altendorf, Bonn University, North-Rhine Westphalia (NRW). Different cultivars were selected to include fruits differing in skin colour, e.g. green-yellow (“Golden D.”), red-green (“Braeburn”) and red-yellow (“Jonagold”) - because parameters to be evaluated are influenced by pigment content and composition.

2.2.2 Tomatoes:

Truss tomatoes *Lycopersicum esculentum cv*. “Cedrico RZ” cultivated at the Vegetable Research Station Marhof, Bonn University (NRW) under protected cultivation and practice-related conditions.

2.2.3 Carrots:

Daucus carrota L. cv. “Bolero” cultivated in farmers’ fields at different locations in Switzerland.

2.2 Technologies for measuring product quality attributes

The common but mostly labour-intensive methods used in practice to evaluate fruit quality and maturity involve destructive estimation of fruit firmness, starch breakdown, analyses of soluble solids and titratable acids content in flesh (Streif, 1996). This is, however, labour and time consuming. Also, with standard methods there is no possibility to monitor maturity or quality changes in the same individual product. Therefore innovative measurement methods are required, such as non-destructive sensor technologies for rapid evaluation of maturity grade in order to estimate the optimal harvest time, for quality detection of the fruits, for automation of commercial fruit grading and for monitoring or predicting fruit quality and storage ability pre- and post-harvest.

2.2.1 Conventional methods used as references

The suitability of innovative non-destructive technologies for determining product quality needs to be validated by comparison with standard reference methods (Kuckenberg et al., 2008). Comparative studies were conducted with “Golden Delicious” and “Jonagold” fruit, harvested in October 2006. Fruits with a diameter of 75/80 mm were selected, assigned to 3 treatment groups and stored in the dark at 10°C, 15°C, and 20°C, respectively, for three weeks. For apple, quality attributes, such as firmness and colour, were regarded as representative parameters for characterisation of fruit quality and were measured immediately after harvest as well as 10 and 20 days thereafter.

Firmness - Penetrometer

Firmness of fruits was measured with a handheld penetrometer (destructive technique) at the equatorial level on two opposite sides of each fruit. With this method, the force needed to penetrate the fruit flesh with a stamp area of 1 cm^2 is measured.

Colour - Chemical analysis

The chlorophyll contents (a, b and total chlorophyll) in the fruit skin were determined photometrically after chemical extraction of the green pigments with dimethyl sulfoxide (DMSO, Blanke 1992).

2.2.2 Innovative non-destructive measurement techniques

Non-destructive technologies offer the opportunity to determine quality changes repeatedly in each individual fruit. This aspect is of great importance for developing product quality models. However, the

technologies differ in their measurement principles, the detection parameters as well as sensitivity and precision of measurements. Hence, innovative sensor technologies need approval of their acceptability as evaluation techniques for selected quality parameters and have to be validated for individual crops and cultivars because of potential differences in specific fruit skin colouration, fruit flesh texture and elasticity, as well as fruit size and shape.

Firmness - Intelligent Firmness Detector (IFD)

Several non-destructive sensor technologies for measuring firmness have been developed (Höhn and Winkler 2003), e.g. acoustic technologies to evaluate the texture or pressure by measuring the elasticity of the fruit skin (Courcoux et al. 2005).

In the present work, firmness of apple and tomato fruit was measured with the "Intelligent Firmness Detector" (IFD, Greefa Co., Geldermalsen, Netherlands). The instrument employed was originally designed as component of a sorting machine; currently it is not used for commercial maturity or quality controls. The IFD firmness module records the fruit elasticity (IFD-Index) along the fruit equator 20 times within one rotation. Velocity of rotating roles has to be adjusted for each species, cultivar and class of fruit size.

Colour

Ripening and senescence processes are accompanied by changes in the content and composition of pigments in the skin and flesh of fruits. Thereby the green colour resulting from the chlorophyll content decreases and the red colour as a result of the anthocyanin content increases. In dependence from the kind of crop and cultivar other pigments like carotenoids with orange colour are of specific interest for evaluation of maturity or quality of products.

