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Preface

The starting point of the techno-managerial approach

In the field of food quality management, much attention is paid to understanding the performance of, particularly, HACCP-based systems. In the past decades, the focus was mainly on the technical aspects (like risk analysis, analytical methods), but then broadened to include managerial processes and people factors. Multiple aspects, as listed below, can affect the system performance.

- Identifying and prioritising chemical/microbial hazards, and assessing critical points on a scientific and quantitative basis.
- Insufficient accuracy and effectiveness of monitoring systems, substandard hygienic design level of equipment, or vulnerability of existing infrastructure of the production environment.
- The behaviour and practices of operators, e.g. inappropriate execution of corrective actions, insufficient record-keeping, inadequate personal hygiene, or misperceptions about safety risks.
- The behaviour and decision-making of managers, e.g. incompetent leadership, inadequate communication skills, etc.
- The organisational structures, e.g. the unclear assignment of responsibilities, accountability, inadequate procedures, ineffective training, or lack of management commitment.

Food quality, encompassing attributes like safety, flavoursome, healthy, and sustainable, is the outcome of a food production system accompanied by a quality and food safety management system. It is thus the result of the dynamics in food products and the accompanying food production systems, as well as the dynamic behaviour of people (Luning *et al.*, 2002, 2006). Therefore, we argue that dealing with food quality management as a straightforward system, assuming simple control circles, ignores all kinds of influencing factors that one cannot easily predict. Consequently, for instance, important factors like unpredictable behaviour of raw materials resulting in production problems, or conflicting individual interests of people resulting in unexpected behaviour, are not sufficiently considered.

In fact, food and food production systems are dynamic. We have to deal with living materials with inherent large variations, which change over time. For example, levels of glucosinolates in processed *Brassica* vegetables upon consumption can vary up to 100 fold, due to variation in raw materials, in industrial processing and storage, and in household preparation (Dekker *et al.,* 2000). The same goes for people. They show dynamic behaviour every day. People have their own way of dealing with problems, more or less subjectively. Much depends on personal characteristics, motivation and ability and on organisational conditions, conflicting interests, availability of information and power. Therefore, human behaviour is rather variable and unpredictable.

Considering the above-mentioned aspects, we proposed that research in food quality management should start with recognising and understanding the dynamic behaviour of both food and human systems when trying to predict process outcomes in terms of quality.

This is the opposite of what people normally tend to do. As stated in Luning and Marcelis (2006), when people are confronted with ambiguity (i.e. a situation where phenomena or events cannot yet be interpreted), they try to ignore it or make sense of it in ways that reflect their own perception of the situation rather than the situation itself (Teale *et al.*, 2003). Luning and Marcelis (2006) argued that food quality management is complex as it encompasses multiple dynamic systems (i.e. food systems, food production systems, individual as well as social systems) that interact and change over time. This basic view was the starting point of introducing the techno-managerial approach as a way of analysing and solving complex problems in food quality management.

Developments of the food quality management book

In 2002, we published the first edition of our book 'Food quality management – a techno-managerial approach'. We introduced the techno-managerial research approach in food quality management (FQM) to acknowledge the complexity of food quality and quality management. The principle view is that food quality is dependent on both food behaviour and human behaviour. Furthermore, we introduced the FQM-functions model as the backbone for the chapters about respectively quality design, control, improvement, assurance, and quality policy & strategy.

In 2009, we revised the book into the second edition entitled 'Food quality management – technological and managerial principles and practices'. In this version, we refined the introductory chapters about food quality and quality management. We also upgraded all food quality management functions chapters, based on our experiences from Food Quality Management courses and MSc-thesis research projects.

In recent years, we have executed many research projects in which we applied the techno-managerial research approach with our PhDs and other researchers, and we have published multiple scientific articles in the field of interdisciplinary research in food quality management. Moreover, we have gathered comprehensive experience from our revised educational MSc Food Quality Management courses, FQM thesis and internship projects in collaboration with our colleagues Dr Elsbeth Spelt (Chair Group Food Quality & Design) and Dr Geoffrey Hagelaar (Chair Group Business and Management Organisation). These experiences and the critical discussions with our students and colleagues provided a challenge and a strong basis for revising our book.

