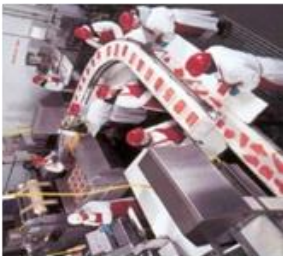**MSc**

THESIS RESEARCH THEMES FOR

FOOD QUALITY MANAGMENT study year 2014 – 2015

MSc Food Quality Management

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General introduction to Food Quality and Design group

We invite you to take a look at the topics that we offer and to embark with us on the exciting journey towards a better understanding of what Food Quality & Design (FQD) actually means!

If you are interested in a full immersion in food quality, FQD is the right place for you. As a food science student, you have already learned a lot about the chemical, physical, microbial properties of food, and you have learned how to process them. That knowledge is essential to build upon when discussing food quality and going into the design of new foods. But there is more to it! To play with Food Quality & Design, you should be able to integrate and connect your knowledge from various disciplines. Food quality is a broad, very dynamic and real life concept. It is obviously related to the properties of the food and the technological conditions it is subject to, and the integration required here is to connect the various disciplines of food technology, but, depending on the topic, perhaps also with plant and animal sciences. Next, it is important to realize that the perception of quality arises due to an interaction between food and humans. So, there you have a connection with social sciences: perception, consumer behaviour, psychology, ethics.

So an effective food design is also determined by the way people handle food all over the food chain. Here you have another connection with social sciences, now more on the managerial level. To summarize, the research and education at FQD is characterized by integration of those scientific disciplines that are needed for a certain quality problem and you can distinguish three different kinds of integration:

1. On the product level (integrating disciplines that are relevant to understand product quality attributes and design new foods with relevant nutritional and healthy attributes)
2. On the food chain level (integrating disciplines that are relevant to describe and understand what happens to a product on its way through the food chain)
3. On the techno-managerial level (integrating technological and managerial disciplines to describe and understand behaviour of people with respect to design, control, assurance, policy, in relation to the applied technology).

Hence, FQD studies are really multidisciplinary and in this way, FQD contributes to the mission of Wageningen UR: For Quality of Life.

General introduction to Food Quality Management group

Food quality management research is performed on the edge of food science and management (social) science. It aims at generating and integrating knowledge on how food quality is effected by dynamic behaviour of food products in their production systems and by dynamic decision-making behaviour of food handlers/managers in their organisational and or chain context. Major food quality issues concern safety & health, sensory attributes, and sustainability (like reduction of losses, alternative protein sources). The **techno-managerial** approach to analyse complex food and management systems is central in FQM thesis projects. This interdisciplinary research approach involves the concurrent analysis of theories and data from technological sciences to understand behaviour of food systems and from management (social) sciences to understand behaviour of human systems in order to <u>analyse</u> and <u>solve</u> quality problems.
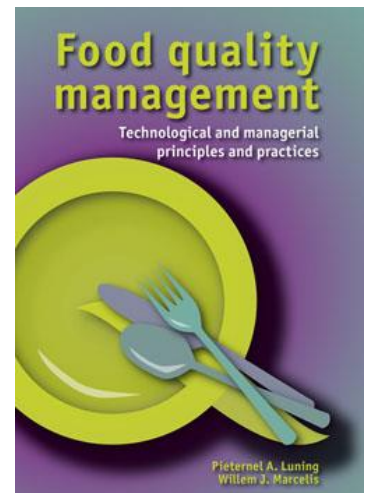
MFQ thesis coordinator: Elsbeth.Spelt@wur.nl
MFQ research programme responsible: Pieternel.Luning@wur.nl
Note: The MSc master thesis themes of academic year 2015 – 2016 will be available after the courses on food quality management research principles which are provided in periods 4 and 5. In these courses the MFQ students will receive information about the application procedure for a MFQ research thesis. If you are not participating in these courses, then contact the MFQ thesis coordinator for information on application procedure to be held in period 6.

Research theme 1 - EFFECTIVENESS AND DYNAMICS OF QUALITY MANAGEMENT SYSTEMS

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.
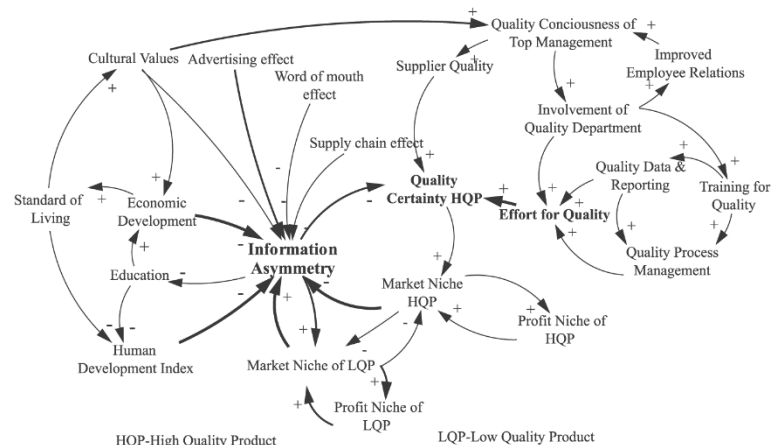
Overall objectives

include understanding of the relationships between context characteristics and quality system (or specific parts) performance and food quality/safety, analysing 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.

Project 1.1 Exploring dynamic systems analysis to support risk-based auditing of quality assurance standards for food chains

Supervisors
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Jochen Kleboth (Jochen.kleboth@wur.nl)

The trend towards consumption of, amongst others, organically produced 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 (such as serious gaming, agent-based modelling)". The aim of the thesis project is to identify crucial technological and management factors that affect the reliability of sustainability labels.

The study includes a literature analysis on auditing, risk based auditing and sustainability labelling, as basis for the development of a causal model that could be further elaborated using serious gaming as tool. The next step is to work with big datasets in collaboration with the PhD/company to get first indications of risk areas in auditing of quality management systems assuring quality seals. The project is suitable for 1-2 MSc students each working on another case: FAIR trade, bio label, MSC.

Project 1.2 Understanding food safety culture on hygiene behaviour in food production

Supervisors
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Shingai Nyarugwe (Shingai.nyarugwe@wur.nl)

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. 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 in small food manufactories: a case study in Zimbabwe. The aim of the thesis study is to get insight in the concept of food safety culture as basis for the development of a food safety culture assessment tool

The study includes a systematic review on the concepts culture, safety culture and food safety culture, combined with expert discussions, to get insight in the concept of food safety culture and its possible relation to hygiene performance of food handlers in (small) food manufacturing industries. When the thesis will be combined, there is a possibility to test an initial food safety culture assessment tool in various food manufacturing sites in Zimbabwe.

Project 1.3 Influence technological and people related factors on performance mycotoxin monitoring systems for bulk products affecting chemical safety

Supervisors
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Wilma Taverne (Wilma.taverne@wur.nl)

Mycotoxins in food and feed can have a negative impact on the health of respectively people and animals. Mycotoxins are secondary metabolites produced by various fungi species. Their toxicity and health impact depends on the type of mycotoxin. In Europe, specific legislation has been established on mycotoxins to enable the control of this chemical hazard in foodstuffs and animal feed. For example, Commission Regulation (EC) No 1881/2006 describes the requirements for food, Directive 2002/32/EC and its amendments is about requirements on undesirable substances in animal feed. The Commission Regulation (EC) no 401/2006 lays down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs and Commission Regulation (EC) no 619/2011. In practice, various factors complicate the implementation/adequate execution of such monitoring systems, e.g. samples need to be taken from bulk products with inhomogeneous distribution of mycotoxins, sampling from large containers in harbours and railway wagons put demands on physical skills, awareness and attitude of food handlers/inspector, etc. The procedure is time consuming, it comprises a comprehensive sampling plan and requires considerable amounts of samples to be taken and subsequently analysed.

The aim of this study is to get insight in the factors (including people related ones) that contribute to inadequate/inconsistent execution of mycotoxin monitoring systems, in order to design a blueprint for a pragmatic sampling plan uncompromised for reliability and accuracy.

The study includes a concise literature analysis to evaluate an framework made by a previous thesis student, followed by the development of a systematic assessment tool to analyse risk factors in mycotoxin monitoring systems in practice, data collection could be done in the internship at different locations and with different bulk products, depending on the outcome research and possibilities at Cargill.

