THESIS RESEARCH TOPICS

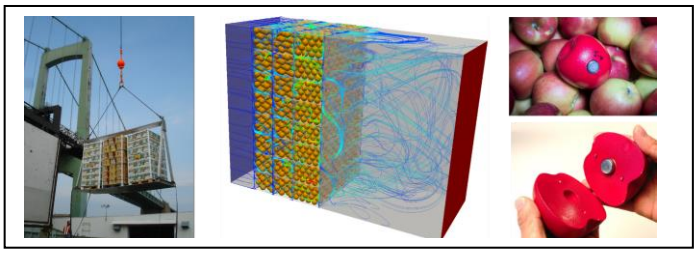
MSc FOOD QUALITY MANAGEMENT 2023-2024

MFQ thesis coordinator: dr. ir. Elsbeth Spelt

These topics were made available in Spring 2023 for students participating in the program Food quality management at Wageningen University. New topics will be issued in Spring 2024 for the current first year students in the master program Food quality management having the required prerequisite courses.

Research theme: Food quality and safety management

1. Digital-twin modeling tools to optimize fresh fruit cold chains from tree to table
Supervisors: Vincenzo Fogliano, Matthijs Dekker, Thijs Defraeye and Deniz Turan-Kunter
Building on previous research of: Yes
Possibility to combine with internship: Yes
MFQ specialisations: Quality control and assurance, quality and food logistics
Open to 1 student



Problem description

Optimizing cold chains of fruits across all unit operations is crucial to maintaining fresh food quality and reducing food losses. Temperature and the gas composition in the air affect decay and fruit quality, so they need to be controlled during precooling, refrigerated transport, and cold storage. By optimizing these environmental parameters, shelf life can be maximized. Currently, extensive monitoring is performed of the environmental conditions in food supply chains (air temperature and humidity). However, this information is not yet optimally used to quantify how the fruit feels and how its quality evolves throughout the cold chain. Linking the measured sensor data with the fruit quality decay is the key objective of this project. With our approach, we want to answer the question when and where in the refrigerated supply chain we lose fresh food quality.

Aim

We look to use such sensor data to better predict the life of each fruit and vegetable in a refrigerated container, truck, or cold storage room. We develop digital twins of the cargo based on commercial sensors' measured air temperature and humidity data in fruit cold chains. These data are fed into a physics-based model to provide theoretical estimates of key performance indicators such as average cargo temperature, mass loss, and remaining fruit quality at the end of the chain. We upcycle the temperature-time data to obtain quality decay data as a function of temperature. Various stakeholders in the supply chain can use such information for decision-making. This physics-based model entails computational fluid dynamics (CFD) simulations of airflow and heat transport in these cooling units.

Approach

This thesis will include following steps: (1) condensed literature review, (2) collect sensor data on commercial shipments from the sensor platform, (3) build digital twins of the cargo, (4) run digital twins to analyse supply chains. After the literature review, we process measured sensor data of commercial cold chains and analyze data for variability. Then you would build a physics-based, empirically-calibrated digital twin for the fruit in a refrigerated container, truck, or cold storage room. Afterward, you use the digital twin to optimize fresh fruit supply chains. With this thesis, you will learn various modeling tools largely used in the digital twin domain, starting from hygrothermal measurements in fresh food supply chains.
Apart from at the Wageningen Campus, the work can also be partially or entirely performed at the Swiss Federal Labs (Empa, St. Gallen, Switzerland), where accommodation will be provided by Empa for the 6 months if required. Further background information on the research at this institute (Empa) can be found on our website (https://www.empa.ch/web/simbiosys).

2. Incentives and barriers of blockchain use in the European meat supply chain
Supervisors: Sara Erasmus and Lars Esbjerg (lae@mgmt.au.dk)
Building on previous research of: Yes
Possibility to combine with internship: No
MFQ specialisations: Quality control and assurance, quality and food logistics
Open to 1 student

Problem description

Blockchain Technology (BCT) is a decentralized, distributed ledger (database) that records the provenance of a digital asset, and through its inherent design, the data on a blockchain cannot be modified. The use of BCT has gained increasing attention in recent years and it has been used in various industries. There have been numerous efforts to use and integrate BCT in supply chain management, such as the food supply chain. For example, Walmart and IBM has been using a BCT system from 2018 for the supply chain monitoring of lettuce and spinach with all blockchain nodes controlled by Walmart and placed on the IBM cloud. In this way, traceability of the product is assured. Another example is FoodSQRBlock, a BCT-based approach developed in 2021 that uses QR code and cloud computing to digitize food supply chain data to improve traceability from farm to fork. Similarly, the Food Trust blockchain of IBM was created to trace foods along the entire chain. Hence, BCT allows brands to track a food product's entire journey. In the case of product contamination, BCT allows the tracing back through each stop to its origin. Provided that the data is recorded at the blockchain node, it also allows companies to visualise everything else that the product may have encountered, allowing the early identification of a risk. However, BCT is not adopted widely in food supply chains and there are still many challenges when it comes to its integration with other data sources.

To address the challenges for the integration of BCT in European meat supply chains, it is first required to determine the acceptance of blockchain by studying the incentives and barriers of blockchain use by industry decision-makers/stakeholders in the chain. The acceptance of BCT in the European meat (pork/broiler) supply chain will be investigated through interviews with key decision-makers/stakeholders along the value chain (i.e., farmers, transporters, slaughterhouses, meat processors, retailers). The thesis will view BCT and other means of documenting and tracking credence characteristics as 'market devices'. Market devices are material and discursive assemblages that play a role in the construction of markets, facilitating the economic exchange of meat products between economic actors. A previously designed questionnaire will be adapted and used to interview key stakeholders along the entire value chain for selected meat products. All interviews will have two main parts. Part one will focus on current collaboration practices along the supply chain, with particular emphasis on the devices used to ensure traceability of meat products, and the credibility of these devices. Part two will explore what incentives and barriers decision-makers see for introducing BCT in the Dutch meat chains. This will enable the identification of barriers to the adoption of BCT and to assess how the use of BCT is likely to influence market practices.