We thereby present the third edition of our book entitled 'Food quality management – technological and managerial principles and practices'. We have restructured this edition of the book so that it presents a clear focus on the core message of the techno-managerial approach. Furthermore, the content has been upgraded and the text has been further refined using the developments in scientific research. As a result, it will provide a solid base for applying and integrating technological and managerial knowledge when analysing and solving food quality issues in research as well as in practice.

The book provides essential knowledge for education in food quality management and can serve as a handbook for professionals in the field.

The new book structure

After an introductory chapter outlining the main characteristics of our approach, Chapter 2 introduces the basics of food science necessary for understanding food quality, and Chapter 3 presents the managerial basics of quality management.

Chapter 4 is a new chapter which elaborates on the techno-managerial approach and its fundamental concepts. It provides an in-depth description of the food quality relationship consisting of food dynamics and human dynamics and the technological and administrative conditions for keeping these dynamics within acceptable limits. Furthermore, it includes the model of the five FQM functions, which is the leading concept for the structure of the other five chapters concerning quality design (Chapter 5), quality control (Chapter 6), quality improvement (Chapter 7), quality assurance (Chapter 8), and quality policy and strategy (Chapter 9).

These five chapters give a detailed description of the five FQM functions.

For all chapters, we have chosen the structure as outlined below:
1. The activities of the technological process essential within each FQM function are indicated.
2. The technological conditions are described and divided into three categories: product conditions, process (equipment) conditions and production (environment) conditions.
3. The managerial processes are described with their essential activities and outcome.
4. The administrative conditions are described and classified into three parts: people (i.e. their competencies and commitment), organisational arrangements (i.e. the organisational structures and procedures), and information (i.e. addressing the tools and methods to gather and analyse information).

In the epilogue, we describe various problems in food companies in the food supply chain for the five functions. We finally provide suggestions for solutions from a techno-managerial point of view.

Our approach in writing the book

We have revised the book using the concept of continuous improvement. We have tried to be customer-focused and make the book accessible for students and professionals. We have also updated the book and stay ahead in this area of scientific research. Moreover, empowerment and teamwork were our watchwords when writing this book. These four pillars of total quality management will make for an enjoyable read!

Wageningen, August 2020
Pieternel A. Luning & Willem J. Marcelis

About the authors

Dr ir Pieternel A. Luning, Associate Professor Food Quality Management, Wageningen University and Research (WUR), Chair Group Food Quality & Design.

Pieternel Luning studied Food Chemistry and Microbiology at the Agricultural University of Wageningen in the Netherlands (1988), which is now called Wageningen University and Research (WUR). After following a post-MSc program in flavour research, Luning performed her PhD as a junior project manager at the Agrotechnological Research Institute ATO-DLO and finished her PhD in flavour research in 1995. After working for several years in an applied research institute (TNO) in the field of active food packaging, she returned to the university in Wageningen. First, she was a lecturer in the group led by Professor Wim Jongen (Chair Group Integrated Food Technology). Since 2006, she has been working an Associate Professor in the Chair Group Quality Management and Product Design of Professor Tiny van Boekel. Since 2013, she is working in the Chair Group Food Quality and Design of Professor Vincenzo Fogliano. She collaborated intensively with Dr Willem Marcelis in the field of food quality management in education and research, from 1999 until his retirement in 2010. Together they were the leading founders of the curriculum of the 2-year MSc programme in Food Quality Management introduced in 2003.

The research area of Dr Pieternel Luning is about understanding the influence of contextual factors (i.e. technological, cultural, organisational, and governmental) on food handler and quality manager practices and performance of quality management systems in relation to food quality, integrity, and safety in food supply chains. She is an expert in developing science-based diagnostic tools for assessing and improving the performance of quality/food safety management systems in food supply chains, by applying the techno-managerial approach. Every year she supervises on average 25 MSc thesis and 15 internship students and 10 PhDs. She is involved in multiple (inter)national projects and has written multiple scientific papers and book chapters in her research field.