Project 1.4 Develop model to predict the dioxin risks in crude oils/fats and products made thereof

Supervisors
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Wilma Taverne (Wilma.taverne@wur.nl)

Dioxin in food, especially vegetable oils, has gained worldwide attention because of the significant economic losses associated with their impact on human and animal health. Dioxins belong to the group of organic polyhalogenated compounds and are environmental pollutants. Out of the 210 different dioxin compounds (they differ in their number and location of Chlorine bounds, these different forms are also called congeners) only 17 dioxin congeners have a toxicity factor and are regulated. Crude vegetable oils contain various dioxin congeners and in different concentrations. The European Rapid Alert System for Food and Feed (RASFF) database reports products exceeding legal limits for rapeseed and palm oil by-products. Based on the risk assessment of FEDIOL (branch organisation for oil and fats) also crude coconut oil may contain dioxin. This means that there are two groups of risky products being the crude oil and the by-products made from the crude oil, which was in compliance. Data showed that less than 0.01 per cent of the crude palm oil samples exceeded the maximum limits over the past five years and that the quality of Malaysian palm oil is comparable to other crude vegetable oils. However, after refining of the crude oil in Europe (and other crude oil importing countries), the palm fatty acid distillates contained too high levels of some of the toxic dioxin forms, whereas the original crude oil complied with the legal requirements. The current legislation sets requirements on the toxic forms of dioxins in oil and by-products based on toxic equivalences. After processing, final products may contain too high toxic levels due to processing resulting in losses and high costs for monitoring. A recent study suggested that the congener profile of the crude oil provide indications on the possible (environmental) contamination routes at primary production. If this is really the case, then the congener profile could provide a prediction of its source and what could happen during processing.
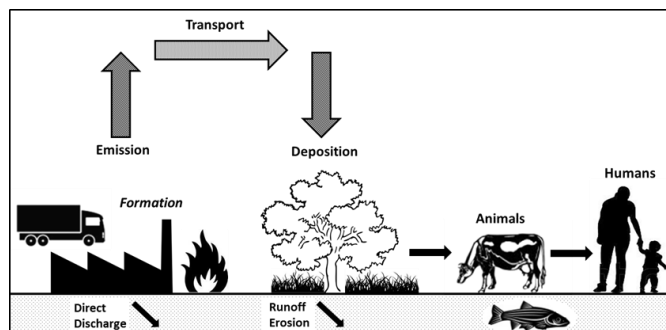
In previous thesis studies and PhD research, data have been collected on dioxin contamination sources and congener profiles. The aim of this study is to develop a model to predict the risk of dioxin contamination in supply chain using these data. The work builds further on earlier research on the identification of contamination routes, factors influencing the risk on contamination and the effect of processing.

The study includes a concise literature analysis to evaluate the previous analytical framework on sources of dioxin contamination and control, and to get a deeper understanding of the possible relation between congener profiles and source of contamination. The model (Monte Carlo simulation) building will be done in close collaboration with the PhD student. The thesis can be combined with an internship at Cargill providing time to validate the model as well.

Project 1.5 Analysing robustness of process and chain control measures aimed at reducing risk of Listeria monocytogenes contamination in ready-to-eat foods; towards a system analysis tool

Supervisors
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Mark Swaison (PhD/UK Lincolm University)

The increasing incidence of food poisoning outbreaks linked Listeria over the past 10 years suggests that current L. *monocytogenes* control systems and procedures are not sufficiently robust for the consistent assurance of product safety in the Ready-To-Eat chilled foods sector.

RTE companies put much effort in implementing control measures as part of their food safety management system, but additional measures along the chain seem to be necessary. The RTE complexity of the RTE supply chain network and the high vulnerability of RTE for Listeria contamination put pressures on the robustness of control measures along the chain. Although much research on listeria contamination is available, fewer studies applied a systems approach taking into account both technological as managerial/chain/governance factors (regulations, standards, enforcement practices, etc.) that can influence effectiveness of current listeria control.

The overall aim of the study is to get insight in possible causes for loss of L. monocytogenes control in Chilled RTE supply chain networks. It involves the systematic analysis of technological and people related factors increasing risk on listeria contamination (root cause analysis) on company level. Moreover, it encompasses a systematic analysis of (possible) control measures taken in the chain environment (e.g. supply chain collaboration, governmental measures/enforcement activities, consumer information, etc.) to control listeria contamination, and in-depth insight in the supply chain network structure.. The MSc thesis project will be further demarcated.

Project 1.6 Barriers for Reformulating Food Products for Health
Target: MFT MFQ

Supervisors
Matthijs Dekker (matthijs.dekker@wur.nl)
Teresa Oliviero (Teresa.oliviero@wur.nl)

Many consumers have an interest in healthy/healthier food products. In order to make product purchase choices for consumers easier with respect to health aspects of foods health logos have been developed, e.g. in the Netherlands by the Choices logo or "Vinkjes". In order to put such a logo on the front of pack of products, they have to meet strict criteria for e.g. salt, added sugar, fat composition, fiber content and energy density. This logo aims at enabling healthier food choices for consumers, but also at stimulating food companies to develop healthier products that meet the requirements of these logos.

This project aims at understanding the technological and other barriers that companies perceive when implementing these criteria in various product categories and to compare this with possible solutions by looking at the state of the art in the scientific literature and other solutions e.g. related to regulation.

The project will be in collaboration with the Choices logo foundation.

Research theme 2 - FOOD AUTHENTICITY AND INTEGRITY

Introduction

Food authenticity and integrity refers to the genuineness and intactness of food products. The series of food fraud incidents – melamine, horse meat, organic eggs, cardboard stuffed dumplings – is demonstrating that the vulnerability of food fraud incidents reaches to every dinner table in the world nowadays. Food fraud is a major concern not only for consumers, but also for producers and distributors. Food adulteration has been practiced forever, but has become more sophisticated in the recent past.

These illicit activities result in considerable monetary losses worldwide and eroded consumer confidence. Foods or ingredients most likely to be targets for adulteration include those which are of high-value and which undergo a number of processing steps before they appear on the market. To understand why fraud possibilities are seen as opportunities fraud risk assessments are required. Since the perceived risk of detection is one of the factors, and food adulteration is advancing more and more, novel analytical methodology are pivotal to uncover food fraud.

HOW THE PUBLIC CAN BE DECEIVED

MEAT
- Selling non-organic meat as organic.
- Adding excessive water to meat without declaring it.
- Selling meat unfit for human consumption.
- Adding beef and other meat to 100% pork sausages.
- Selling 'lean' meat that contains as much fat as standard.
- Substituting Parma ham with a cheaper product.

FISH
- Selling farmed fish as wild.
- Mislabelling the geographic origin.

FRUIT AND VEGETABLES
- Selling conventional produce as organic.
- Giving the wrong geographical origin.
- Selling cheaper varieties of potato as an expensive variety such as King Edwards.
- Adding GM soya beans to conventional beans, without declaring them.

EGGS
- Selling battery farm eggs as free-range.

CHEESE
- Using cow's milk rather than buffalo milk to make mozzarella.

OLIVE OIL
- Dyeing it dark green with chlorophyll to make it look like extra virgin.
- Diluting olive oil with cheaper hazelnut oil.

ORANGE JUICE
- Diluting it with inferior quality juice.
- Adding beet sugar to sweeten 'natural' orange juice.

COFFEE
- Adulterating highly sought-after arabica beans with cheaper varieties.

ALCOHOL
- Selling counterfeit versions of big brands, which can include dangerously high levels of methanol.
- Watering down spirits.
- Substituting cheap varieties for expensive premium brands in bars.
- Adding extra sugar during wine making to increase alcohol content

RICE
- Using cheap varieties to bulk up expensive basmati rice.

Objectives

The main objectives are to elucidate economic/criminological risk factors contributing to food fraud vulnerability, and to discern markers which substantiate the identity of food products. Both information on vulnerability and detection options will help to set up food fraud management systems.

Detailed objectives are:

- To explore food fraud risk factors from product and business perspectives
- To develop analytical methodology to ascertain the authenticity of food product constituents
- To advance detection techniques to substantiate the history of food products, i.e. the production system (e.g. organic, halal), provenance (geographical origin), and processing.