3. Identifying barriers and opportunities in the digital transformation of auditing of food safety management systems

Supervisors: Selcen Semercioz-Oduncuoglu (FQD) and Pieternel Luning (FQD)

Building on previous research: New

Possibility to combine with internship: No

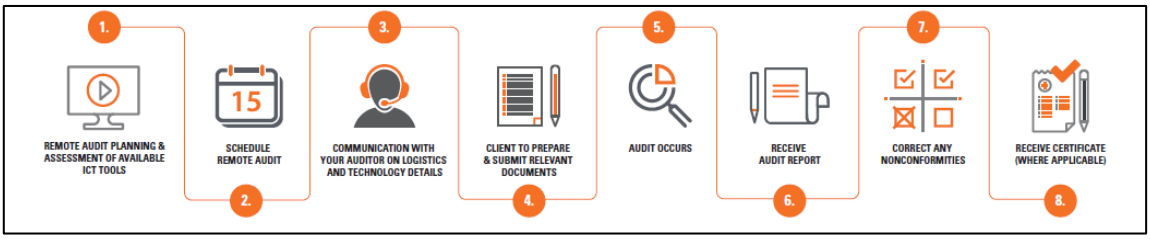
MFQ specialisations: Quality control and assurance, quality management and entrepreneurship

Open to 2 students

Problem description

In last years, sustainably producing safe, high-quality food has become more challenging due to dynamic and competitive conditions in food supply chains. Digital transformation in food quality management seems a powerful tool for improving quality outputs, enabling proactive management of possibilities and risk mitigation. By integrating digital technologies (e.g. data processing, automation, blockchain, AI etc.) companies can modernize and ease their quality management processes. Multiple food companies are now investing in the digitalization of their food quality and safety control and assurance processes.

For example, traditional in-person audit processes can be time-consuming, specifically when the company's food safety management system is still (partially) paper-based, thus open to errors, less efficient and cannot always be done on-site. Digital transformation offers opportunities to enhance audit transparency, and accuracy by using and integrating digital tools (e.g. mobile applications, blockchain-based data collection systems, automated data analysis, real-time reporting etc). Virtual or remote digital technologies could enable auditing through the food supply chain, from farm to fork. Recently, various private standard owners have published remote and/or blended audit manuals (SGS, 2023; BRCGS, 2022; SQF, 2020; FSSC22000, 2020) e.g., when sites cannot be accessed because of serious events. However, digital transformation needs critical consideration on data security, data collection, and data integrity and requires additional training of employees.



The study aims to identify barriers and opportunities for the digital transformation of auditing food safety management systems from different perspectives such as private standard owners and food companies. The research includes literature analysis, expert interviews and/or other relevant methods. At the start of the project, the topic will be further refined in collaboration with an interested private standard owner and a dairy company. The research is expected to contribute to encouraging the food industry to adopt digital transformation in quality control and assurance processes.

Food Safety System Certification 22000, Full Remote Audit Addendum, Version 1, (2020); British Retail Consortium Global Standards (BRCGS) 08, Position statement and procedure for blended audits – Remote auditing using ICT BRCGS, Version 4, (2022); Société Générale de Surveillance (SGS) Remote Auditing Solutions Brochure, Maintain Your Certifications with Remote Auditing Solutions (2023); Safe Quality Food (SQF) Institute Policy Manual, The Use Of Information Communication Technology (ICT) In The Audit Process (2020).

4. Digital transformation opportunities and barriers for routine quality control applications
Supervisors: Selcen Semercioz-Oduncuoglu (FQD) and Pieternel Luning (FQD)
Building on previous research: New
Possibility to combine with internship: No
MFQ specialisations: Quality control and assurance, quality management and entrepreneurship
Open to 1 student

Problem description

The food industry is confronted with various challenges, such as feeding a growing population, climate change, food loss and waste, and inefficient production. Additionally, there is a rising demand from consumers for increased food origin, traceability, and sustainability within the food system (Henrichs et al., 2022). Monitoring and controlling food quality in real-time is also challenging due to numerous factors that influence it, including food types, chemical components, moisture content, storage temperature, oxygen levels, and storage time (Pounds et al., 2022). Especially, the recent pandemic has introduced new barriers for quality control professionals striving to maintain consistent food quality. All stakeholders in the food system rely on information for their food safety and quality decision-making. In the current Industry 4.0 era, digital technologies (e.g., digital twins, automation, artificial intelligence (AI), artificial neural networks and machine learning, internet of things (IoT), virtual and augmented reality, cloud-based platforms, blockchain etc.) offer huge opportunities to food quality control, inspections and management to enhance their performance which is positively reflected in consumer satisfaction (Bakalis et al., 2022).

Digital technologies offer opportunities to collect a huge amount of data from various points along the food chain and its surroundings (WHO, 2019) supporting fact-based decision-making. Through digitalization in routine quality control from farm to fork, real-time monitoring of quality parameters and data collection, transparency and data analysis securing of data via blockchain and data sharing become more accessible technologies. However, the implementation of such technologies needs adjustments in the technological as well as the administrative infrastructure of food companies, and the transformation process may face multiple barriers, besides opportunities, to overcome.

Source: Google images

The study aims to identify digital transformation opportunities and barriers for routine food quality control applications supporting fact-based decision-making through systematic literature research and expert interviews and/or other relevant methods. Based on research findings, the ultimate aim is to develop recommendations for the food industry on how digital technologies can be integrated into existing routine control processes. The research is expected to contribute to encouraging the food industry to adopt digital transformation in quality control and management activities.

Henrichs, E., Noack, T., Pinzon Piedrahita, A.M., Salem, M.A., Stolz, J., Krupitzer, C. (2022), Can a Byte Improve Our Bite? An Analysis of Digital Twins in the Food Industry. *Sensors*, 22, 115.
Pounds et al., (2022), Real-Time and Rapid Food Quality Monitoring Using Smart Sensory Films with Image Analysis and Machine Learning, *ACS Food Sci. Technol*, 2, 1123−1134.
Bakalis et al. (2022), Food Industry 4.0: Opportunities for a digital future, Chapter 21, *Food Engineering Innovations Across the Food Supply Chain*, Elsevier.
WHO (2019), Digitalization, Food Safety And Trade, International Forum on Food Safety and Trade.

5. Investigating food safety culture dimensions

What is the role of food safety communication in food hygiene behaviour?

How is the prevailing FS culture reflected in the technological and administrative conditions?