Dr ir Willem J. Marcelis, Associate Professor Food Quality Management, Wageningen University and Research Centre, Chair Group Management Studies (Now Chair Group Business Management & Organisation).

Willem Marcelis finished his degree in Mechanical Engineering at Wageningen University in the Netherlands in 1972. Thereafter, he conducted research on maintenance management and published two books and various articles on that topic. In 1984, he finished his PhD and was a management consultant in the field of maintenance management for many years. He collaborated with Professor A.A. Kampfraath in developing a management theory based on administrative processes published in a book in 1981. From 1974, he was a teacher and researcher in management at Wageningen University and Research Centre. From 1985, he was an associate professor. In the mid-eighties he started with the initial educational programme on Food Quality Management. Since that time, he has collaborated with the different technological departments on extending and improving the field of food quality management. In 2002, together with Dr ir P. A. Luning and Prof. Dr W. M. F. Jongen, he published the book 'Food Quality Management, a techno-managerial approach' and published various articles and book chapters in the field of food quality management.

In 2003, he developed the 2-year MSc programme in Food Quality Management at Wageningen University along with Dr ir P. A. Luning. Since 2004, he has worked within the research programme about food quality management on topics like food safety management, critical quality points, and quality controlled logistics. He retired in 2010.

Chapter 1

Introduction to food quality management

Nowadays, overall quality performance, alongside financial performance, is a major objective of agri- and food businesses along the whole food supply chain worldwide. Food quality management (FQM) has become an integral part of today's business management. Our general view is that food quality management is a necessary activity in realising food quality in food production processes (Figure 1.1). What seems to be a logical activity, however, is far from easy. We consider various challenges confronting today's food quality managers, such as the complexity of the agri-food production chain, the interaction between food production and people involved in production, and the high demands placed on food quality by consumers and society as a whole. To understand food quality management, it is important to see food quality management as a set of activities as well as challenges to be dealt with.

Firstly, Section 1.1 briefly describes the unique characteristics of the agri-food production chain, discusses the importance of and multiple requirements on food quality, and introduces the complexity of food quality management. Section 1.2 introduces the techno-managerial approach as the theoretical framework for analysing food quality management issues. As there is no univocal food quality concept, a broad quality concept used within this T-M approach is described (Section 1.3). Section 1.4 explains how the structure of the book reflects the basic concepts of food quality management.

1.1 Food quality management

Food quality (FQ) and quality management (QM) are the two basic components of food quality management. It deals with the physical aspects of quality as well as managing the people who have to realise it and applies to all stages in the agri-food production chain.

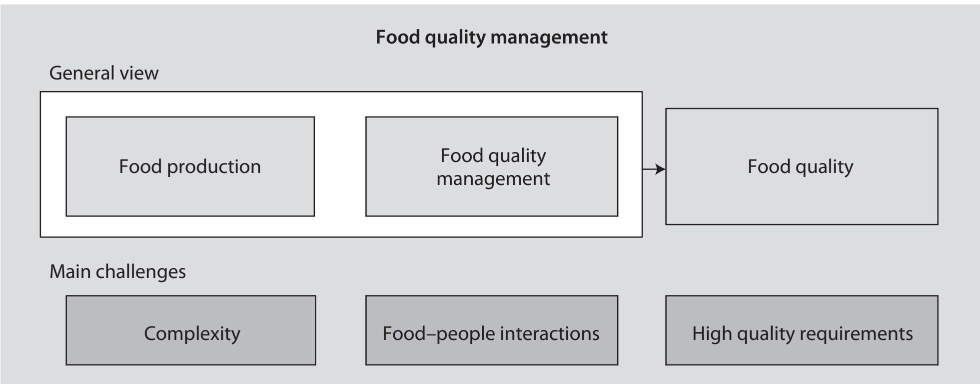

Figure 1.1. Introduction to food quality management.