Pigment Analyzer (PA):

Colour was measured with a handheld pigment analyzer (PA, CP Co., Falkensee, Germany. The innovative potential of this relatively new instrument is based on the fruit light remission measurement with simultaneous detection of different pigments within one recording. For evaluation of chlorophyll content (fruit ground color), remission intensities at 650 (R650) and 780 (R780) nm were estimated and Normalized Differenced Vegetation Index calculated as NDVI = (R780-R650)/(R780-R650). Anthocyanin content was evaluated with the Normalized Anthocyanin Index (NAI value) by remission (R) measurement. The respective formula is as follows: NAI = (R 780-R 570)/(R 570+ R 780). Before taking PA readings, a circle with a diameter of 2 cm was marked, both on the sun and shade-exposed side of each individual fruit. This was to follow-up colour changes even on the same spots on the fruit surface.

Mini-Veg N:

MiniVeg is a non-destructive instrument to detect chlorophyll content in plants and fruits by Laser Induced Fluorescence (LIF). The instrument has been developed by Fritzmeier Co., Großhelfendorf, Germany, and is used for estimating the nitrogen supply as basis for site-specific fertilisation of agricultural crops. In the present investigation the MiniVeg sensor was applied to test whether LIF is an appropriate method to assess maturity grade and quality of fruits and vegetables (Kuckenberg et al., 2008).

The objective of these investigations was to document that chlorophyll degradation is closely related to changes of maturity or quality attributes in apple fruit. The research studies were performed with apple cultivars differing in colour like "Golden Delicious" (green-yellow) and "Jonagold" (red-yellow). Measurements were taken over a period of 3 weeks with 8 readings at a 3 to 4-day interval both on the sun and shade exposed fruit sides.

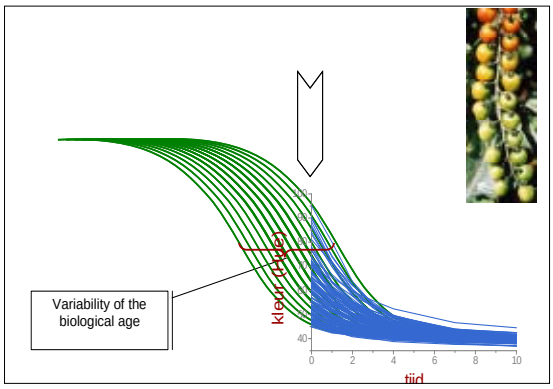
2.3 Batch quality models

Predicting product quality requires establishing a model on the dynamics of product quality changes. In order to achieve this ultimate goal, detailed knowledge on the underlying basic processes is needed. This can only be achieved by implementation of data into so-called fundamental, process-oriented models. The new approach of the applied quality model is based on consideration of the biological age of the products as a tool for modelling in pre- and postharvest horticulture. The biological age includes:

- the biological time
- the physiological time
- the state of development

and depends on various and varying factors during growing period and shelf life, e.g. fertilisation, disease status, position on the tree and environmental conditions within the post-harvest phase (Hertog 2006, Tijskens and Konopacki 2003). These biological variation influences the maturity stage at harvest and senescence processes in the post-harvest and shelf life period (Hertog et al. 2002, 2004, Tijskens et al. 2003). In combination with the calendar time it is expressed as the Biological Shift Factor (BSF, Tijskens et al. 2005).

The biological shift factor can be estimated and data pooled. The factor is directly related to the biological variation of batches, populations or individuals and an important factor in the new approach for modelling product quality.



In the present work for apples and tomatoes, the effect of maturity level at harvest, storage period and temperature on product quality of apples and tomatoes had to be analyzed. Therefore batches were combined, whereas a batch is defined as products with the same growing history. Hence, the batches were considered as a) colour and firmness behaviour at harvest (initial quality) and b) the colour and firmness behaviour as function of storage time and storage temperature. Storage of batches at different temperatures was necessary to calibrate quality change models. A variation in initial quality attributes was essential, as colour and firmness are linked per batch. In order to reach the overall objective of predicting product quality, colour and non-destructive firmness data were included into quality models, which may be applied to apple, tomato and other fruits or vegetables.

