Research theme 1 – FOOD QUALITY MANAGEMENT SYSTEMS: KEY RISK FACTORS

Introduction
Globalisation of trade, changes in consumption and food preparation behaviour, food security, fair trade, safety concerns, health trends, climate changes… just to mention a few issues in society that impact food quality management in agribusiness and food industry. These pressures increased the need to design, control, improve, and assure production and preparation of healthy and palatable food that is safe, and is produced in a sustainable way.
In anticipation to these pressures from society, agribusiness and food industry have put much effort in designing and upgrading their quality/safety management systems based on a wide range of quality assurance standards (like HACCP, BRC, SQF, GLOBAL GAP, ISO22000). However, the recent food scandals and emerging food safety issues worldwide indicate that a deeper understanding of the (context) factors influencing the effectiveness of these systems is needed.
In the last few years, various diagnostic tools have been developed to systematically affect the core control and assurance activities in view of the riskiness of the context wherein the systems have to operate. However, the relation between context characteristics and quality system performance and quality output is still under study. Moreover, these diagnostic tools enable an overall assessment of the current system performance in their context, but do not yet take into account the dynamics in the system, i.e. dynamics of the food production systems and management systems. System dynamics is a research area well-known in logistics and computer science but scarcely applied in the area of food quality management. It requires a deeper understanding of the cause-effect relationships between the people operating in the system and the food production system itself.

Overall objectives
The investigation into the relationships between context characteristics and quality system (or specific parts) performance and food quality/safety, into the influence of safety/quality (organisational) culture on variable decision-making behaviour and food quality, modelling dynamics in quality management systems and the impact on food quality.
1.1 Analysing influence of food safety culture on hygiene behaviour in food production systems

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Safety is a permanent threat in the food supply chain up to final preparation and food consumption. Consumers want guarantees, organizations concern about brand reputation and shareholder value, governments lack necessary resources to inspect all businesses in the food supply chain, and media ensure that incidences and outbreaks are reported. Food producers at all levels of the production chain up to food service establishments have the responsibility that proper safety and sanitation practices are followed to ensure the health of their customers. The primary focus of food companies - establishing food safety management systems - is on implementing the required quality assurance guidelines and standards resulting in process monitoring systems, preventive control measures, technological infrastructures (e.g. hygienic equipment design, zoning), and procedures to guide people in executing their safety tasks. However, studies about self-reported behaviour and observational studies suggested that unless systems are in place, food handlers often do not comply with required safety tasks. Systems are especially under pressure when dealing with susceptible high-risks products (such as ready-to-eat food) made under vulnerable production circumstances. The increasing awareness on the impact of people on food safety boosted the efforts in training and safety communication, but the effects on sustainable changes in food handlers’ behaviour seem yet limited. Recent studies suggested that collective food safety practices in an organization can be only achieved by taking into account both food safety culture (FSC) and food safety management systems. The importance of organizational culture, human behaviour, and systems thinking is well-documented in the occupational safety and health fields but the scientific literature on these topics are limited in the field of food safety management.

The thesis is part of a PhD project on understanding impact of national culture on food safety culture and hygiene practices in food factories and small food manufactories: a case study in Zimbabwe. The aim of the thesis study is to validate a previously developed and pre-tested diagnostic tool and to analyse the influence of food safety culture in dairy (and or other) food production systems on quality and safety of dairy products. A possible alternative topic would be to study the role of domestic hygiene culture on hygiene practices of operators in (dairy) food manufacturing in Zimbabwe. In both cases the thesis is to be combined with an internship in Zimbabwe (and possibly other locations).
1.2 Model to be able to determine effective control measures for a global supply chain for feed ingredients

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Globalization resulted in increase of awareness of the various risks and vulnerabilities that products are exposed to as they move along the supply chain continuum from design and sourcing to manufacture, transportation, distribution, and final sale. Supply networks are long and complex resulting in higher risks. The risk of the global supply chain must be covered in the Food and Feed Safety Management Systems / Product Safety Systems. In Europe when there is product in the market which is unsafe or not in compliance with the regulatory requirements, there is an obligation to report this to local authorities. When more member states are involved it is reported to the Rapid Alert System for Food and Feed (RASFF). It is a tool that facilitates the cross-border flow of information. However, it is also a tool that influences trust. On the other side it supports risk assessments. A fact is that a high number of Rapid Alerts are related to supply from non-EU countries. So, there is a need for global supply, but there are also challenges for companies in this globalized business environment. Therefore, appropriate control measures must be installed for food and feed ingredients for a global supply chain based on the risk.

The aim of the study is to develop and test an analytical framework/tool for assessment of risk-based chemical control in global feed supply chains. The study includes and a literature search on chemical hazards along feed supply chain literature to obtain an understanding of risks on chemical contamination caused by intentional and unintentional handling; develop an analytical framework/model to analyse chemical control system along world-wide supply chain; test the developed model in a company during the internship at Cargill.
1.3 Cost-effective allocation of resources for monitoring mycotoxins along the spices supply chain

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Many alerts from European Countries via the Rapid Alert System for Food and Feed (RASFF) over the past years included spices and herbs, indicating the need of the monitoring in this commodity. The spices chain has been seriously affected by chemical hazards incidents. Hence, monitoring mycotoxins is crucial for detecting contaminations in the spices chain. The objective of this study is to develop an optimization model to determine cost-effective monitoring schemes for detecting and tracing a mycotoxins contamination along the spices supply chain.