1.1.1 Characterisation of the agri-food production chain

The agri-food production chain refers to the chain in which people transform agricultural products into food products for use and consumption. The usual approach to analysing this chain is holistic and encompasses the comprehensive analysis of the actors, and their activities and contribution to food quality for final consumption; it is also called the stable-to-table, farm-to-fork, or seed-to-food approach (Knura *et al.*, 2006). The agri-food chain covers the production of animal feed for animal-derived products, the production of seed for plant-based products (e.g. vegetables, grains, beans, oilseeds, etc.) and other biological ingredients (e.g. spices, colourants, etc.), and the manufacturing of food products. Agriculture products are the initial materials produced in primary production at the beginning of the chain, like animal feed, seeds, and seedlings; these agri-materials are the inputs for the production of food products. Food products are plant-based (fresh) products, animal-derived products, and manufactured foods for direct consumption or consumption after preparation, e.g. at home, in catering and restaurants.

Agri-food production chains differ from other product manufacturing chains as agriculture and food products are living systems. They usually have a restricted shelf life, are harvested seasonally, are mostly heterogeneous, and have large variability (10% is common). Moreover, they may contain hidden safety risks, such as chemical contaminants or pathogens, which usually cannot be visually detected. These characteristics have consequences for activities, such as storage technology and conditions, packaging, tracking and tracing systems, and quality control and assurance systems.

Other typical characteristics of agri-food production chains are:

- complicated production chains, e.g. a variety of converging and diverging production processes;
- networks with many suppliers and customers;
- unintentional and unwanted by-products;
- high turnover volumes but low-value products;
- substantial environmental impact, e.g. packaging material, surplus products, used product;
- public interests and concerns (e.g. health, safety) of organisations and stakeholders in all links of the chain (Luning and Marcelis, 2006).

All these features of agri-food products and production chains require an understanding of the behaviour and dynamics of the living food systems as well the way food quality is managed in food production and its complex food supply chains. However, food quality is not a static concept and is subject to trends and developments in society, as briefly elaborated on below.

1.1.2 Importance of food quality

In the last few decades, awareness of the importance of food quality – in all its aspects – has increased in agri- and food businesses worldwide, as they have had to cope with multiple serious food scandals with a major impact on human and animal health, which in turn have led to considerable consequences for control and assurance of food safety.

For example, in Europe, Bovine Spongiform Encephalopathy (BSE) and Classical Swine Fever (CSF) in 1997, the Belgian dioxin affair in 1999, and the Foot and Mouth Disease outbreak (FMD) in 2001, resulted in fundamental changes to European Food Law (Jacxsens *et al.*, 2015; Mulder and Hupkes, 2007). Ongoing foodborne issues (e.g. *Escherichia coli* 0104:H4 outbreak due to contaminated sprouts in 2011 in Germany), food fraud scandals (e.g. horse meat scandal in 2013 in the Netherlands and UK; fipronil contaminated eggs in 2017 in the Netherlands), and numerous recalls related to allergen contaminants (Covaci *et al.*, 2008; Mort *et al.*, 2008; Wales *et al.*, 2006) have led to continuous adaptations to regulations and the introduction of additional food safety measures (Kleboth *et al.*, 2016).

Likewise, in China the food scandal concerning baby powder contaminated with melamine initiated substantial constitutional changes in the food regulation framework (Han, 2015; Jia and Jukes, 2013; Ren *et al.*, 2016). Moreover, various large foodborne outbreaks in the USA resulted in substantial changes to the Food Safety Modernisation Act (FSMA)[1] shifting the focus from responding to preventing foodborne illness. The numerous incidents have enhanced consumer and governmental concerns about food quality and safety (Mazzocchi *et al.*, 2008; Van Wezemael *et al.*, 2010; Yin *et al.*, 2016). Moreover, other consumer and governmental concerns, like the environmental burden of food production, increase in food waste, the impact of climatic changes, and increasing number of obese people (Jacxsens *et al.*, 2010; Kirezieva *et al.*, 2015a; Roodhuyzen *et al.*, 2017) set requirements on food quality and its production systems along the food supply chain.