In the case of carrots a batch consisted of an amount of carrots that were wounded and inoculated with *Chalara sp*. spores at a determined level. The aim of the study was to determine the maximum temperature at which carrots can be stored without appearance of *Chalara* symptoms during distribution and sales. To be able to predict the losses caused by *Chalara sp*., it is important to understand the disease progress in fresh and stored carrots at different temperatures.

2.3.1 Apple batches

Fruits of the cv. “Braeburn” were harvested at three different maturity stages (unripe, ripe, overripe), separately harvested from sun and shade-exposed sides and from three different positions within the tree (top, middle, bottom). The apples consisted of 18 batches of 40 fruits each, and were stored in the dark at three different temperatures (5°C, 15°C, 20°C) for three weeks after each harvest date. Firmness and colour were measured at a constant interval depending on storage temperature. The combined apple batches might be characterised as a function of position in the tree, sun/shade side and harvest maturity (pre-harvest parameters) with regard to colour and firmness changes at different storage temperatures (post-harvest treatments).

2.3.2 Tomato batches

Fruits, cultivated at two different concentrations of Ca nutrition (4,5 mmol/l Ca, as commonly used in practice, and by 30 % reduced Ca supply) were harvested on October 26, 2006, with a diameter of about 40 mm in three different maturity stages (green = ”breaker stage”, orange = ”pink stage”, red = ”red stage”). Fifteen tomato batches were combined and stored in the dark at 3 different temperatures (10°C, 15°C, 20°C) for 3 weeks. Firmness and colour were measured at a constant time interval. The tomato batches might be characterised as function of Ca supply and harvest maturity grade with regard to postharvest colour and firmness changes at different storage temperatures (Lana et al. 2005).

2.3.3 Carrot batches

Contamination of carrots with black rot fungi (*Chalara* sp.) are a tremendous problem in Switzerland (Heller et al. 2005) and originates in the field but post harvest factors like harvest time, storage duration and conditions, washing and packing procedures and temperature influence disease outbreak at the retailer level. In most cases the symptoms do not develop at the moment of sorting and packing but rather appear in the store or even after the consumer purchased the carrots. For a better quantitative understanding of disease progress in time and for later disease progress modelling as a forecasting and management tool, disease progress in time at different temperatures was measured in different carrot batches characterised by determined inoculation levels.

Carrots were grown in seramis or in seramis soil mixtures which have been previously disinfected by heat treatment. (>60°C). After the harvest carrots were stored at temperatures between 0°C and 2°C and were used for the trial at three different times. The first experiment started directly after harvest (July/August 2006), the second one after two month of storage (Sept. 2006) and the third one after 5 month of storage (January 2007).

C. elegans and *C. thielavioides* were used for the inoculation of the carrots, except for the second experiment only with C. elegans. The conidial suspension [30*103 spores/ml] of *C. elegans* and *C. thielavioides* was made from 7-10 day old culture, crowing on malt agar.

Each carrot was wounded at 3 spots with an acerb borer (8 mm diameter and at a depth of 1-2 mm): on the top (top), in the center (medium) and near the root tip (peak). In every wound 10µl of the suspensions was inoculated. The carrots were incubated at 5 different temperatures: 1, 2, 4, 8, and 20°C, were placed individually on moist paper towels in plastic boxes and stored at the mentioned temperatures. Ten carrots were used per treatment. Additionally, 10 carrots were wounded as described but not inoculated and stored at 20°C for control. The storage time was 0, 2 and 6 months (Tab. 1). The development of mycelium was monitored by daily measurement of the lesion diameter with a digital calliper. Lesion diameter was measured in the width (D1) and in the length (D2). The measurements were taken at least 20 days and at the most 60 days.