Supervisors: Pieternel Luning, possibly Lais Zanin, others

Building on the research of MFQ students: Partly

Possibility to combine with internship: No

MFQ specialisations: Quality assurance and control, quality management and entrepreneurship

Open to 2 students

Problem description

Nowadays, every food company from small vendors to large multinationals acknowledge the importance of maintaining their food safety management system and considers food safety as an integral part of the culture of a company. The importance of FS culture is stressed by the General Food Law, the Codex, and the Global Food Safety Initiative Benchmarking Requirements, which all have incorporated FS culture. Consequently, private food safety standards such as IFS, BRCGS, FSSC 22000, and SQF also included FS-culture in their schemes. The prevailing FS culture in a company is shaped by many determinants, such as their food safety policy & strategy, leadership, commitment, employee characteristics & risk awareness, FSMS, technological/work environment, and FS communication (Zanin et al, 2021a, Nyarugwe et al, 2016). Although there is an increasing number of publications that defined the dimensions and developed mixed methods/tools for FS culture assessment, there is still a need for empirical studies that elicit insights into how these dimensions express FS culture and how they affect people's attitudes, beliefs and mindset and actual food safety behaviour in practice. To further contribute to the food safety research field and practical knowledge for companies, we defined two thesis topics.

The **first topic** is about understanding the role of food safety communication, employee characteristics, and technological and administrative conditions on food hygiene behaviour. This topic builds further on previous ethnographic research where an MSc student in a real company setting analysed how the above-mentioned factors relate to personal hygiene and cleaning and disinfection practices. We would like to conduct similar research for other case studies to elicit common patterns. The students are stimulated to find a company that is willing to collaborate

The **second topic** is about systematically analysing which FS culture dimensions are included in existing assessment tools and how these tools evaluate these dimensions to conclude on the prevailing culture. Various tools assess different dimensions in different ways such as positive/negative or weak/strong or reactive/active/positive culture, etc. which makes it also challenging for companies to choose a suitable tool. The topics will be further defined at the start of the thesis.

Nyarugwe, S. P., Linnemann, A., Hofstede, G. J., & Fogliano, V., & Luning, P.A. (2016). Review: Determinants for conducting food safety culture research. Trends in Food Science and Technology, 56, 77-87; Zanin, L.M., Luning, P.A., & Stedefeldt, E. (2021a). The evolvement of food safety culture assessment: a mixed-methods systematic review. Trends in Food Science & Technology, 118, 125-142. https://doi.org/10.1016/j.tifs.2021.08.013; Zanin, L.M., Luning, P.A., da Cunhac, D.T., & Stedefeldt, E. (2021b). Influence of educational actions on transitioning of food safety culture in a food service context: Part 1 - Triangulation and data interpretation of food safety culture elements. *Food Control*, 119 doi: https://doi.org/10.1016/j.foodcont.2020.107447

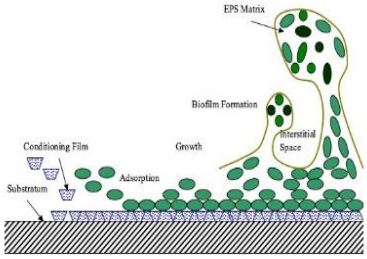
6. Further development of a self-evaluation tool to assess Listeria biofilm control measures given the technological and administrative infrastructures of RTE companies
Supervisors: Pieternel Luning (FQD) and Mark Swainson (Lincoln University, the UK)
Building on previous research: Yes
Possibility to combine with internship: Yes
MFQ specialisation: Quality control and assurance
Open to 1 student

Problem description

The cause of Listeriosis, *Listeria monocytogenes* is the deadliest foodborne pathogen in the UK and EU with a particularly high mortality rate (30%) associated with this pathogen (Public Health England 2018, 2020). Also, the capacity grows at low temperatures and its ability to form biofilms enables *Listeria monocytogenes* to persist in food manufacturing facilities. It is particularly a threat to Ready-To-Eat (RTE) food manufacturers because, in case of contamination, there will be no further opportunity to remove the pathogen from the product before consumption. These facts about Listeria pose high requirements for cleaning and disinfection and hygienic design of equipment and facilities.

However, in food manufacturing, misunderstanding of the contamination routes of Listeria and inadequate cleaning practices combined with poorly designed facilities and/or equipment still commonly occur. Often there is confusion about how to clean and disinfect high-care and high-risk environments and human mistakes are easily made.

Early MSc thesis research investigated the product, cleaning and disinfection, and hygienic design-related factors that can influence biofilm formation increasing the likelihood of Listeria growth through a semi-structured literature review and interviews with experts from cleaning and disinfection and hygienic design, which was by two other thesis students used as a starting point for the development of a self-evaluation tool to assess the status of the food supply (to avoid Listeria entering the company) and food hygiene measures (i.e. cleaning and disinfection and inspecting the efficacy). The tool also allows for the assessment of the technological and administrative infrastructure that may affect the Listeria biofilm control measures.



This follow-up thesis aims to further develop and improve the self-assessment tool for food companies by validation through expert interviews or surveys and conducting pilots with food companies in collaboration with the University of Lincoln in the UK. The ambition is to publish the data gained in the thesis work combined with the findings from the previous studies.

7. Change of food safety risk of food and feed ingredients caused by the war in Ukraine
Supervisors: Pieternel Luning (WUR), Wilma Taverne and Klementina Kirezieva (Cargill)
Building on the research of MFQ students: Yes
Possibility to combine with internship: Yes, in principle combined with an internship at Cargill Rotterdam
MFQ specialisation: Quality control and assurance
Open to 2 students

Problem description

In February 2022 the invasion of Ukraine started. Ukraine is playing an important role in the supply of agricultural raw materials and ingredients to the EU. The inability to import from that country created a shortage, both for the feed and food industries. The Black Sea region represents an important supply of grain and oilseed products for the world market. Ukraine exports about 60 million tonnes of grain to the world (wheat and corn), but also other commodities such as sunflower oil.