Figure 1.2 depicts the broad range of quality requirements and concerns of consumers, customers, government, and other stakeholders regarding food products, ingredients,

1 https://www.fda.gov/food/guidanceregulation/fsma/.

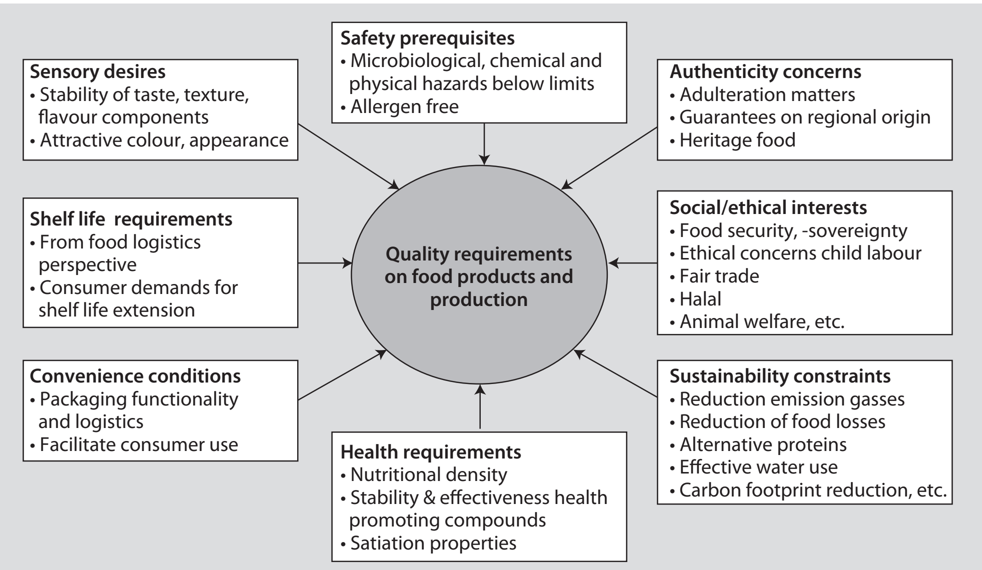

Figure 1.2. Overview of quality requirements on food products and production.

Chapter 5
Quality design

5.1 Introduction

This chapter describes relevant technological and managerial aspects that should be considered in the quality design of food products and processes. Quality design is very important because this function builds the foundation for realising quality in all later processes.

Nowadays, companies in the agribusiness and food industry invest heavily in product design and re-design to stay competitive and profitable in the dynamic food market. Unfortunately, the failure rate of new food products is still relatively high, because the design process and subsequent product management are dynamic and complex (Horvat, 2019). Many firms try to improve product quality or design new products while at the same time increasing the speed of launching the newly designed products. However, to stay competitive, costs of production should be low, and principles of mass production are still important. According to Juran (1992) and Evans and Lindsay (2010), high quality can only be achieved by starting at the source of the production cycle. In other words, quality should be incorporated at the design stage of products and corresponding manufacturing processes. Quality is generally summarised as 'meeting or exceeding customer or consumer expectations'. Therefore, it is essential to incorporate consumer/customer requirements and expectations, also called 'voice of the customer', into the design. Moreover, minimal costs, optimal productivity, the minimal environmental impact of product and production, and compliance with legal requirements should be guaranteed.

5.1.1 Food quality design function

Figure 5.1 shows the food quality design function with its main elements, i.e. the design process and its connection to the technological process, and the relevant administrative and technological conditions that can support or can constrain or set boundaries on the execution of the design activities to achieve the design goals.

'The core mechanism of quality design is building in quality into the product and production process over the product life cycle by setting specifications on product properties, process parameters, and technological and administrative conditions in a way that final quality will meet or exceed customer/consumer needs and legal requirements' (Luning and Marcelis, 2007).

The quality design process encompasses multiple phases in which specific quality design (Q-design) activities take place. Achieving the defined quality design objectives requires the in-depth analysis of customer/consumer food quality demands, the translation into product and process specifications, and setting requirements for technological, human, and other resources to produce the new/modified product. After the product launch, the activities focus on product marketing, sales monitoring, and identifying needs for improvement.