3. Results and discussion

3.1 Comparison of destructive (conventional) and non-invasive methods for characterizing apple fruit quality

3.1.1 Firmness

A close correlation between destructive (penetrometer) and non-destructively measured firmness values (IFD) in Golden Delicious fruit could be determined.

- The highest correlation occurred at harvest (R2=0.99) when the fruits were still firm.
- Fruit storage at high temperature (20°C) caused a clear decline in firmness and lower R2 values.
- Correlation was still high for low storage temperature (R2 = 0.85 for 10°C) as well as for high temperature (R2=0,87 at 20°C).

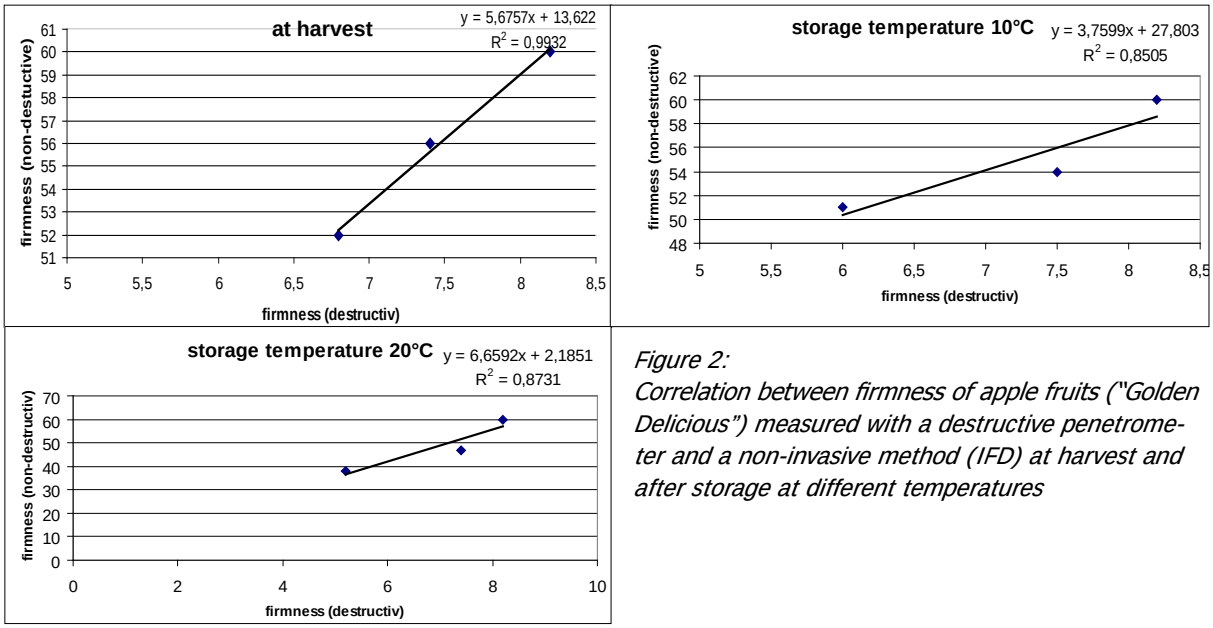


Figure 2:
Correlation between firmness of apple fruits ("Golden Delicious") measured with a destructive penetrometer and a non-invasive method (IFD) at harvest and after storage at different temperatures

Conclusion: The non-invasive technique with the "Intelligent Firmness Detector" is an appropriate method for evaluation of firmness in firm fruits at harvest as well as in softer fruits in the more advanced maturity stage in the post-harvest period

3.1.2 Colour

Relationship between destructive and non-destructive colour measurement technologies under shelf life conditions:

- The senescence-induced breakdown of chlorophyll content in the fruit skin could be successfully monitored with the non-destructive methods, e.g. laser induced chlorophyll fluorescence (MiniVeg; F730) and light remission (PA; NDVI).
- The sun-lit and shaded sides of both fruit cultivars differed in their chlorophyll content, and these differences could be detected by both fluorescence and remission techniques around harvest time.
- In cv. "Jonagold" the red anthocyanin pigmentation could be directly detected by NAI index and indirectly by higher F730 values.