The study includes the conduct of a literature search on monitoring chemical hazards along food chain literature to obtain an understanding of possible modelling approaches and formulations; the development of an optimization model (mixed integer linear program (MILP) with important practical constraints) to determine cost-effective monitoring schemes for detecting and tracing a mycotoxins contamination along the spices supply chain; the comparison of the results of the optimization model with the results of the current monitoring system to show improvement potentials.
1.4 Identification of determinants of effective food safety training in moderate and high-risk RTE food production systems

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The increasing incidence of food poisoning outbreaks linked to Listeria and persistence of outbreaks linked to other pathogens over the past 10 years foods suggests that current safety control systems and procedures could be further developed to support the consistent assurance of product safety in the Ready-To-Eat (RTE) chilled foods sector. RTE companies put much effort in implementing control measures as part of their food safety management system, however recalls and epidemiological data indicate that there may be inadequacies in the competencies of factory staff and shortfalls in knowledge of quality / technical management which could contribute to inadequate design and execution of control measures, lack of procedure compliance, inadequate verification activities, etc.
Although much research on listeria contamination is available, fewer studies apply a systems approach taking into account both technological and managerial/chain/governance factors (regulations, standards, enforcement practices, competencies, etc.) that can influence the effectiveness of current listeria control.

The overall aim of the PhD study is to gain an insight into the major technological and people-related causes for loss of specifically L. monocytogenes control in Chilled RTE supply chain networks. The specific aim of the MSc project is to gain a deeper understanding in critical determinants of food safety training for different target groups (e.g. Factory operators, QA Managers etc.) by performing a literature review and developing an analytical framework. This framework will be used to systematically analyse the current situation with respect to employee requirements, training features and effect of training on behavioural changes (improvement of compliance to procedure, increasing awareness etc.). The data collection will be focused on UK companies producing moderate to high-risk RTE foods.
1.5 Identifying risk factors in auditing of sustainability standards implemented in cultivation of cacao, tea, or coffee

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The trend towards consumption of organic food, sustainably produced foods, and care about social aspects of food production has stimulated the production of food with specific labels, such as FAIR TRADE, MCS (Marine Stewardship Council Scheme), Carbon Foot Print; just to mention a few. However, recent issues with sustainability labels has increased consumers’ sceptic towards these quality seals and emphasised the desire for more trustworthy labelling. As a consequence, assurance of label reliability has put additional pressures on the quality management systems of companies. A common strategy to evaluate the effectiveness and performance of quality systems is by auditing. Internal auditing by internal company experts and external auditing by competent authorities or certified bodies check the compliance to quality assurance requirements. These audits are often costly and time consuming, and do not always provide the full guarantees they aim for. Currently, there is a tendency to shift from traditional auditing (check on compliance to standards) towards risk-based auditing (RBA) in the food supply chain. In RBA, risk concepts should be integrated into the strategies and approaches used for management systems. Though this concept has been applied in some other sectors e.g. finances, veterinary medicines there is yet restricted scientific knowledge on how to design risk-based audits for food applications. Control bodies collect data for inspection and certification purposes according to the EU regulations and large datasets exist. However, there is yet little knowledge on how (existing) auditing datasets (e.g. on sustainability standards) could be used as input for risk-based auditing, and what modelling tools could be useful.

The thesis is part of a PhD project on “Risk-based management in food supply chains exploring the applicability of systems thinking and use of multi-method models”. The aim of the MSc thesis project is to get insight in factors increasing the risk on unreliable quality seals, by evaluating a previously developed tool (for identification of possible risk-factors in auditing of sustainability seals), analysing audit databases, and collecting data on actual auditing practices in empirical case studies.
1.6 Influence of quality and logistic control on post-harvest losses in fresh produce chains in transition countries

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The problem of food losses is urgent in developing countries. Yearly losses for fruit and vegetables can be as high as 70%. Scarce resources, such as water used during crop production, are being wasted because of food losses after harvesting. Reducing food losses can therefore help to improve the sustainability of fresh produce chains. Recent studies showed that at least 30% of post-harvest losses (PHLs) are avoidable. This presents a great opportunity to reduce PHLs. Several solutions to reduce PHLs in fresh produce chains have been put forward in literature. However, the proposed solutions fall short in that they are only either from a logistics control or from a quality control perspective, and context factors are not considered. Recent literature, however, shows that integrating quality control and logistics control could be a more effective way to reduce the incidence of food losses in fresh produce chains. There is thus a need to improve concurrently quality control and logistics control activities along fresh produce chains to reduce post-harvest losses. However, there is not yet a tool to analyse systematically crucial control and logistic decisions that increase the chance of post-harvest losses, taking into account the context characteristics, wherein these activities take place. Moreover, few real-life data are available on the actual variation in quality parameters under different logistic systems and control activities.