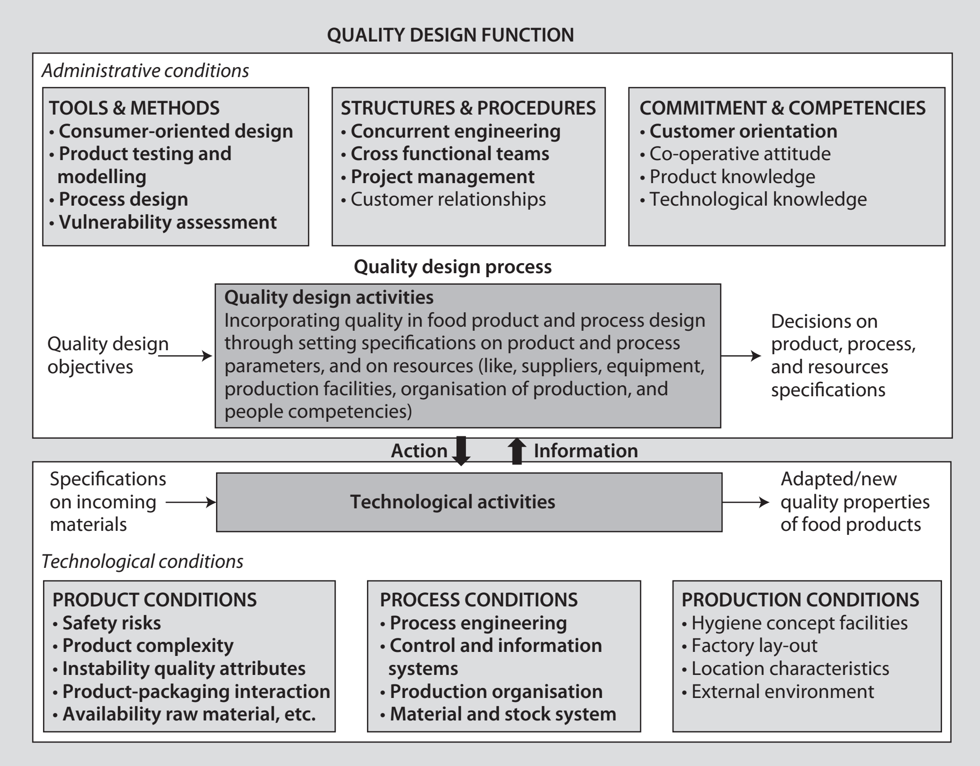

Figure 5.1. Elements describing the quality design function.

In the quality design process, characteristics of product conditions must be considered, e.g. safety aspects, dynamics of shelf-life processes, and packaging-product interactions. Moreover, the present technological infrastructure, encompassing the inherent characteristics of the existing processes, equipment, and production conditions need to be considered. The company's available technological conditions shape the boundaries and opportunities for the design process. Figure 5.1 also shows common tools and methods that can support decision making in quality design activities, e.g. quality function deployment (QFD) is a method to support decision-making in translating customer requirements into technical product specifications. Other tools and methods, such as failure mode and effect analysis and hygienic design principles aim at supporting and/or improving process design. Typical organisational conditions relevant for the design process include the type of collaboration, because of the involvement of multiple departments and functions (e.g. R&D, marketing, consumer research), and the type of project management, because of the multiple go-no-go decisions in the design process and the corresponding costs.

5.1.2 Chapter outline

The chapter starts with an introduction to the need for quality design, followed by a brief explanation of the quality design function (Section 5.1). Section 5.2 describes the phases and design activities of the quality design processes and illustrates the type of quality design decisions. Section 5.3 addresses relevant technological conditions in quality design, focusing on new product requirements, and product and process conditions. The 'special section' (5.4) focuses on customer-oriented design as customer-oriented product and process design has become the common approach. Section 5.5 elaborates on tools and methods that can support design decisions. Section 5.6 explains the typical organisational structure and procedures in quality design.