In summary, it could be documented that in both tested apple cultivars difference in ground colour due to chlorophyll decline during ripening could be measured with the MiniVeg-System as well as with the Pigment Analyser. Both technologies are suitable for evaluation of green and red fruit colour as attribute for product quality.

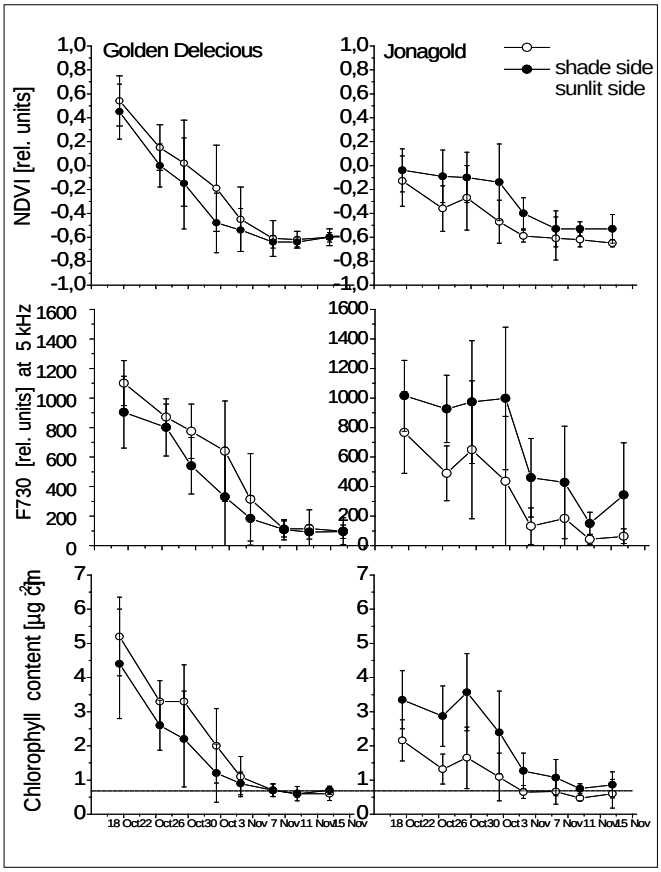


Figure 3: Chlorophyll decline during storage measured with destructive and non-destructive methods

3.1.3 Firmness and Colour

All measured destructive and non-destructive values showed a good correlation between fruit colour as external quality attribute and firmness as internal attribute. A close linear regression between the destructively measured chlorophyll content in the fruit skin and the firmness could be established both in "Golden Delicious" and "Jonagold" (Figure 4). The correlation of data was closer when specifically referring to the sun-exposed or shade side (Table 1).

Table 1: Correlation coefficient (r) between chlorophyll content and firmness in the fruit skin of two apple cultivars

	Firmness		
cv. / side	sun side n=80	shadow side n=80	both n=160
Golden D.	0,78	0,77	0,77
Jonagold	0,74	0,76	0,65

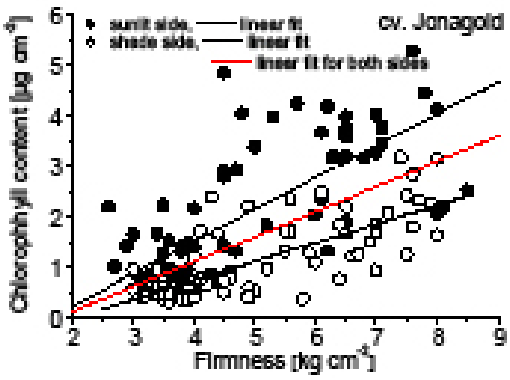


Figure 4: Relationship between chlorophyll content and firmness in the fruit skin of two apple cultivars

Also, a very close correlation was found between firmness and the non-invasively estimated fruit colour as measured with the Pigment Analyser (NDVI) and the MiniVeg (F740, Table 2).