The war, first, resulted in a shortage of products (e.g. sunflower oil in the supermarket). Secondly, due to the grain deal, it was possible to ship products to Europe. However, due to the current circumstances, commodity products may need to stay longer in storage. To illustrate, in April 2022 there were still about 20 million tons of commodity products in storage. The impact of this situation is already reflected in the Rapid Alert System for Feed and Food (RASFF) as the number of notifications related to these products increased. Finally, in 2022 maize crop in Hungary, Croatia, Serbia and Romania was significantly contaminated with aflatoxin (10% of the Hungarian crop was estimated as unfit for food and feed use), which further increased the shortage.

The risk profile of feed ingredients purchased from areas subject to armed conflicts may be affected by the possible emergence of new hazards, different risk profiles, change in exposure, lack of official certificates or the practical impossibility of safety assurance schemes to perform audits.

The research consists of two projects. *One project* will focus on understanding the potential risks of food/feed fraud due to the current shortage in the commodity market. *The other project* will focus on the food/feed chain and investigate the change in risk profile due to potential contaminants in armed conflict areas. The thesis topics will be further defined upon the start of the project in collaboration with the Cargill supervisors. The research includes, among others, a literature search, a study of the risk profiles, data analysis, and interviews with stakeholders in the food and feed industry.

8. Eliminating food waste by valorising food side streams
Supervisors: Elsbeth Spelt and Ralf Hartemink
Building on previous research of: Yes, consultancy project report by ACT team
Possibility to combine with internship: No
MFQ specialisations: Quality control and assurance, quality management and entrepreneurship
Open to 1 student

Problem description

Producing food products results in food side streams, also called by-products. These side streams have valuable components which can be separated via several separation techniques and then valorised (e.g. Raak *et al*., 2022; Moreno-González&Ottens, 2021). An example in this respect is the production of beer that results in brewers spent grain which is valorised by the start-up company MagieCreations in Ede to the ingredient of flour. Consequently, existing products can be enriched by these valuable separated components. Another example is existing dairy products which can be enriched by dietary fibres such as polyphenols (Granato *et al*., 2022). The development of new products by adding separated side stream components requires safe and high-quality production processes of the new components and the new products enriched with these components. It also requires changes in the supply chains and the food safety and quality management systems involved.

The development of these new ingredients and these new products is complex as multiple issues need to be addressed. For instance, the safety of side streams and the components to be separated need to be addressed. Additionally, the legislative requirements on the use of these components to enrich existing products need to be clear. Next, the quality standard requirements to market these products to the retail need to be known. Therefore, this research aims to get a deep understanding of all the issues involved in developing new products by the use of side stream components. What does it mean when *food producing companies* decide that their side streams are no longer available for feed for animals but will become available for use of food for human? What does it mean when *food companies having side streams* decide to separate components from their side streams? And what does it mean when *food producing* companies decide to use these side stream components in their existing products? Which issues do they have to consider?

Could you ‘step into the shoes of these companies’ and do first a systematic review to gain insight in the latest scientific understanding on the possibilities and challenges of valorising food side streams for each of these three companies? A conceptual framework will be the result of this review demonstrating the possibilities and challenges involved for each company. The empirical work will aim at getting an understanding on how to cope with the challenges found in the systematic review study by e.g., interviewing relevant stakeholders to come up with advice to overcome these challenges.

References

Moreno-González, M. & Ottens, M. (2021) A structural approach to recover valuable compounds from agri-food side streams. (2021). *Food and Bioprocess Technology*, *14*, 1387-1406.

Raak, N. et al., (2022). Blending side streams. A potential solution to reach a resource efficient, circular, zero-waste food system. *Future Foods*, *6*, 1-4.

Granato, D. et al., (2022). Implementation of sustainable development goals in the dairy sector: Perspectives on the use of agro-industrial side-streams to design functional foods. *Trends in Food Science & Technology*, *124*, 128-139.

9. Analysing the implementation of QACCP in dairy factories

Supervisors: Elsbeth Spelt and Eric Timmermans of Friesland Campina
Building on previous research of: Yes
Possibility to combine with internship: No
MFQ specialisations: Quality control and assurance
Open to 1 student

Problem description

Food companies strive for high quality food day-by-day. Integrated supply chains, sophisticated control measures, quality-controlled logistics (QCL), and novel measurement techniques facilitate food companies in realizing high quality food. Each of these measurements addresses a single aspect in realizing food quality and lacks an integrated, preferably techno-managerial, point of view.

The Quality Analysis Critical Control Points (QACCP) method involves the integrated techno-managerial analysis of Critical Quality Points (CQPs) affecting food quality. A CQP is a critical point in controlling quality attributes in order to prevent unacceptable food quality and to achieve less variation in food quality. Previous research (e.g., Verkerk et al., 2007; Van der Spiegel and Vollebregt, 2008) highlighted the benefits of using this method for the food industry. These benefits are the reduction of food quality losses and minimization of variation in the quality of the produced food. Multiple MFQ thesis students did the QACCP analysis using the few aforementioned publications mentioning a QACCP method. However, these analyses remained quite theoretically.

In response to these theoretically analyses, it would be interesting to use the more pragmatic HACCP method for defining a CQP by drawing a parallel for each HACCP principle. A CQP is then defined as a risk to variation in one or more quality attributes (e.g. shelf life, sensory etc.) which (may) lead to complaints from customers. Drawing this parallel with HACCP (see for instance: Mortimore and Wallace, 2013), a quality risk analysis chart can be made (principle 1), followed by a QACCP control chart (principles 2-5), a monitoring plan (principles 4&5) and a verification plan (principle 6). One MFQ student identified CQPs for stirred yoghurt by using the QACCP method based upon HACCP.

Friesland Campina implemented the QACCP method based upon HACCP in their factories. It turned out that the implementation varies over the different factories for various reasons. Interesting to investigate is: What are the reasons that this QACCP method is being implemented differently? What are the similarities and differences in implementation across factories? To what extend do these similarities and differences influence the identification of CQPs? To what extend does the assurance of the identified CQPs lead to better quality and less waste in the dairy factories? To what extend do the food safety and quality management system differ across factories? To what extent does the application of the QACCP method in the dairy factories meet the quality policy of Friesland Campina? Based upon the insights gained from these research questions, an advice can be given to the corporate director quality on how to continue with the application of the QACCP method in agreement with the quality policy of Friesland Campina and more general an advice can be given to other food companies who would like to implement the QACCP method based upon the HACCP method.