Project 2.1 Towards a robust tool to assess fraud vulnerability of company in complex supply networks

Supervisor:
Saskia van Ruth (Saskia.vanruth@wur.nl)

Food ingredients are sourced globally nowadays, with price being the main governing feature. The food supply chain network has become very extensive, which increased its susceptibility to fraud. Food fraud covers issues with composition, processing, shelf-life, geographical origin as well as production practice (e.g. organic). Recently, cases of meat fraud received considerable media attention (e.g. horse-meat scandal). Fraud may relate to the species of meat and the meat content in a product, but also processing (injection of water; defrosted meat sold for fresh), the geographical origin, and production practice (organic). Rather than looking at specific incidents, a system analysis approach is preferred in order to prevent fraud in the future. For both policymakers and food industry there is a need for tools to systematically assess the vulnerability to fraud in food supply chains from various perspectives such as the offender, organisation and chain, and analytical perspective (how well can fraud be detected with current techniques). In anticipation to these needs, various initiatives are currently undertaken (USP guideline, PAS96, GMA guideline, BRC, SSAFE), but each follows a different approach.

In a previous student project, an analytical framework has been developed to get insight from a systems perspective in technological and social (people) factors increasing the risk on fraud in meat supply networks based on in-depth theory analysis and expert interviews. In the previous student project, the possibilities for fraud with beef were inventoried, the beef meat chain mapped and analysed, people factors in fraud studied, as well as market economics providing fraud opportunities. Currently this analytical framework is further elaborated into a vulnerability assessment tool in the frame of SSAFE. However, many other initiatives are running.

The aim of the study thesis is to perform a concise literature analysis to evaluate the preliminary fraud risk assessment tool and to compare the structure, approach and content it with other tools that have been developed recently. Based on this analysis, modifications can be made, and the tool should be validated and evaluated in practice.

Project 2.2 Chocolate: linking sustainability to flavour composition and release

Supervisors
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Valentina Acierno (valentina.acierno@wur.nl)

Novel analytical techniques are able to measure naturally occurring compositional characteristics of chocolate, which in turn may demarcate the place and way of production/processing of sustainable chocolate and chocolate ingredients. This will ultimately improve the traceability of sustainable chocolate.

In this student project you will examine the release of volatiles from chocolates during consumption, in order to examine differences due to origin and production system (e.g. organic, sustainable). Volatile release will be measured by Proton Transfer Reaction Mass Spectrometry in the nose of volunteers while they are consuming the chocolates. You will set up a method to measure adequately in the nose of people. Subsequently, a representative set of chocolates will be analysed. Data will be subjected to statistical analysis in order to examine the different patterns observed and to link origin/production of chocolate to their flavour (volatile) characteristics.

Project 2.3 How to detect fraud with spices?

Supervisors
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Herbs and spices are costly commodities, vulnerable to adulterations. An example of food adulteration is the blending of the spices with lower value ingredients to increase own economic benefit. In this case, other parties in the chain and consumers are deceived. Saffron is a spice derived from the flower of *Crocus sativus.* Prices of saffron may be go up to €7,500 per kg, which makes the spice susceptible to adulteration. Typical adulterations include mixing in extraneous substances like beets, pomegranate fibers, red-dyed silk fibers, or the saffron crocus's tasteless and odorless yellow stamens. To support saffron production and genuine trade, measures against deliberate adulterations are required. The general project aims at improvement of non-targeted analytical fingerprint methods which could be used for screening for anomalies.

In this student project, you will develop methodology to analyse different grades and adulterations of saffron. A fingerprint type method based on mass spectrometry will be used and adapted for saffron. The method will be compared with the colorimetric ISO method for grading saffron which is based on spectroscopy. Eventually, retail samples will be collected and tested with the newly developed method.

Research theme 3 - QUALITY DESIGN OF FOODS: FROM PRODUCT TO CHAIN DESIGN
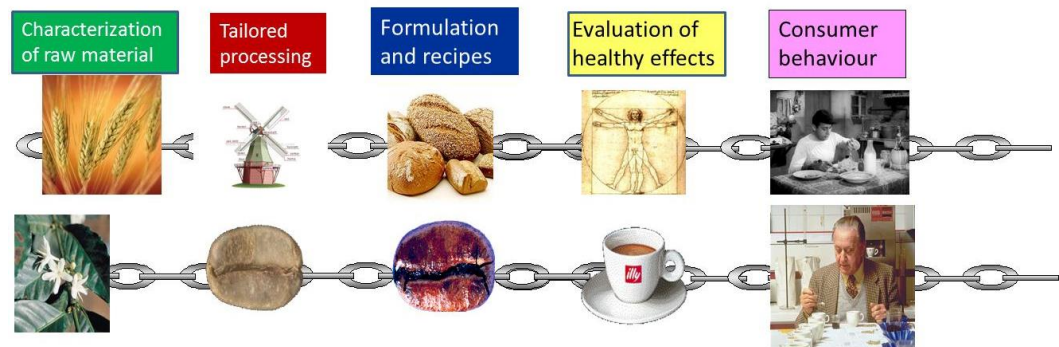
Introduction

In this research theme, the design of healthy foods is approached in a holistic way from the nutritional, technological, and managerial point of view to find out the more suitable strategies to create value at the different points of each food chain. All aspects that should be considered to achieve quality in developing food products, in developing food process designs, and in developing food chain design will be considered. Quality design is very important for companies in agribusiness and food industry to remain competitive. Similarly, the adoption of quality design approach into the food chains deals with incorporation of critical chain aspects, for instance, trustful customer-buyer relationships determining optimal food quality.

Objectives

The overall objective of research is to find out critical quality points in developing new food products, in developing new food process designs, and in new food chain designs to establish an optimal food quality that helps companies in remaining competitive. Food healthiness is one of the main driver in the creation and marketing of new food products. Different strategies can be pursued to design healthy foods such as the adoption of new ingredients having potential health benefits or the implementation of production processes to optimize the formation of desired compounds and to reduce the formation of those potentially harmful. Also, foods targeted at specific categories can be designed: children, pregnant women, elderly, sportsman, students population. As well as foods intended for the prevention of specific pathological conditions: foods for weight management, osteoporosis, gut health, mental performance and so on.

- To design healthy foods looking at the different point of the production chain from raw materials to consumer satisfaction. Developing formulation and processing strategies for designing foods tailored for different health benefits
- Evaluate the possibility to introduce new ingredients having additional health functionality over those already claimed also using in vitro models for the systematic design of functional food for the benefit of gastrointestinal tract
- To control the development of Maillard reaction minimizing the formation of potentially dangerous products and increasing the formation of desired ones
- To find out critical quality points in developing new food products, in developing new food process designs, and in new food chain designs to establish an optimal food quality that helps companies in remaining competitive.

Project 3.1 Quality parameters influencing consumers' perceptions of canned tomato products

Supervisor
Vincenzo Fogliano (Vincenzo.fogliano@wur.nl)

Tomatoes in cans are commonly used in all kinds of food recipes. On the shelves, the canned tomatoes might seem for consumers very similar but large differences in quality parameters exist among peeled tomatoes, chopped tomatoes, cherry tomatoes, tomato puree, tomato sauces. The different types of canned products have different cost, taste, destination of use, however, many consumers are not aware of this.

The research focus is on consumers' perceptions of canned tomatoes: 1. What do consumers perceive as quality determinants regarding this food product? 2. How are these quality parameters influenced by the consumers' knowledge about this food product? The gained insights in consumers' perceptions would be used to analyse opportunities for creating added value to the existing products and communicating properly their quality. The research aims to identify those key quality parameters that could be changed based upon consumers' perceptions.

The research approach is in this thesis would be first a literature review on the known quality parameters of canned tomatoes. Subsequently, a consumer survey and/or consumer interviews and/or sensory tests could be done to gain insights into the perceived quality of a selected number of canned tomatoes. Finally, the analysis of key parameters should be translated into product changes.

Consumer panels/focus group discussions might be used to verify the perception of the quality of these 'optimised' products by different categories of consumers.

Project 3.2 Quality design of functional pasta to increase market share

Supervisor
Vincenzo Fogliano (Vincenzo.fogliano@wur.nl)

Vegetables can contribute to a healthy diet, but the intake is for various consumers still limited. The food industry is searching for innovative products containing vegetable ingredients that are tasty and healthy. Pasta enriched with vegetables can be a good strategy to increase the vegetables intake, because (1) pasta is routinely consumed, and (2) dry pasta is a perfect carrier to stabilise phytochemicals that otherwise are easily degraded.

Currently some vegetables containing pasta products (mainly spinach) are available at the market but they are purchased just one time or ad hoc and repeated purchase is limited. The main research question is what are the key factors contributing to repeated purchase for this type of products?