The PhD project aims at developing a diagnostic tool to analyse the influence of control and logistics decisions on post-harvest losses, given the typical context characteristics of Zimbabwean fruit/supply chains, in order to develop effective interventions to reduce food losses. A first diagnostic tool has been developed and tested for fresh tomato chains in Zimbabwe in combination with tools to systematically analysis quality parameters/post-harvest losses. The next step is to compare different types of fresh supply chains to gain a deeper understanding of the factors contributing to post harvest losses depending on different context characteristics, such as organisational characteristics, supply chain characteristics, type of governmental or other support (e.g. NGOs), etc. The tools were tested for the Zimbabwean context, but it would be interesting to compare fresh produce chains in (neighbouring) African countries. The MSc project will be further demarcated based on the output of the research of the PhD student and previous MSc student.
1.7 Development of tools to assess bottlenecks in production of safe and high quality dairy products in the African context

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In East African countries, the demand for safe, nutritional and palatable dairy products is increasing in response to the rise in food supermarkets, growth of affluent population but also due to increasing foodborne outbreaks. The supply of fresh milk and processed dairy food occurs via different channels and often depend on the milk system (small farm holder versus large producer). Currently, the equipment capacity is not fully used, so there is potential for growth. For example, a study in Tanzania indicated that the dairy industry utilises less than 30% of the installed capacity. Nevertheless, the growing demand poses a challenge for the dairy industry to increase capacity and improve processing conditions in order to consistently meet the market, consumer and legal demands. The dairy sector is indeed confronted with many challenges. Common problems are milk adulteration, spoilage, microbial, and chemical contamination. Poor and inconsistent quality has been frequently reported for locally manufactured dairy products such as pasteurised milk, ultra-high treated milk, cultured milk, yoghurt, cheese, ghee, and ice cream. Moreover, high post-harvest milking losses (ranging from 16.4% in the dry season to 25% or more in the wet season) have been attributed to limited storage facilities and inadequate processing capacity contribute to high post-milking losses. Furthermore, these products frequently do not meet quality and safety requirements of local, regional, and international export markets. There is thus a need for gradual improvements towards more effective, efficient and sustainable dairy supply chains to satisfy both local and export markets with safe, nutritional and palatable dairy products.

The overall aim of this new PhD project is to get an in-depth understanding of technological and people related causes of safety and quality failures and bottlenecks in the control systems in the typical dairy supply chains in East Africa, in order to develop dedicated roadmaps for gradual improvement of quality in different dairy supply chains. The MSc project aims at analysing possible technological and people related causes of safety and quality defects in dairy production as basis for a first diagnostic tool to assess the dairy control systems. Moreover, crucial safety and quality parameters need to be identified as basis for the development of a safety and quality assessment scheme. Preferably the thesis is combined with an internship to enable pre-testing of the tools in the Tanzanian context.
1.8 Development of a gluten-risk assessment tool for the food industry

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About 1% of the Caucasian population suffers from coeliac disease (CD), one of the gluten sensitivity disorders. The only remedy for people sensitive to gluten is a lifelong gluten free diet. As many food products contain gluten (for example wheat flour), CD patients have to take knowledge of the ingredients (read the labels) of all food products before consumption. Furthermore, gluten is added in many composite products as functional ingredient, making the range of suitable products for CD patients even smaller. Labelling of products is crucial. When the presence of gluten is labelled well, this will prevent problems. But when labelling is incorrect or cross-contamination has taken place during processing, the presence of gluten is not identified on the packing, which can lead to hazards. Regulation concerning the maximal concentration of gluten present in gluten-free food products is stated in the European law. Since January 2012 the allowed maximum concentration of gluten in a food product, with the claim gluten-free, is 20 parts per million (ppm) (20 mg /kg). In the food industry, the application of allergen management principles during food production is not yet very consistent. The practical acquaintance of allergens and cross-contamination during the production process is often lacking scientific evidence and may differ per quality manager. There is yet no common approach to perform risk assessments on food allergens to a common standard. The current HACCP-plans concerning cleaning and microbial hazards of food producing factories need to be extended for gluten/allergen management.

In a previous MSc research a first draft of a gluten-risk assessment tool was made and major control measures were derived from literature analysis and structured expert interviews. The results however revealed that context factors play an important role in the risk on gluten contamination. Therefore, the basic tool needs to be further elaborated to enable the assessment of initial risks inherent to context characteristics, combined with the analysis of the implemented control measures to mitigate the risk of gluten contamination in end products. The extended tool needs to be tested in practice to evaluate the applicability for the food industry. This work will involve questionnaires and /or visits to Dutch companies, and therefore a Dutch speaking student is preferred. The extended tool needs to be tested in practice to evaluate the applicability for the food industry. Depending on the student interest and possibilities at RIKILT there may be a possibility to perform laboratory work with gluten test kits, or other gluten test as part of an internship.