5.2 Quality design process

The overall quality design process consists of the development of new or modified food products and the activities in the subsequent product life on the market. In the first part, product opportunities are transformed into requirements for products/ingredients, processes, and resources for the actual production of new products. This is the so-called 'new product development' (NPD) process. If a product meets certain metrics in one NPD phase, it can move to another phase. Once a company starts to produce commercially, products move through several phases, including the introduction, growth, maturity, and decline phase. This is the so-called product life cycle (PLC) process.

The quality design process needs well-organised decision-making processes and its success is typically dependent on communication and collaboration within the company. The following sections describe in more detail the major activities in the NPD phases and PLC phases.

5.2.1 Technological activities

As described in Chapter 4, technological activities encompass, on the one hand, all activities related to the physical supply, transformation, and physical distribution of the food product. On the other hand, in design processes, they include all technological activities in the laboratory and in the production place when new products and/or processes are designed and tested.

In the quality design process, technological activities can support the development of new products and/or production processes. These technological activities are executed by people involved in the design process. Typical activities include developing the recipes of new products and testing them in the laboratory, designing the prototypes of production processes and testing their effectiveness, and developing and analysing new production conditions (e.g. new packaging or storage conditions). These technological activities take place mainly in the second phase of the design process, i.e. product development and process design (see Section 5.2.2). Table 5.1 shows some examples of relevant technological activities specific to the Q-design function.

5.2.2 Quality design activities in new product development

The formal organisation of a new product development (NPD) process and classification of the phases and corresponding activities can differ per company, and the literature shows no clear consensus. Depending on the competences and experience of the NPD team, a

Table 5.1. Examples of technological activities specific to the quality design function.

Type of activities	Overall technological functions		
	Supply (& storage)	Production (i.e. transformation)	Distribution (& storage)
People activities	• Testing materials for new products • Developing and testing new hygienic conditions in incoming materials storage • Testing a new inspection method for incoming materials	• Creation of samples of food products by food technologists and/or culinary experts • Developing and testing product prototypes • Packaging and labelling design and testing • Production of the prototypes, as created in the lab, in a real process line	• Developing and testing new temperature conditions in distribution rooms • Developing and testing new cleaning conditions in distribution rooms • Testing a new method for measuring final product quality

company may modify or even skip activities, and the rules for decision-making may depend on the extent of novelty and complexity of the new product (Barbachan, 2018). However, an analysis of NPD design literature revealed three main phases: (1) concept development, (2) product development and process design, and (3) launching of the new product (Barbachan, 2018; Horvat, 2019). Figure 5.2 shows the three main phases and the corresponding design activities. The model depicts the quality design process as a linear process with sequential steps. If a product meets certain metrics in one NPD phase, it can move to the next phase. Straus (2009) described this process-oriented approach as a stage-gate process. However, the NPD process is much more complex because of the presence of multiple feedback loops and the interdependencies between decisions of e.g. marketing experts, food technologists, and consumer researchers (Horvat, 2019).

Figure 5.2 distinguishes product development and process design. Product development includes all activities that are carried out to translate the voice of the customer/consumer into a product that can be effectively manufactured. Process design involves not only the design of process equipment but also includes the planning of physical facilities and the development of information and control systems required for the manufacturing of the product (Evans and Lindsay, 2010). Ideally, the design process should be an integrated process of product development and process design. Products in development set requirements for the process design, whereas existing process, equipment, and production conditions may limit or facilitate the product development opportunities. The sections below describe the common design activities in the different NPD phases.

Chapter 10

Epilogue

Starting from the characteristics of food and human systems and the content of food quality management, we developed a techno-managerial approach for analysing issues in food quality management (Luning and Marcelis, 2006). The techno-managerial approach advocates the importance of understanding the behaviour of both food and human systems and their interdependency. The approach includes the integrative use of technological and managerial theories, whereby technological theories can help explain food behaviour and managerial theories can explain human behaviour and integrative refers to integrating the knowledge of these theories (Luning and Marcelis, 2006, 2009). We derived the need for such a framework from the developments in the agri-food production chain, and the problems and challenges they create for companies and institutions in the chain.