Typical sub-research questions are: What are consumer expectations and perceptions of "coloured pasta" that contain vegetable ingredients? Which steps need to be undertaken along the pasta supply chain to allow this functional pasta to exit from the niche market and become a regular choice?

The research will consist of a literature review on quality parameters of vegetable pasta. Interviews with consumers could be done to gain insight into current pasta use and expected quality attributes of vegetable pasta in order to implement them in product design.

The case study of broccoli pasta will be the starting point to define a general strategy that could be used in product design and in the definition of key messages to consumers. More details will be provided next year.

Project 3.3 Crucial correlations between product and process variables in processing pre-cooked rice

Supervisor
Vincenzo Fogliano (Vincenzo.fogliano@wur.nl)

Dry rice sold at retailers usually has a moisture content of appr. 12% or lower. This moisture level prevents micro-organisms to grow on rice, which makes the product shelf stable for a long time at ambient conditions. When rice is sold as pre-cooked rice, dry rice will have to be cooked, filled and subsequently processed in flexible packaging materials (e.g. pouches) to deliver an ambient shelf-stable product for consumers. Any micro-organisms present in the pack will need to be inactivated to guarantee food product sterility. Inactivation of these micro-organisms is depending on a number of factors like time, temperature, pH but also Aw (related to moisture content) of the food product. Key in this master thesis is to gain insight in the crucial correlations between all the involved factors and particularly the role of Aw/hydration in the inactivation of micro-organisms. Therefore, the overall research question is: "*What is known about the crucial correlations between time, temperature (processing conditions) and Aw/hydration and pH (food dynamics) and particularly the role of Aw/hydration in the inactivation of micro-organisms i.e. spores on pre-cooked (dry/hydrated) rice?*"
The literature review on factors determining the inactivation of micro-organisms in rice has two aims:

1. To identify implications for HACCP systems of rice supply chains to guarantee an ambient shelf-stable product for consumers
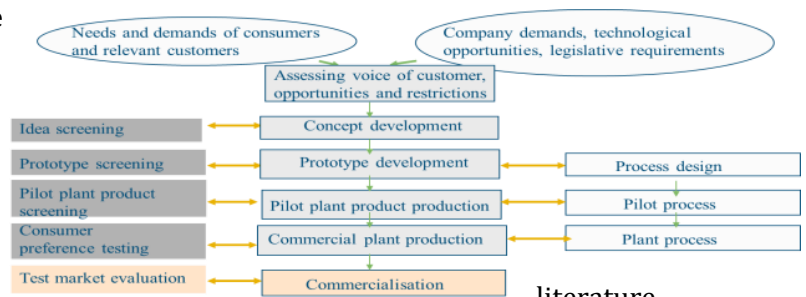2. To identify implications for consumers' use of rice products at home to guarantee their health
   The research approach in this master thesis is majorly literature review combined with consultations of rice supply chains and consumers depending of the literature findings. Finally, the deliverables of this thesis should be an advance in understanding on the possible contamination routes of the relevant micro-organisms along rice supply chains, the inactivation factors at factories, the CCP's along rice supply chains and the consumers' role in this respect.

Project 3.4 Constructing 'Critical Quality Points' frameworks on quality designing of new products

Supervisor
Elsbeth Spelt (Elsbeth.spelt@wur.nl)

New Product Development (NPD) is of crucial for food industry in maintaining consumers buying their brands. NPD can be technological-driven or consumer-driven. In both kinds of NPD, it is necessary to understand the critical quality points of the new product development processes. Since understanding of the critical quality points of NPD processes may enhance the success rates of those innovations involved. Critical quality points of NPD processes are, for instance, adequate communication between departments or clear product specifications. The critical quality points of NPD processes can be distinguished into three categories: (a) the food product, (b) the food processing, and (c) the food packaging. The aim of the master thesis is to clarify the critical quality points of NPD processes in order to optimize these processes in the food industry in term of innovation success and process efficiency. The clarification of critical quality points will be done via literature review and experts consultations across the academia and food industry. The consultation of the academia and the food industry will be purposefully conducted to increase the added value of the framework for scientific purposes as well as for business purposes. One of the task is to validate an existing framework on quality designing of new product development processes on its usefulness for a particular part of the food industry, for instance dairy industry or beverage industry. Another task is to research the feasibility of applying the lean thinking framework in order to gain in efficiency of new product development processes in food industry.

Project 3.5 Importance of factors determining fresh meat quality

Supervisor
Jozef Linssen (jozef.linssen@wur.nl)

Meat is one of the sources of food having a high nutritional value. As for each food product a high quality is important for consumers. The major components determining of high meat quality are:

1. Yield and gross composition
- Quantity of saleable product
- Ratio of fat to lean
- Muscle size and shape
2. Appearance and technological characters
- Fat texture and colour
- Amount of marbling in lean (intramuscular fat)
- Chemical composition of lean
- Colour and WHC of lean
3. Palatability
    - Texture and tenderness
    - Juiciness
    - Flavour
      4. Wholesomeness
          - Nutritional quality
          - Chemical safety
          - Microbiological safety
    5. Ethical quality
        - Acceptable husbandry of animals
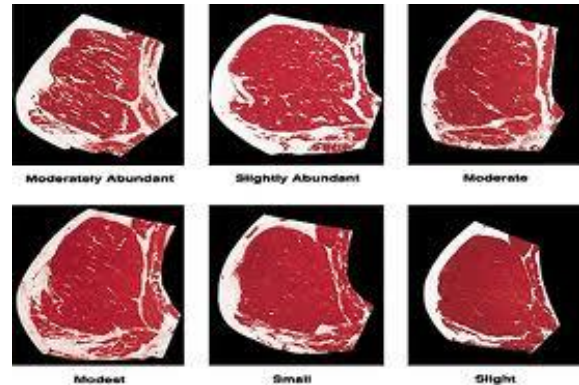
Several factors determine the quality of fresh meat in meat chains. These factors are for example feed or stress before slaughtering or other factors. Moreover, slaughtering of animals yields different types of meat with different quality. Quality factors of for instance a steak or a slice of bacon are different. Also meat quality of meat from different animals (beef, pork, chicken, lamb, etc.) are different. Two overall types of quality can be distinguished. *Functional quality* refers to desirable attributes in a product. For example, we might want red meat to be tender and chicken meat to have good flavour. *Conformance quality* is producing a product that meets the consumers' specification exactly. For example, pork chops must be trimmed or we want "portion sized"chicken breasts. Most people tend to mean *functional quality*, but quality management often focus on *conformance quality*. However, both types are important. Your task is to distinguish the importance of factors determining fresh meat quality.

Project 3.6 Food design strategies to add value to the coffee chain

Target: MFT (or MFQ depending on the specific research questions)

Supervisor
Vincenzo Fogliano (Vincenzo.Fogliano@wur.nl) plus others depending on

the specific research questions

Short Description
The Coffee production is still of major importance in the trade between transition countries producing the raw beans and developed countries where most of the roasting and consumption occur. There is a continuous effort to create new business opportunity around coffee with the development of new products such as the coffee capsules for domestic consumption. Roasting and processing of coffee also offer opportunities for differentiate the products and different chemical composition can also lead to different food and health implication

Research questions
Question 1: Can dry separation technology be applied to obtain different coffee products?
Question 2: Can the addition of precursor during wetting influence the formation of melanoidins keeping the same roasting degree ? Are the aroma key odorants influenced by this practice?
Question 3: Which are the key determinant of quality perceived by consumer and how this is related to previous consumption experience (i.e origin country)

Proposed approach
To answer the different research question appropriate methodologies will be used combining chemical and physical analysis with formulation strategies and new processing technique. Focus group and consumer survey will be employed to answer question 3

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Fogliano V, Morales MJ. Estimation of dietary intake of melanoidins from coffee and bread. Food and Function 2011, 2, 117-123

Research theme 4 - PRODUCTION AND CONSUMPTION OF NOVEL PROTEIN FOODS: INSECTS

Introduction

In view of the ever increasing world population the demand for protein will increase over the next decades, and new protein sources are searched for. Insects have been proposed as one of the potential future protein sources of protein. Although insect consumption is new in the western world, world-wide over 1900 insect species are consumed and appreciated for their taste. Several reasons exist for considering insects as a promising alternative source of animal protein in this part of the world. First, the production of insects is highly sustainable in comparison to production of cattle, pork, and poultry. Farming insects is characterised by higher food conversion efficiencies, lower environmental impact, and higher potential to be grown on waste streams. Sustainability is expected to be an increasingly important aspect for consumers when choosing foods and evaluating food quality, although also nutritional and sensory aspects are among the aspects of major importance. The research is focussed on generating knowledge on how to use insects in a tailored way as an alternative source of protein for human consumption, direct or indirect through the feed chain.