Reference & further reading

Mortimore S. & Wallace, C. (2013) HACCP – a practical approach third edition, Springer, New York.
Van der Spiegel, M., & Vollebregt, H. M. (2008). QACCP - verbinding van product en proceskwaliteit. Wageningen: Wageningen University and Research.
Verkerk, R., Linnemann, A., & VanBoekel, M. A. J. S. (2007). Quality analysis critical control points in consumer-oriented agro-food chains. In R. Ruben, M. A. J. S. VanBoekel, A. VanTilburg, & J. Trienekes (Eds.), Tropical food chains. Wageningen: Wageningen Academic Publishers.

Research theme: Governing food safety and sustainability in food supply chains

10. Strategies for sustainable and circular food quality management: A managerial perspective
Supervisors: Maria Annosi and Pieternel Luning
Building on previous research of: No previous research available
Possibility to combine with internship: Yes
MFQ specialisations: Quality management and entrepreneurship
Open to 1-2 students

Problem description

Environmental sustainability and circular economy principles are becoming increasingly important in the food industry, particularly when it comes to ensuring the quality and safety of food products. The depletion of natural resources, climate change, and environmental degradation pose significant challenges to the food industry's sustainability, and there is an urgent need for sustainable and circular business models that can support food quality management.

With this call for theses, we invite you as students to explore effective strategies for sustainable and circular food quality management and how to measure their impacts. We welcome both empirical and theoretical work, including:

- Theorizing the concept(s) of sustainable and circular food quality management in the context of food industry management scholarship
- Examining effective strategies and policies for sustainable and circular food quality management
- Analyzing sustainability dynamics in sustainable and circular food quality management
- Examining the impact of disruptive competition and externalities on sustainable and circular food quality management
- Examining the governance of sustainable and circular food quality management systems.

11. Auditing food quality & safety systems
Supervisors: Geoffrey Hagelaar and Elsbeth Spelt
Building on the research of MFQ students: Yes
Possibility to combine with internship: Yes
MFQ specialisation: Quality control and assurance
Open to 1-2 students

Problem description

Certification of food quality & safety management systems reflects a shift of public governance to private governance. Private governance means that organizations like retailers develop their own standard and relate the standard to a certificate which can be adopted by their suppliers. 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. Because of the commercial benefits the number of certifications rises (aimed at developing specific markets) but as well the number of companies that implement certificates increases (aimed at reaping the benefits). At the same time certificates are interpreted as signals of trustworthiness of the products towards the customers/consumers.

However, auditing of certificates is a complex matter. Auditing requires from the auditor competencies on the standards but as well on the processes of the audited company and the competency to position the general standard requirement in the specific company processes. The auditor needs to have the social skills to gather the necessary information and to cope with possible resistance from the company to the auditing process. Besides, there is time pressure on the auditor to finalize the audit within a certain agreed upon timeslot. These possible factors raise the question of how certificates are audited in reality in such a manner that the outcome of the audit is objective and reliable.

12. Introduction of new technologies in food processing companies
Supervisor: Geoffrey Hagelaar
Building on the research of MFQ students: No
Possibility to combine with internship: Yes
MFQ specialisation: Quality management and entrepreneurship
Open to 1-2 students

Problem description

In a company new processing technology is introduced to become more efficient, to reach a higher quality (e.g. higher nutritional value, longer shelf life, more environmentally friendly) or to reach a higher market share and/or to access a new market (in which higher and/or other quality attributes are valued). These are all good reasons to implement new processing technology. However, by introducing new technology a company doesn't necessarily achieve the intended goals. From research we know that regularly the intended company goals of implementing a new technology are not met. The company has to cope with two main challenges which are; (1) integrating the new technology in the already existing (technological) processing activities including as well in existing administrative procedures for operators to work with the technology (technology assimilation) and (2) to align the quality improvements to the consumer target group (business model innovation). In handling the assimilation and business model innovation companies are able to reap the benefits from the introduction of the new technology. To optimize these two processes and their interdependence, research into factors which influence the successful introduction of new technology is then called for.

13. Entrepreneurship and quality
Supervisor: Geoffrey Hagelaar
Building on the research of MFQ students: No
Possibility to combine with internship: No
MFQ specialization: Quality control and assurance, quality management and entrepreneurship
Open to 2 students

Problem description

Entrepreneurs can be characterized by their entrepreneurial orientation. This orientation encompasses three dimensions being innovativeness, pro-activeness and risk taking. These three dimensions of entrepreneurial orientation shape the way in which entrepreneurs exploit business opportunities and by that drive the business performance.

Following and better yet anticipating on consumer preferences seem to be key for entrepreneurs to develop their company's business. However, the food sector's reputation seems to be conservative in bringing innovations to the market. At the same time companies in the food sector are pressured by the globalisation of the food market which urges companies to deal with global competitors. Moreover, consolidation in the domain of retail forces processing companies to deal with upscaling and increasing (standard) requirements. Hence, whilst on the one hand there is conservatism in the food industry to innovate, on the other hand there is pressure induced by (global) competition to be more competitive. This leads to the question what role entrepreneurial orientation plays in food companies and why food business entrepreneurs have such an entrepreneurial orientation. Possibly entrepreneurial orientation is constraint by the context in which food companies operate. This context can be described by the complexity of food processing, strict public regulation on quality and safety of food stuffs and the standards/certificates which also put requirements on the operations of the food processing companies.

This research topic is introduced to better understand the food entrepreneur and his/her entrepreneurial decisions to develop their business.

Research theme: Designing new products and processes

14. The interaction between anthocyanin and bioactive compounds and their influence on anthocyanin bioavailability

Supervisors: Xiyu Jiang and Matthijs Dekker

Building on previous research of: Xiyu Jiang

Possibility to combine with internship: No

MFQ specialisations: Quality control and assurance, user-oriented food quality, quality management and entrepreneurship

Open to 1-2 students

Problem description

Fruit and vegetables are a fundamental component of cuisines, and play a key role for supplying consumers of all ages with fresh, nutritious and healthy food worldwide (Wallace et al., 2020). They are food sources of phytochemical compounds like phenolics (flavonoids, quinones, tannins, and others), alkaloids (betalain, theophylline, theobromine, and others), and terpenoids (carotenoids, diterpenoids, monoterpenoids and others), which have been associated with many health benefits. As one of the main compounds in F&V, anthocyanins contain a variety of functional and biological properties such as antioxidant activity, free radical scavenging activity, detoxification activity, anticancer properties, antimicrobial, anti-diabetic effect, neuroprotective effect, and controlling type II diabetes functions. They are also known to have functions to prevent cardiovascular disease, to prevent obesity by inhibiting the digestive enzymes, and to improve the immune system.