Table 2: Correlation coefficients (r) between fruit firmness and fruit colour (NDVI and F740)

	Golden Delicious			Jonagold		
Cultivar/Side	Sun (n=80)	Shadow (n=80)	both (n=160)	Sun (n=80)	Shadow (n=80)	both (n=160)
NDVI	0,81	0,73	0,76	0,72	0,78	0,70
F730 (5kHz)	0,72	0,69	0,69	0,65	0,68	0,61

Compared with conventional practices all investigated non-invasive methods are appropriate techniques for evaluating important fruit quality attributes. The collected data may be used to validate the existing model for predicting product quality at any point of the supply chain and to forecast shef life period.

3.2 Carrot black rot disease progress in time at different temperatures

Temperatures below 2°C completely inhibit the lesion-development by *C. elegans* and *C. thielavioides* although the carrots were inoculated with densely concentrated suspensions conidia of the pathogens. A temperature of 4°C can suppress the development of *C. thielavioides* for more then a month. The same temperature can completely suppress the development of *C. elegans* for more then two months. At a temperature of 8°C, after 10 days at earliest, the development of *C. elegans* and *C. thielavioides* occurred independent of the duration of storage. The first symptoms (conidia) of *C. elegans* and *C. thielavioides* incubated at 20°C were visible after 4 days (Fig. 5). Incubation at 20°C for one month allowed lesion development to 6-8 mm diameter.

Independent of the site of inoculation (top, medium, peak) the lesions of *C. thielavioides* showed no significant differences in size by the development. In contrast the development of *C. elegans* at 20°C was faster on the top compared to the center (medium) and the root tip (peak).

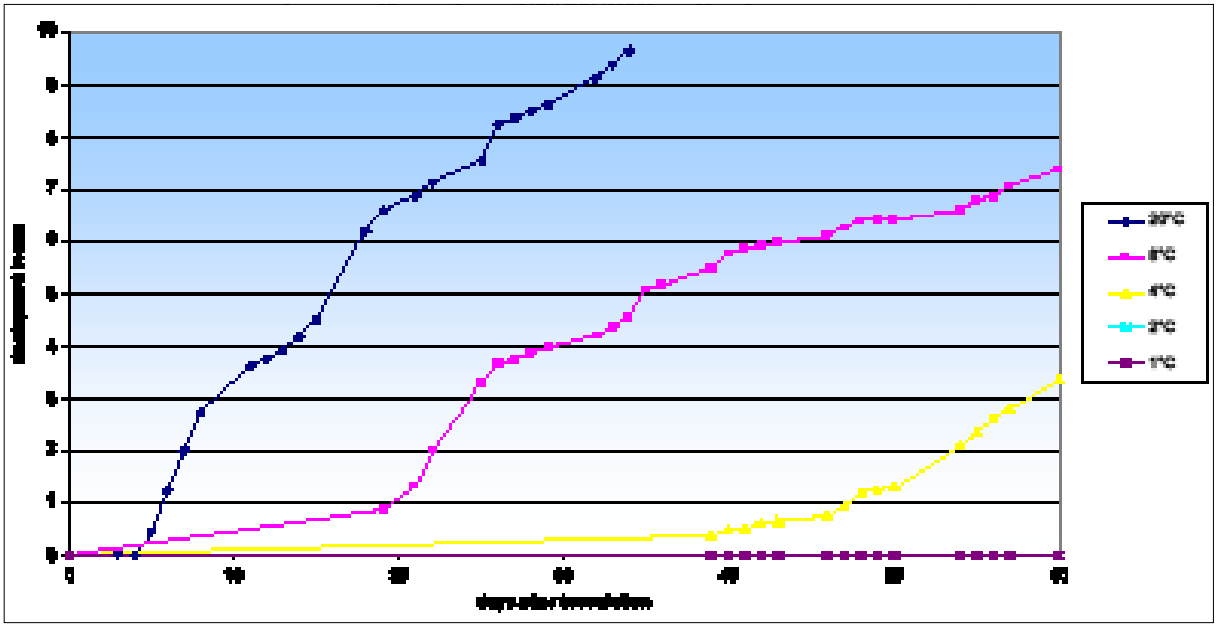


Figure 5: Development of C. thielavioides by different temperatures

At temperature below 8°C, there was no significant difference in lesion development between *C. elegans* and *C. thielavioides*. At 20°C the development in width increased faster than in length. This trend has been observed in all experiments.