Overall objectives - with a view on defining pathways towards insect-based food consumption - are:

Processing of whole insects in order extract proteins, fats in relation to functional aspects of the fractions obtained (MFT topics)

Consumer acceptance in relation to processing and sensory quality (MFT/MFQ)

Project 4.1 Healthiness of edible insects: nutrient profiling

Supervisor
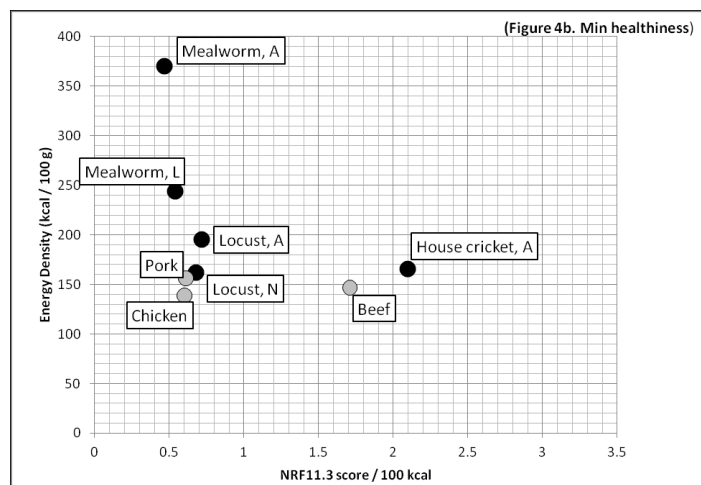Catriona Lakemond (Catriona.lakemond@wur.nl)

Commercial farming, processing and marketing of edible insects are hot issues now because of sustainable potential. In general, the reproduction of insects is less time-consuming compared to conventional livestock (e.g. pig, cattle). Moreover, a potential shift of human diets from animal meat to insects has beneficial impacts on environment and ecosystem. Consuming insects could contribute in solving the increasing requirement of high-value protein globally. As a possible replacement of animal protein, edible insects can be progressively served up for human consumption.

Consumers like their food to be healthy. Currently there is little insight into overall healthiness of edible insects. In most cases, each insect nutrient was evaluated individually; a healthiness comparison between insects and conventional food groups was neither comprehensive nor systematic. Without powerful nutrition and health claims, consumers have no clear idea about the healthiness of insect-based foods.

To help the public make more healthful food choices, the latest American dietary recommendations -2010 Dietary Guidelines for Americans- underlined the use of the **nutrient density** concept, and approved of **nutrient-dense foods** and beverages which contributed to achieving and maintaining a healthy weight (USDA and HHS, 2010). In fact, nutrient density deals with the principle of "the amount of nutrients per calorie". In France, according to the national program on nutrition and health (PNNS), the nutrient density of a food corresponds to its content of essential micronutrients in relation to its energy value. In the United States, according to the United States Department of Agriculture (USDA) and the US Department of Health and Human Services (HHS), nutrient-dense foods offer vitamins, minerals, and other substances that may have positive health effects, with comparatively few calories.

(Figure 4b. Min healthiness)

Consuming nutrient-dense foods enables people to achieve nutrition goals without exceeding daily energy requirement, which is more beneficial to human health. In this sense, nutrient density can be a good indicator for food healthiness; a higher nutrient density manifests more nutrient-dense and more healthful the food is.

In order to assess nutrient density different nutrient profiling systems are used in literature. Nutrient profiling aims at ranking foods based on their nutrient content as opposite to their energy content. The research will aim at gathering nutrient data of specific insect species, and ranking them for nutrient density using appropriate nutrient profiling systems. Comparisons will be made with traditional and novel protein sources/products. The approach taken will be from a Q-design perspective.

Project 4.2 Towards a sustainable insect production chain

Supervisor
Catriona Lakemond (Catriona.lakemond@wur.nl)

Insects are considered to be a future alternative protein source. Literature supports that rearing insects is sustainable in comparison to traditional meat sources. Insects are already offered as a whole on the market. Another foreseen development is bio fractionation of insects into a protein, a fat and a chitin rich fraction. In order to be able to offer insect fractions as being sustainable to the public, it is important to use sustainable processing technology and handling along the food chain. This research will identify sustainability criteria in food supply chains and will develop a tool to analyse levels of sustainability.

One of the topics that will be studied is chitin. Chitin is, after cellulose, the most abundant polysaccharide found in nature. It is present in cell walls of bacteria and fungi, and in the exoskeleton of crustaceans and insects. Chitin is a non-toxic, water-insoluble biodegradable linear polymer. It is converted into chitosan upon deacetylation, a degree of deacetylation below 50% causes it to become soluble in aqueous media. Industrial use of chitin and its derived products include medical applications, as in wound healing, and usage in cosmetic products, i.e. in hair and skin care products. In view of these industrial applications chitin is extracted from its matrix using harsh conditions; an acid hydrolysis step (e.g. 2M HCl….) is required for demineralisation, an alkaline treatment (1 M NaOH…) for deproteinisation, and usage of organic solvents for elimination of lipids and colour. The current methodology used is expensive, environmentally unfriendly and, therefore, not seen as sustainable, which legitimates the search for more sustainable processing methods for using chitin-rich side streams.

Project 4.3 The identification of law-bottlenecks along the supply chains producing insect based foods

Supervisor
Catriona Lakemond (Catriona.lakemond@wur.nl)

Multiple research and development projects are undertaken at Wageningen UR to start up insect-based food supply chains. The starting up is done to meet the worldwide food demands which will increase over the years. This starting up requires various changes in the current law and regulations systems as the introduction of insect-based foods is new in Europe. Therefore, this thesis research will analyse the requirements for setting up supply chains producing insect-based foods. The research question is: What are the requirements to set up supply chains producing safe and high quality insect-based foods?
Approach:

1. A theory analysis on setting up supply chains producing safe and high quality insect-based food using the law perspective
2. A theory analysis on setting up supply chains producing safe and high quality insect-based food using the food quality and food safety perspectives
3. An integration of the knowledge of the three perspectives to make an inventory of requirements
4. A comparison of the requirements with the actual situation to identify the bottlenecks/changes
5. A derivation of implications for theory in terms of further research recommendations
6. A derivation of implications for practice in terms of implementation scenarios

Project 4.4 Nutritional quality of indigenous edible insects of Zimbabwe

Target: MFT MFQ

Supervisors
Faith A. Manditsera (faith.manditsera@wur.nl);
Dr. ir. Catriona Lakemond (Catriona.lakemond@wur.nl)

Indigenous edible insects of Zimbabwe are one of the underutilised natural resources that can help to reduce the problems of food insecurity. The FAO reported that nutrients found in insects have a potential of reducing nutrient deficiencies in a population consuming them, thus directly contributing to food security. Indigenous edible insects can also be used as fortified blended foods, mainly because of their protein and micronutrient content. However, there is a high variability in the nutritional value of insects. The nutritional value of insects depends, amongst others, on the type of species, type of feed, insect stage, habitat, origin, and method of cooking. Knowledge of the nutritional value of insects is important to have a clear understanding on how insects can be used in filling dietary gaps in malnutrition. Eulepida species (mandere) also known as chaffer beetles and Henicus whellani (majenya) also known as monster/king cricket are amongst indigenous edible insect species that are consumed in Zimbabwe. The protein content of mandere and majenya are 52.2% and 53% respectively.

The thesis will focus on determining the current state of the art in the insect value chain with respect to the protein quality of indigenous edible insects harvested from different regions. In-vitro protein digestibility and amino acid determination will be carried out to determine the protein quality of the insects.