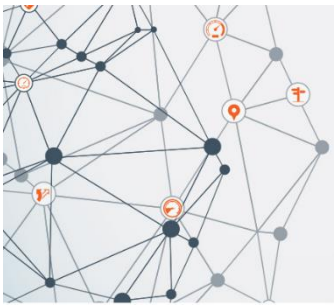
The physicochemical stability of anthocyanins is easily affected by several factors such as oxygen, pH, temperature, enzymes, light, and interaction with other compounds which will relatively influence color and bioactivity. For example, during processing, anthocyanins in fruit juice are released and the physicochemical stability of them are affected by the presence of bioactive components such as carbohydrate polymers (e.g. pectin) and proteins which interact with each other. Currently, there is a lack of scientific understanding in these multiple interactions between anthocyanins and the bioactive compounds and what the effect is on the bioavailability of anthocyanins. Therefore, a systematic literature review to increase the scientific understanding into the effect on the physicochemical and bioavailability properties of anthocyanin with these bioactive compounds will be conducted in this thesis.

Additionally, some experiments can be conducted during this thesis. The anthocyanin and pectin are already extracted, so the experiments may focus on investigation of some functional properties (e.g. Zeta-potential, Isothermal Titration Calorimetry) of pectin and anthocyanins.

Eventually, based upon the insights gained advice can be given on how R&D departments should innovate and process new products with maximum health benefit(s) of anthocyanins and the bioactive compounds for consumers.

Research theme: Food authenticity and integrity

15. Social networks to combat food crimes
Supervisors: Xiangyu Liu and Sara Erasmus
Building on the research of MFQ students: Yes
Possibility to combine with internship: No
MFQ specializations: Quality control and assurance, quality and food logistics
Open to 1 student



Problem description
Nowadays, food fraud is an emerging global issue that disturbs normal market environment and leads to vital economic lost. Because of globalization, food ingredients are sourced globally and towards high price ratio. Besides, food supply chain networks have become more intricated and adaptive in response to current world-wide incidents (such as the COVID-19 pandemic and the war in Ukraine). Combating with food fraud crimes is encountering great challenges, not only due to their concealment and ease of operation, but also due to the difficulty in supervising the cross-border supply chain networks. It is worth noting that recently developed authentication techniques perform exceptionally well in detecting fraudulent vulnerable food quality traits. However, rather than defensing passively, an approach to actively prevent the fraud crimes happening in the early stage need to be investigated.

In the past years, the food fraud vulnerability assessment tool has been developed (van Ruth et al., 2017) and fraudulent company characteristics have been studied (van Ruth et al., 2021). Zhao et al. (2019) have conducted an empirical study on the supply chain adaptation for disruptions. Gomez et al (2021) studied how supply chain diversity fight against food shocks. Nonetheless, food fraud-oriented supply chain network mechanisms have not been extensively studied and can be considered a knowledge gap. To this end, crime script analysis can outline the consequential steps and actions that are undertaken to prepare for, engaged in, and complete fraud crimes. Meanwhile, social network analysis as a developed tool can provide insights on social structures and supply chain actor interactions.

The thesis project will investigate the embedded mechanisms of fraud for a specific food product (to be decided) behind actors' social networks. The initial step is to build the food product's actors supply chain network. Afterwards, crime script analysis will be conducted to assess the opportunities and regulatory loopholes through previous food fraud cases. Social network analysis will then be implemented to identify the significant differences among their social networks and their critical nodes. Questionnaires oriented structural equation model and exponential random graph model will be utilized to provide insights into the relationships between social networks and food fraud crimes.

van Ruth, S. M., Huisman, W., & Luning, P. A. (2017). Food fraud vulnerability and its key factors. *Trends in Food Science & Technology*, *67*, 70-75.

van Ruth, S. M., & Nillesen, O. (2021). Which company characteristics make a food business at risk for food fraud? *Foods*, *10*(4), 842.

Zhao, K., Zuo, Z., & Blackhurst, J. V. (2019). Modelling supply chain adaptation for disruptions: An empirically grounded complex adaptive systems approach. *Journal of Operations Management*, *65*(2), 190-212.

Gomez, M., Mejia, A., Ruddell, B. L., & Rushforth, R. R. (2021). Supply chain diversity buffers cities against food shocks. *Nature*, *595*(7866), 250-254.

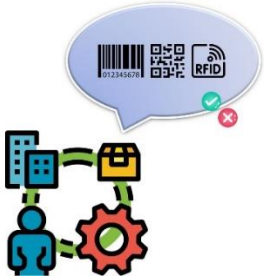
16. Drivers and barriers of identification technologies implementation in food anti-counterfeit
Supervisors: Sara Erasmus and Pengfei Li
Building on previous research of: No
Possibility to combine with internship: No
MFQ specialisations: Quality management and entrepreneurship, quality assurance and control
Open to 1-2 students

Problem description

There are currently different types of identification technologies attached in the packaging of batches of products and single items. These identification technologies, including barcode, QR (Quick Response) code, and RFID (Radio Frequency Identification), always play important roles on food delivery through the supply chain, transparency and integrity, marketing, and payment. To be specific, a barcode, corresponding to a type of food product, is generally used to distinguish the food from others by entities in supply chain; RFID enables identification of an object from a distance without requiring a line of sight and transmit measured environmental factors during food transportation, such as temperature and relative humidity; QR codes are always attached on single food packaging and available to consumers, who can use their phone to scan for much online information. GS1, a non-profit global organization, are working on further promoting the usage of identification technologies in food sectors.

Although many identification technologies are effective tools to produce the digital information, not all food packages use these labels for some various reasons. Some packaging is attached with identification technologies, but these identification technologies are not used efficiently. The reasons of barriers in identification technologies usage may be subjective and objective, such as low demands and higher costs.