10.1 Developments in the agri-food production chain

The situation in the food market and the agri-food production chain remains turbulent due to changing consumer requirements, environmental concerns, government interests, internationalisation, and a growing world population. The focus of agribusiness and the food industry changed from productivity and cost orientation towards a customer/consumer orientation resulting in a more dynamic and demanding situation for the agri-food chain.

From a chain perspective, there are three major cycles of change:

- The first cycle encompasses developments in the market. The decreasing life cycle of products and rapidly changing preferences of consumers lead to consumer behaviour that is more impulsive, and consumers have become a moving target for product developers.
- The second cycle refers to the technologies associated with processing and production systems. In general, innovation in technologies is slower than changes in the market situation.
- The third cycle deals with plant breeding and primary production and is actually the slowest cycle even with the use of modern biotechnology. Short-term changes in market requirements are difficult to implement rapidly at the source of food production.

From a chain perspective, it is important for those actors who are active in the primary production cycle or the processing cycle to have a strategic view on dealing with market developments and identifying market niches. In this way, they can create a competitive advantage. On the other hand, it is necessary to have a clear understanding of the technological possibilities and limitations from the processing and the primary production perspective to be able to follow the most effective quality strategy.

Another development, relevant in this context, is the globalisation of food production systems. Raw materials are sourced from all over the world, and finished products are also sold all over the world. In Western countries, consumers are used to the fact that all kind of food products are available all year round. Trade barriers are disappearing, reinforcing this type of development. From this perspective, the need for strategic collaboration within the supply chain is obvious.

Considering the cycles in more detail reveals that each actor in the chain faces different requirements and environmental influences. On the consumer side, the many changes in the market for new food products call for a repositioning of existing food production systems and raise the question as to whether the concepts currently used can survive the challenges of the future. Apart from market saturation, several other developments have a huge influence on market conditions. In general, consumers are now better educated and more demanding. Furthermore, they have become less predictable in their purchasing behaviour, they eat out more frequently, and they are more conscious of health and environment-related aspects of foods and food production. As a result, there is a continuous need for new products and a more differentiated food product assortment. One typical example is the ongoing development in the functional food area. Related to these developments, product life cycles have become shorter and the efficiency and flexibility of food production systems have become even more important.

In addition to the continuously changing consumer demands, retailers have become very powerful as they put increasingly high demands on their food product suppliers with respect to safety, quality, profit margins, and supply frequency. Retailers are in fact the main link between consumers and food companies. Their knowledge about consumer purchases has even increased due to the use of information technology, which puts them in a very powerful position. Food manufacturing companies attempt to anticipate these dynamics by concentrating on product development, intensifying their knowledge potential, geographic expansion, and differentiation by brands.

The primary sector also faces dynamic demands. Due to several serious food safety problems, which originated in the primary sector, they need to pay much more attention to reinforcing their food safety and quality management systems. Furthermore, they are faced with increased costs due to environmental regulations, labour and soil prices, and there is pressure on prices due to the liberalisation of the market.

The various technological and organisational changes in the food supply chain place great demands on food quality management. More specifically, typical technological changes, such as the trend towards less intensively processed food, the higher level of preparation (like ready-to-eat components and meals), incorporation of active health-improving compounds, and replacement of products and ingredients, set huge demands on quality control and assurance. In addition, more flexible supply chains, higher frequency of supply, stricter requirements on tracking and tracing, and the increasing number of food outlets have their consequences. The trend towards 'fresh-on-demand' with higher supply frequencies has increased the demands on quality management systems along the whole food supply chain. The increase in food outlets selling prepared, and therefore more vulnerable, food products, puts stricter demands on hygienic behaviour, hygiene knowledge, and compliance with safety control procedures. Finally, yet importantly, the ongoing concern of public and government with regard to food safety, sustainability, and wholesome food production has also placed increasing demands on food quality management (Luning and Marcelis, 2009).