The presented results shows that cooling of carrot throughout the whole chain, harvest, storage, sorting, producing, POS and at customers home is essential for maintaining their quality. A temperature below 8°C suppresses the development of *C. elegans* and *C. thielavioides* on carrots during at least ten days. If the customer leaves the carrots in the fridge the appearance of visible symptoms of either *C. elegans* or *C. thielavioides* should not occur within one week.

4. Summary and Conclusion

Availability of suitable non-destructive techniques for determining quality attributes is a prerequisite for development and validation of models as basis for product quality prediction at any point of the supply chain. In this project the non-invasively determined parameters of apples and tomatoes showed a close correlation with data obtained with conventional procedures; therefore they can be recommended for application in practice.

The Intelligent Firmness Detector is suitable for firmness measurements of spherical fruits like apple and tomato with a minimum diameter of 4 cm. However, the Greefa instrument is not applicable to fruits with an irregular shape like pears, avocados or cucumbers or to small fruit like plums and radish. Other restrictions are low-firmness fruits like berries (strawberries or currants) due to impinging force of the measurement device. In this case, a non-invasive instrument is the method of choice. Despite of the representative and reproducible results in comparison with conventional firmness measurement devices, the IFD is not an all-purpose or universal instrument which could be used by producers, sorters/packers, distributors or retailers for a wide range of goods. Moreover, the IFD at the current developmental stage is not a portable or handheld instrument because of its size, weight and sensitivity to vibrations. In the present form, the IFD is well-suited for research purposes or as integral unit of sorting machines. It has the potential for supplementing other sensors or technologies for automatic evaluation of external and internal product quality characteristics.

For fruit colour estimation the pigment analyzer and MiniVeg proved applicability because of close correlations of data with those of conventional methods. Both the PA and the MiniVeg are prototypes at the

advanced stage with lots of potential for precise determination of product quality in fruits and vegetables. Furthermore, LIF offers the chance to detect

- physiological diseases, e.g. internal browning, water core, sunburn and others
- pathogen infections pre- and post-harvest long before damages or disorders becomed apparent. Therefore this method is of further interest to horticultural science and practice.

More research driven by the project partners is on the way. This will open-up potential and perspectives for introducing and establishing product quality models in horticultural supply chains. Furthermore, a quantitative understanding of the quality change in time is another prerequisite for the development and validation of models as a tool for quality management.

In this project the black rot disease progress (caused by *Chalara sp.*) in time as affected by temperature was documented for the first time. This quantitative knowledge can be used for practical carrot quality postharvest management as well as for respective modelling purposes.

Modelling product quality

From the present work, the potential of process-oriented modelling becomes evident. The specific knowledge of experts and specialists, whether scientific (theory), practical (empirical) or commercial (application) can be used and is being applied to develop models on product quality and behaviour that span the complete range of transregional supply chains. It is possible to include effects of seasonal (within and between), regional and management practices. Provided that mechanism upon which the models are based, do reflect (more or less) the process occurring in the produce, the parameters estimated are valid over the seasons and regions of provenience. That really offers the opportunity for modelling and optimising supply chains. Of course a lot of work still needs to be done to achieve that goal of modelling: predict future behaviour in any circumstance, from any region, grown in any season. More research is necessary, more experiments need to be conducted, but from these few examples we can deduce the framework for this new approach. And it has to be quite different compared to the traditional research setups applied up till now. And the basis for this fascinating development has been established by this project activity.

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