The Global Brand Counterfeiting Report (2018) estimates that the value of global counterfeiting is $1.2 trillion per annum and will reach $1.82 trillion by 2020 with online distribution of counterfeit products being in the region of $323 billion annually. Counterfeiting of food is an age-old problem. The identification technologies can contribute to food supervision. Investigating the drivers and barriers to the implementation of identification technologies in preventing counterfeiting is key to promoting further their usages. The aims of this topic are to explore the drivers and barriers for the usage of these identification technologies in food anti-counterfeit. All the possible drivers and barriers of identification technologies implementation are listed through literature. After interviewing the entities in the supply chains, the recognized factors are confirmed and selected, and the entities' opinions and use strategies to different identification technologies are collected. How to further improve the implementation of these identification technologies in food anti-counterfeit will be elaborated in the end.



17. Using quality label information in models for estimating potential sources and paths of contamination

Supervisors: Ayalew Kassahun and Yamine Bouzembrak

Building on previous research of: *Tracking-and-tracing potential sources and paths of contamination in meat supply chains using trade data* (2018, 2019, 2021)

Possibility to combine with internship: No

MFQ specialisations: Quality control and assurance

Open to 1-2 students

Problem description

Food fraud is a serious problem that may compromise the safety of the food products being sold on the market. Previous studies have shown that food fraud is associated with a large variety of food products and the fraud type may vary from deliberate changing of the food product to the manipulation of documents. It is therefore important that all actors within the food supply chain have methodologies and tools available to detect fraudulent products at an early stage so that preventative measures can be taken. This MSc project aims to study how local food quality labeling can be used to develop a predictive model that can forecast food fraud.

In the past MFQ thesis projects, we investigated traceability models for food supply chains. We first used graph theory to predict the potential sources of contamination and vulnerabilities of the Dutch poultry chain using publicly available trade data (Hao, 2019). We then improved the model by using additional data and an improved optimization approach (Rue, 2020). Finally, we studied the various quality labels used in the Netherlands with the intention of studying quality labeling on traceability of food (Berns, 2021).

The aim of this assignment is to examine the use of food quality labels (e.g., organic, beter-leven and halal) for estimating potential sources and paths of contamination. The approach followed can have either a conceptual character or use analytical methods such as machine learning, depending on the desire and competencies of the student.

References & further reading

- Hao S, Kassahun A, Bouzembrak Y, Marvin H (2020) Identification of potential vulnerable points and paths of contamination in the Dutch broiler meat trade network. PLoS ONE 15(5): e0233376. https://doi.org/10.1371/journal.pone.0233376
- Rue, T. 2020. Introducing quality labels in the identification of critical actors and paths of contamination in the Dutch broiler meat chain. MSc thesis. Supervisors: Ayalew Kassahun, Yamine Bouzembrak & Hans Marvin.
- Berns, I, 2021. Proprietary Food Quality Labels in The Dutch Supply Chain: An analysis of the initiation and enforcement of proprietary food quality labels in the Dutch supply chain. MSc thesis. Supervisor: Ayalew Kassahun

Research theme: Consumer perceptions and product interactions

18. Topics on Consumer Studies
Supervisors: Bea Steenbekkers and Pieter Groen
Building on previous research of: No
Possibility to combine with internship: No
MFQ specialisations: User-oriented food quality
Open to students that passed the course FQD33806, YSS31806 and/or YSS33306

Problem description

For this topic you can choose a consumer-food quality related topic of your own choice. General guidelines for the topics are:

- Consumer perceptions and behaviour related to (innovative) food is involved
- Starting point should be the consumer-food product interaction which might influence food quality
- The topic can be studied within different consumer segments and/or different contexts of use.

The final topic will be decided upon in consultation with the supervisor(s).

All topics have in common that it is aimed to get a deep understanding of consumer perceptions and behaviour, taking place in a certain daily-life context. Therefore, in most cases qualitative research will be applied during your thesis. Some experience in doing qualitative research is thus required.

19. Understanding food safety communication to consumers about emerging risks in a circular economy- differences in Europe?
Supervisors: Niels van der Linden (PhD FQD/Food Law) and Pieternel Luning (FQD)
Building on the research of MFQ students: New topic
Possibility to combine with internship: No
MFQ specialisations: Quality assurance and control, user-oriented food quality
Open to 1 student

Problem description

Within the European Union, there is a strong drive towards a more circular economy, however, this transition does come without potential food safety risks. For example, contamination from various sources can end up in packaging materials, which can migrate to the food itself. Although the extent of this problem is slowly developing from the point of view of Food Safety Authorities and industry, the perception of consumers is poorly understood. Nowadays, consumers are exposed to a lot of information but it is yet unclear how they perceive food safety-related information about e.g. recalls due to contamination, the risk assessment process of emerging food safety risks, but also complex behavioural requirements related to packaging waste separation. We would like to know more about to what degree they are aware of these issues, who they consider reliable sources of food safety communication, which factors they consider crucial for communication, etc. to elicit the requirements for effective risk communication from a consumer perspective.

The topic is part of a PhD project aimed at investigating the different barriers that actors in the food safety system experience in the transformation toward a more circular economy which is part of the European project FoodSafety4EU (https://foodsafety4.eu/project/). This project aims to design, develop and release a multi-stakeholder platform and innovative digital tools to help citizens, scientists, companies, EC, EFSA, and Food Safety Authorities co-design and shape the future Food Safety System in Europe.

The thesis aims to investigate to what degree consumers are aware of the potential food safety issues within a circular economy, and how they perceive the risk communication about these issues in different European countries to identify what kind of measures can be taken to create more effective risk communication. A (partial) dataset is available on consumer perceptions of risk communication and its effectiveness, which includes several different European countries based on an FS4EU survey. The data need to be analysed in-depth and reflected against models about effective food safety communication to infer possible strategies for improvement.