Research theme 5 - CONSUMER-PRODUCT INTERACTIONS IN CONSUMER CHAINS

Introduction

In the production and supply chain, the quality of food products is controlled to keep it at an optimal level. However after the product is purchased by the consumer, it has to be stored and prepared before actual consumption takes place. In this last part of the chain the quality can deteriorate due to product handling processes by the consumer. Hardly any research is done on consumer handling and practices at home with food products. In order to gain more insight into these behaviours, consumer research in daily life situations is needed to understand practices and motives behind these practices. The methods used will be in home observations and interviewing of consumers. With lab analysis the influence of the consumer behaviour on the final, consumed quality can be assessed. When the final steps in the chain are taken into account during product design, possible quality loss can be prevented by anticipating on the behaviour of the consumer. The aim of the projects will be to generate knowledge that can be used to improve product design and/or to inform consumers about more appropriate food handling.

Overall objectives

Understanding consumer behaviour (and their motives) related to food storage /food preparation and the effect on food quality

Understanding consumer behaviour (and their motives) related to optimal use of appliances for food preparation

Project 5.1 Analysing how (mis)alignment in quality requirements along the supply chain can affect food waste

Supervisor
Bea Steenbekkers (bea.steenbekkers@wur.nl)

How to reduce food lases and food waste is a core issue for policy makers and scientist.. Studies are currently focussing on specific parts of the food supply chain (e.g. improvement of techniques in food processing) although they acknowledge importance of a chain perspective. An explorative chain study indicated that quality requirements vary markedly along the supply chain.

The aim of this study is to assess to what extent quality requirements in different parts of the chain can be aligned in order to reduce the amount of food waste. The focus of this project is on understanding the motives for the set quality requirements in order to be able to define more realistic quality requirements.

The study comprises the chain from production to consumption by the consumer (at home or in a restaurant/ catering). An important aspect is to define 'food waste' and to assess a feasible yet reliable measuring method to assess food waste.

Project 5.2 Understanding influence of technological and social/people factors on the occurrence of unnecessary food losses

Supervisors
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Pieternel Luning (pieternel.luning@wur.nl)
Daphne Roodhuyzen (daphne.roodhuyzen@wur.nl)

How to advance towards sustainable food supply chains is a topic that is high on the agenda of policy makers, NGOs, researchers, and the food industry. In order to reduce food losses during processing and food waste at consumption stages (i.e. catering, restaurants, households) it is necessary to get insight into the factors that incite unnecessary losses. Several studies have provided insights in the amount of food waste in catering settings and at household level, but analyses from a systems perspective are limited. A systems analysis requires an assessment of crucial elements in the system that could affect food waste, and understanding of the causal relationships. To our knowledge, much less is known on the relationship between food product characteristics, household/institutional facilities, social context (family/institutional), food handler characteristics and the occurrence of food waste. These insights are necessary to develop effective system interventions to reduce food waste

The thesis work is part of a new PhD project about: A systems approach to the development of effective interventions for reducing food waste at consumption stages. The aim of the thesis project is to get insight in how food product characteristics, technological facilities, social/organisational context factors, and food handlers' characteristics could affect food rejection behaviour in institutional catering and domestic settings. One MSc student will focus on catering and the other on the domestic circumstances

The study includes an in-depth literature and document analysis of food waste amounts, characteristics of waste streams and possible causes as input for the development of an analytical framework to identify and assess risk factors contributing to unnecessary food waste. Also serious gaming as a new tool for identifying cause-effect relationships could be explored as part of the thesis.

Project 5.3 Analysing causes of food quality decay occurring between purchase and actual consumption

Supervisor
Bea Steenbekkers (bea.steenbekkers@wur.nl)

In the last few decades, actors along the food supply chain invested a lot in control and assurance of, amongst others, safety, nutritional value, and sensory quality parameters of their products. Correspondingly, many studies focused on understanding factors influencing these quality parameters along the food supply up to the retailer. However, the quality of a food product is finally determined at actual consumption. This is after the food is prepared and served for consumption. This last part of the chain gained much less attention in research. Are the actual quality parameters in compliance with the intended quality as realised in the food supply chain?

The aim of this study is to get insight into technological and people-related factors that contribute to the decay of specific quality parameters (e.g. Vitamin C, low microbial levels, etc.) between the moment of purchase and actual consumption. The focus of this topic is on understanding user-product interactions and the motives behind this interaction. The study comprises the analysis of actual purchase, storage, meal preparation, and serving behaviour of people in real life situations, and measuring the impact on specific quality parameters at consumption. An important aspect here is how to set up accurate and reliable observation experiments (methodological research question). The study investigates also the motives behind current behaviour in order to identify dedicated opportunities for different types of interventions (e.g. via communication, or technological/technical tools). Depending on the research progress and time, a selection of interventions might be tested on its impact on the measurable quality parameters.

Project 5.4 Understanding consumer perception of 'Naturalness' in different product categories

Supervisor
Bea Steenbekkers (bea.steenbekkers@wur.nl)

Companies promote their products using all kinds of claims on the packaging of their products or in advertisements. The use of the claim 'organic' is regulated, but for 'natural' no rules are available. This implies that producers of food products can define their own rules and guidelines for claiming the naturalness of their products. It is not known to what extent consumers understand this claim, how they perceive and interpret it and what relationship they expect with food quality.

The aim of this study is to get insight into product, proces and human related factors that contribute to the perception of naturalness of products and to what extent that differs for different product categories.

The study links the perception of naturalness by consumers to product and process characteristics of (to be) selected product categories.

The goal of this study is to give recommendations for companies on how to take consumer perception with respect to their specific product into account when deciding about claiming 'naturalness'.

The study will be based on study of the literature, interviews/questionnaires with consumers and experts within companies.

Project 5.5 Consumer Behaviour and Food Quality

Target: BLT MFT, MFQ with interest in consumer behaviour

Supervisor
Bea Steenbekkers (bea.steenbekkers@wur.nl)

Hardly any research is done on consumer handling and practices at home with food products. How are products stored and prepared and how do these practices influence the final product quality. In order to gain more insight into these behaviours, consumer research in daily life situations is needed to understand practices and motives behind these practices. The research methods used will be in home observations and interviewing consumers. With lab analysis the influence of the consumer behaviour on the final, consumed quality can be assessed.

When these final steps in the food production-consumption chain are taken into account during product design, possible quality loss can be prevented by anticipating on the behaviour of the consumer.

This type of research needs to be done with all food products, according to the students' own preferences: e.g. vegetables (including new products like sea weeds), dairy, meat, meat replacers (incl. insects), convenience products etc. Examples of products recently studied are broccoli and carrots as part of a hot meal. Also the influence of in home behavior on the quality of ready-to-eat meals has been studied.

The aim of the project will be to generate knowledge that can be used to improve product design and/or to inform consumers about more appropriate food handling.

Project 5.6 Consumer attitudes and willingness to consume processed cape gooseberry products (Dutch case study)
Target: MFT MFQ

Supervisors
Anita Linnemann (anita.linnemann@wur.nl)
Bea Steenbekkers (bea.steenbekkers@wur.nl)
Mary Luz Olivares Tenorio (maryluz.olivarestenorio@wur.nl)

Cape gooseberry is a promising fruit given its functional properties and fruit characteristics, which make it a good raw material for numerous products such as juices, jam, pulp, desserts, dehydrated fruit, oil, etc. Therefore, those processed products have been entered into the market to give an added value to the supply chain. The market for these processed products, however, currently is local and despite an interest by international markets there is a need to improve the knowledge about consumer willingness to repeatedly purchase these new products.

Aim
Assess consumer attitudes of Dutch people and willingness of consumption of cape gooseberry new products.

Project 5.7 Preferences on quality-attributes of European (or Dutch) actor of supply chain of cape gooseberry (Physalis peruviana L.)
Target: MFT MFQ

Supervisors
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Mary Luz Olivares Tenorio
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The Cape gooseberry is a very important fruit for Colombia, given its international demand. The supply chain, however, still faces some barriers due to, among other factors, the lack of knowledge of consumer and buyer preferences. The market context in terms of quality attributes of the fruit and their importance in the purchase decision of chain actors is not clear. For this reason this project proposes to investigate the quality-attributes of Cape gooseberry and their importance for actors in the chain who have a purchasing role (importers, distributers, exporters, supermarkets).

Aim

Set up a list of contacts of European actor of supply chain and assess quality-attributes preference on cape gooseberry.

Research theme 6 - GOVERNING FOOD SAFETY AND SUSTAINBILITY IN FOOD SUPPLY CHAINS

Introduction

In food policy, we can witness a shift in governance. From a regulatory, top down mode of governing, the responsibility is increasingly transferred to companies. Nowadays in Europe, companies have to account fully for their policies and actions in the field of food safety and sustainability. Government by means of the national Authorities do not anymore inspect the shop floor but inspect the quality systems of companies in order to assess whether or not a company is abiding by the goals of the food safety policy. Such a change in mode of governance affects the focus, organisation, and capabilities of the government but also that of companies. What are the consequences of such a change for the inspection by government officials, both technological and administrative? How can we assess that a governmental inspection at a distance of the shop floor, renders a reliable image of the more or less complex processes in the company and between companies in the food chain and ultimately of the food safety of the product.

From a more global perspective, one can notice big differences in enforcement philosophies (facilitative versus systematic), - strategies (state versus market driven), and – practices (e.g. standards, sanctions, audits, information support etc.).

The **overall objectives** include the understanding of how (differences in) enforcement philosophies, strategies, and practices affect the governing of food safety and sustainability in (international) food supply chains. Understanding of how companies (industrial to small and medium enterprises) translate QA requirements into their systems. Designing tools to support companies in assessing how they perform in the sustainability dimensions.

Project 6.1 Developing FSM-systems in a multi-stakeholder environment

Supervisor

Geoffrey Hagelaar (Geoffrey.hagelaar@wur.nl)

Food Safety Management-systems are designed on the bases of quality and safety goals. All the control activities are directed at reducing risks concerning food safety and reducing variety in quality output. The choice for the goals to be achieved on strategic level and on an operational level and the measures to be taken are ultimately made by a company. However, these decisions are taken in an environment in which different stakeholders from differing perspectives pose quality assurance requirements to that company. Especially when dealing with an international supply chain requirements to food quality and safety can be far apart. The quality and food safety output on which the demands are focussed can be labelled as a wicked problem i.e. a problem with multi-dimensions and possibly conflicting aspects. Within the companies, choices need to be made in which the technological infrastructure and the organizational capabilities need to be aligned in order to reach the goals.

In this research, an international supply chain will be focussed upon. For this supply chain (1) stakeholders will be identified, (2) the perception of the stakeholders of certain aspects of food quality and safety will be analysed, (3) the influence of these requirements of different stakeholders will be analysed from a technological and managerial angle.
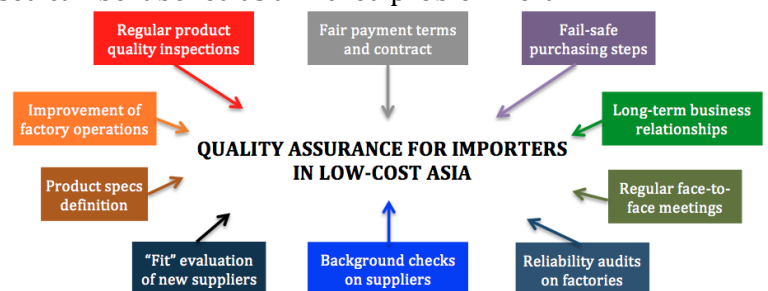
Project 6.2 Tailoring FQM-systems to small and medium sized companies

Supervisor
Geoffrey Hagelaar (Geoffrey.hagelaar@wur.nl)

Food quality management systems have a tendency to be designed and to develop into a conglomerate of rules, norms and measurements, including training, tasks and responsibilities throughout the organisation and related to a managerial and technological infrastructure. From this point of view one can assume that fqm-systems are developed for the bigger companies which have the capacity to deal with all these presumed managerial and technological conditions. On the other hand, the majority of companies is not a bigger company but is a small or medium sized company. Those kind of companies are in a certain sense the mirror image of bigger companies. The organisation is rather informal, not that much specialisation of employees, different functions are intertwined including quality and the director-owner is leading from a strategic level to the operations. Flexibility is a characteristic of such companies and a strength.

In this setting a FQM-system is to be implemented which is apart from internal drivers, required as well by stakeholders as consumers, buying companies, (international) governments. Ultimately, the goal for big companies as well as for small and medium sized companies, is to produce products with a certain level of quality and safety. However, small and medium sized companies, because of their different organisational conditions compared to big companies, will cope with this task in a different manner. The thesis goal is to deepen the insight in how in the setting of small and medium companies cope with the organisational and technical requirements presumed by a FQM-system.

Project 6.3 Developing a diagnostic to assess Food Sustainability to support the governance of sustainability
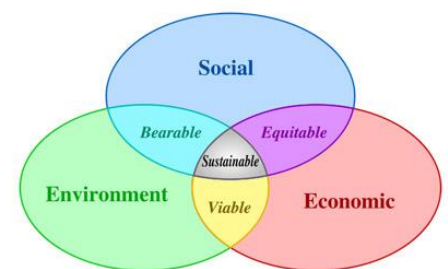
Supervisor
Geoffrey Hagelaar (Geoffrey.hagelaar@wur.nl)

Labelling and (third party) certification reflects a shift of public governance to private governance. Certification provides assurance to stakeholders about the production process and the product itself. The rise of private governance in the form of certification is in line with the globalization of the food supply chain. This has a consequence that an increasing amount of food is produced in other countries then it is consumed. The purchase of food stuffs is evidently done from suppliers who function under different regulatory regimes on food safety and food quality. Moreover, the speed in which new demands on food quality and food safety are introduced puts a strain on governmental agencies. Governmental agencies tend to lack behind the newest developments in production practices. This holds true not only for food quality but also for sustainability.

The effect of this trend is that not only governmental organizations, like the global WTO, is standard setting but also internationally operating retail organizations see themselves as standard setting organizations. For supermarkets, standard setting is not only targeted at governing the stakeholders in the supply chain to ultimately selling the product with the intended food safety and quality attributes. The standard is developing into a strategic issue as well with which new markets can be developed and penetrated. Sustainability seen as a food attribute is one of the characteristics of food stuffs which becomes increasingly important as a strategic attribute as well.

Because of the previously mentioned trend of the increasing usage of certification by retail organizations, the number of sustainability certification rises. With this increasing number of certificates, the overview of consumers or of representing consumer organizations becomes blurred. Every certificate seems to develop their own line of attention, which ends up in different sustainability issues taken into account by specific certificates. In this study, we want to address this variety of sustainability certificates by examining a bases for comparing sustainability certificates.

The master thesis focusses on the identification of critical decision points on measures taken in production and processing from the perspective of sustainability and assessing the impact of those decisions on the sustainability of the product. On the basis of the developed assessment instrument different sustainability labels can be compared and get an overview on the sustainability certificates.

Project 6.4 Assessing the potential for large scale production of insects: a chain perspective

Supervisors
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Geoffrey Hagelaar (Geoffrey.hagelaar@wur.nl)

The increasingly growing population puts great pressure for sustainable food production. Environmental and ethical concerns of the intensive traditional livestock production to feed the world population have been pointing out for the need to develop production for alternative supply of animal protein. Insects are a potential alternative because they are nutritious, easily reared requiring minimum space and can help limitation of the environmental footprint. However, to have a significant impact on the environment, the production of insects needs to be on a large scale and barriers such as consumer acceptance and requirements for the production and commercialization of these products need to be addressed.

Previous research shows that the main bottlenecks for the expansion of large scale production of insects as human food are the lack of close collaboration between partners, the relationship with customers/consumers, and the lack of appropriate technical knowledge in insect rearing and processing. Multiple efforts throughout the insects supply chain must be made to allow for availability of insect on a large scale basis, especially aspects related to consumer orientation, chain collaboration and expansion of the current knowledge in insect production. The research will focus on potential successful strategies to build in these aspects to a larger extend in design of the entire insect chain.

Research theme 7 - MODELING FOOD LOGISTICS MANAGEMENT

Introduction

Logistics in food supply chains is a key factor in controlling quantity and quality, and more recently also sustainability. Traditionally, logistics is mainly focused on quantity, cost, and location, quality controlled logistics aims for a concurrent analysis of logistic- and food quality parameters to support the design of effective and efficient food supply chains resulting in satisfied customers, less waste and more sustainable supply chains. The focus of this research theme is on the evaluation of opportunities and bottlenecks of this concept in which logistics flows are controlled (steered) using quality data and sustainability data. How can we optimize the product availability in the different market segments and optimise product quality and sustainability using quality prediction models and logistic models.