20. Getting a deeper understanding of the slow acceptance process of meat substitutes- how do consumer characteristics and dietary patterns play a role

Supervisors: Pieternel Luning (FQD) and Hanneke Elzerman (Hogeschool van Hall Larenstein)

Building on previous: Yes

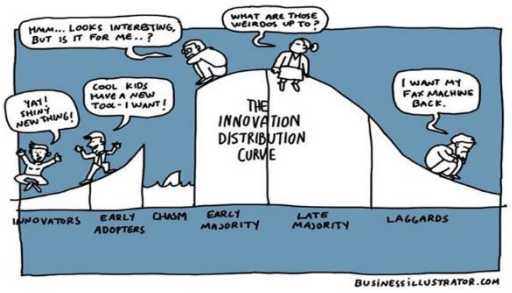
Possibility to combine with internship: No

MFQ specialisation: User-oriented food quality, quality control and assurance

Open to 1 student

Problem description

The substantial environmental impact of our food consumption and production systems has become clear over the last decades. Especially, the production of meat puts a heavy burden on the environment but also can have negative implications for human health. Both researchers and policymakers now plead for a shift towards a more plant-based diet. Meat substitutes/replacers but also other non-meat proteins such as lentils, beans, etc. are products that fit in such a diet. However, although numerous meat substitutes have been launched on the market in the last decades, the widespread adoption of such products is still going slow. Consumer acceptance can be affected by different types of factors. Like other new foods, the acceptance of meat substitutes can be affected by product characteristics, contextual factors around the consumption of meat substitutes, and consumer characteristics of users of meat substitutes (Elzerman, 2022).



Previous qualitative research demonstrated that consumer characteristics, particularly their dietary patterns regarding meat consumption (e.g., being flexitarian, vegan, etc.) affect the motives to consume meat substitutes (that mimic meat) or non-meat proteins or just meat (Elzerman et al, 2022). Follow-up MSc research tried to gain a deeper understanding of the motives to start, continue, or stop consuming meat substitutes to gain initial insight into the acceptance process through a survey in the Netherlands. MSc thesis research of last year further analysed the data of this survey and conducted additional in-depth interviews to gain more insight into the underlying reasons beyond the motives for the consumption of meat substitutes and non-meat proteins. The findings of the qualitative research formed a solid basis for quantitative research.

The new MSc research project will build further on getting a deeper understanding of the slow acceptance process and how consumer characteristics such as the dietary consumption pattern (and other factors) affect starting, continuing (i.e., full acceptance), or stopping the consumption of meat substitutes. The ambition is that the project will provide further insights into possible actions that would be needed to accelerate the acceptance process of meat substitutes to enhance the transition toward a more plant-based diet.

Elzerman, J. E. (2022). Consumer acceptance of meat substitutes: The roles of product, context and consumer characteristics. Ph.D. manuscript. Wageningen University. https://doi.org/10.18174/571109.

Elzerman, J.E., van Dijk, P., & Luning, P.A. (2022). Substituting meat and the role of a situational context. Associations and motives of meat substitute-users. British Food Journal, 124 (13), 93-108. DOI10.1108/BFJ-09-2021-1051

Research theme: Law and food quality

21. Implications of the Green Deal for food companies- How to anticipate the new sustainability reporting requirements?
Supervisors: Pieternel Luning (FQD), collaboration with KTBA
Building on the research of MFQ students: No
Possibility to combine with internship: No
MFQ specialisations: Quality assurance and control, Quality management and entrepreneurship,
Open to 1 student

Problem description

The Green Deal is the new growth strategy which aims at transforming the EU into a modern, resource-efficient and competitive economy while protecting, conserving and enhancing the Union's natural capital, and protecting the health and well-being of Union citizens from environment-related risks and impacts. The Green Deal led to various amendments in European legislation. In 2022, the Directive (EU) 2022/2464 of the European Parliament and of the Council amended, among others, Directive 2013/34/EU regarding corporate sustainability reporting. It is expected that this amendment will increase the comparability of data and harmonise standards and it is expected that the practices of third-party data providers will improve (https://eur-lex.europa.eu/legal-content).
This amendment has substantial implications for food companies as they have to collect and document data about their sustainability footprint in their reporting system. They have to adjust their management system to manage and improve the sustainability of their processes. Moreover, products need to get a kind of sustainability passport containing information about the sustainability performance along the whole supply chain, expressed in a kind of sustainability score. Recently, KTBA, an international provider of consultancy and expert services and part of the Merieux NutriScience Company focused on the food industry and quality management, initiated a project to get insight into how to develop a standard/procedure to support companies in complying with these sustainability reporting requirements. This raised multiple questions including

- What are the legal requirements and what is a correct interpretation of them in line with the practice of food companies?
- What kind of data/information regarding sustainability must be collected and reported and how?
- How to make a sustainability passport for a product?
- What data need to be collected and how will this be translated into a score?

The thesis project aims at getting first insights into the above questions based on analysis of legal documents, literature analysis, and expert interviews. The insights will provide a basis for follow-up and in-depth questions regarding the implications of the legislation for sustainable food production and how companies can deal with it.
The thesis topic will be further demarcated at the start of the research.

22. Green claims
Supervisors: Food law supervision team, contact person: Francesco Cazzini
Building on previous research of: No
Possibility to combine with internship: No
MFQ specialisations: All
Open to 1 student

Problem description

The European Commission has proposed a directive on regulating so-called 'green claims', that lays down rules on the substantiation, communication and verification of voluntary environmental claims and environmental labels used by companies that market products to EU consumers. The proposal would oblige Member States to enact domestic legislation which ensures that traders that make a voluntary, explicit environmental substantiate and present such a claim accurately to the consumer. Greenwashing cases have already been brought under the existing EU framework that prohibits misleading claims, while the Green Claims Directive would further raise the bar, and complement the existing framework by introducing detailed requirements on substantiation and communication to consumers. The research will look at and investigate the regulatory challenges brought by this initiative.

23. Deforestation
Supervisors: Food law supervision team, contact person: Francesco Cazzini
Building on previous research of: No
Possibility to combine with internship: No
MFQ specialisations: All
Open to 1 student

Problem description

The European Union is adopting an important new regulation to require companies to ensure that their imports and exports are "deforestation-free" as well agricultural commodities are produced in conditions that comply with "relevant laws" in their country of origin, like laws on land use rights; labor rights and human rights.
The Regulation aims to avoid products Europeans buy, use, and consume contribute to deforestation and forest degradation; reduce carbon emissions, and address all deforestation driven by agricultural expansion.
Compliance with the EU deforestation-free regulation could be challenging and costly for companies as it likely means adaptations in different facets so that research in this area will address all these potential issues.