Overall research objectives include understanding the impact of context characteristics on the effectiveness of combined logistics and quality control, identifying and modelling strategies to improve sustainability of food supply chains.
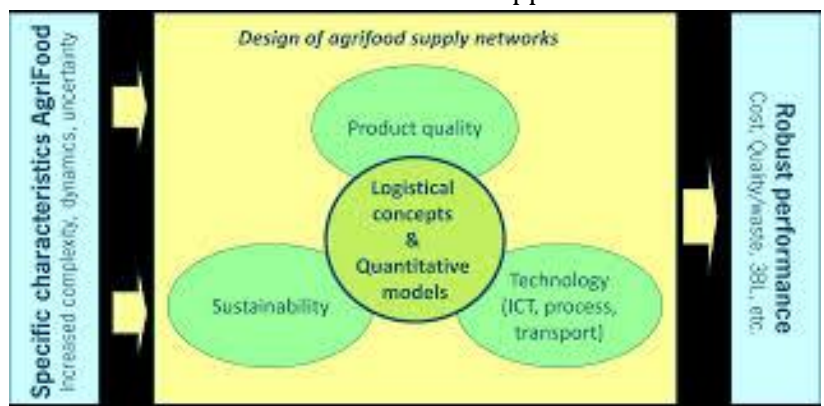
Project 7.1 Analysing the actual variation in quality parameters along fresh produce supply chains under different storage facilities, logistic systems, and supply chains

Supervisors
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Pieternel Luning (Pieternel.luning@wur.nl)
Lesley Macheka (lesley.macheka@wur.nl)

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. The MSc project will be further demarcated.

Project 7.2 Further developing and testing a diagnostic instrument of quality controlled logistics in food supply chains

Supervisor

Jack van der Vorst (jack.vandervorst@wur.nl)

Western-European consumers have become not only more demanding on product availability in retail outlets but also on other food attributes such as quality, integrity, and safety. When (re)designing food supply-chain networks, from a logistics point of view, one has to consider these demands next to traditional efficiency and responsiveness requirements. The concept 'quality controlled logistics' (QCL) hypothesizes that if product quality in each step of the supply chain can be predicted in advance, goods flows can be controlled in a pro-active manner and better chain designs can be established resulting in higher product availability, constant quality, and less product losses. Van der Vorst et al. defined the six elements of the QCL concept and discusses opportunities of using real-time product quality information for improvement of the design and management of 'AgriFood Supply Chain Networks'. A previous MFQ thesis project developed a preliminary diagnostic instrument for assessment each of these six elements and applied the instrument in a banana and tomato trading company. However, no full chain assessment has been done and not all aspects of the instrument have received the same attention.

Aim of this thesis project is to further refine the diagnostic instrument and test its applicability in a complete supply chain. Part of the assignment is to typify food supply chains by its specific characteristics and impacts on the benefits of QCL. Objective is to assess the opportunities of QCL on the supply chain, and potentially (also depending on the background of the student) to model and quantify the impact using optimisation or simulation models.

Project 7.3 A diagnostic instrument for sustainability improvement of food supply chains

Supervisor

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Food companies are increasingly challenged to balance business performance and economic gains with environmental and social performance. Therefore, in 2012, we started a collaborative project on this topic named SCALE (Step Change in Agri-food Logistics Ecosystems). SCALE aims to improve the sustainability of food and drink supply chain logistics in the context of rising food demands, increasing energy prices and the need to reduce environmentally damaging emissions. More in particular, SCALE aims to deliver a number of tools and frameworks valuable for the agri-food sector to secure a step change in operational practices, which will improve the efficiency and sustainability of supply chain logistics. In the project, we developed a sustainability research framework for food supply chains logistics including drivers, strategies, performance indicators, metrics and improvement opportunities to measure and potentially enhance sustainability performances. Next to this, we analysed and diagnosed the current status of Dutch food & drinks companies and logistics service providers using this framework.

Now that we have the preliminary findings it becomes important to develop a diagnostic instrument for sustainable food supply chains. Key factors and indicators should be identified and defined that facilitate or obstruct the sustainability of the food chain. The instrument could be tested in case studies and supported by structured interviews with Dutch food industry and logistics service industry.
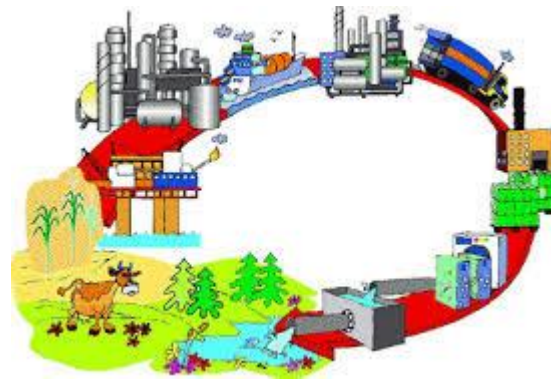
Project 7.4 Simulation of a fresh food supply chain to reduce spoilage: the impact of technological and logistical measures

Figure 4-1. Retail outlet (LI inventory pattern (——) of four weeks (9 consumers = 496) with Z = 24 hours and 2 =54 products, including lost sales (+) and amount of food lost (■), starting at Monday morning 08.00 am.

During the time a fresh Romaine lettuce product is in the FSC, its visual quality is decreasing and should be restocked at the retail outlet when it becomes below 6 (López-Gálvez et al., 1996). For verification, eight products are tracked along their stay in the simulated SC, four of them end up as 'sold products' while the other four end up as 'food loss at retail' (Table 4-3, raw data in Table 9-7, Annex). Table 4-3 shows also that the time windows correspond with Figure 4-1 and quality levels decrease over time.

Supervisor

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About 30-50% of food gets spoiled in modern supply chains. In a current research project technological as well as logistical measures are evaluated to reduce food spoilage. By simulation one can quantify and study the effect of diverse measures on food spoilage as well as on costs. In Decision Science 2, students have learned about simulating supply chains in Enterprise Dynamics (ED). Such a model can be extended to include perishability, and to study options to reduce food spoilage. These options, can be logistical measures like improving the replenishment policy of the actors in the supply chain, or redesigning the supply chain, or technological improvements, such as choice of cultivar, package, or improving the climate (temperature and humidity) under which products flow through the chains. In a previous project an MFQ student has developed a basic model. This model can be used as a starting point of future work.

This project can be extended in multiple directions, applied to different products (meat, vegetables, fruits, flowers), and can be combined with lab research (to estimate quality decay model as inputs to the simulation model), and may include an internship
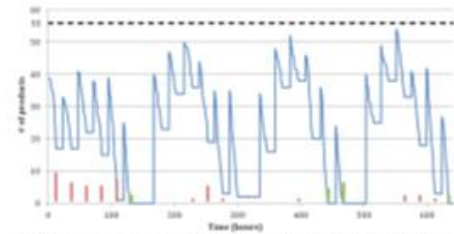
Project 7.5 Determining strawberry shelf life using visual data" and "Modelling quality and logistics in the strawberry supply chain

Supervisor

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Strawberries are highly perishable products, that typically have large variation in quality between and within batches of strawberry punnets from the same origin (e.g. the same production region, truck, farmer, or field). Problems related to poor strawberry quality frequently arise, resulting in large product value losses, stock-outs at retail level, and poor customer satisfaction. To optimise the match between available strawberry batches and demanded quality features in the international market (e.g. a customer far away might require higher quality than a local customer), distributors / wholesalers would like to estimate the quality and variation in quality of individual strawberry batches. These quality estimates can be used to predict the remaining shelf life (and the acceptance period) of a strawberry batch, and to assess whether a batch fulfils the quality requirements set by a customer.

Research indicates that visual information (both in the visible and invisible area) might be used to determine two key determinants of strawberry quality, being

    i.   the 'red'-level, which is a key determinant for consumer acceptability, and

    ii.   the infection level with Botrytis cinerea, which is an important strawberry spoilage driver.

If this data would be available for individual strawberry batches this would allow for an advanced quality driven logistics concept, which brings a large potential for reduction of waste, cost, customer complaints, etc.

Aim of the two foreseen thesis projects will be to:

1. Determine if and how well we can use visual data of strawberries to predict the start of the acceptance period / the remaining shelf life. Also determine where in the chain this method can be used. Advantages and enables/disablers should be analysed. This study involves laboratory research and literature review.

2. Assess the possibilities for use of visual strawberry quality data in a supply chain context using quantitative modelling techniques. Key is to assess the applicability of this information in logistics decision making. Using the case of the strawberry supply chain, simulation models will be developed to assess the value of this kind of information on strawberry quality/safety and logistics performance indicators. This part is more related to the supply chain business and will foremost involve modelling activities.