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Viewpoint

# A food quality management research methodology integrating technological and managerial theories

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In this article it is argued how the complexity of food quality management combined with the high requirements on food quality requires a specific research methodology. It is concluded that food quality management research has to deal with two quite different paradigms, the one from technological and the other from managerial disciplines. Moreover, it must combine two types of research, i.e. managerial problem solving and fundamental scientific research.

The research methodology is described as a stepwise process, wherein theory and practice are connected with a prominent place for selecting useful technological and managerial theories.

This selection process is supported by a grid showing important topics in different research phases. The methodology is illustrated with a case example. Moreover, attention is paid to the role of the researcher in this type of interdisciplinary work, both as the intermediate between theory and practice and as the one to be critical towards theory-selection and use of data.

## Introduction

Food quality management has become increasingly challenging due to, amongst others, changes in consumption patterns, developments in technology, and increasing legislative requirements and changing environmental conditions (Luning & Marcelis, 2006, 2007; Luning, Bango, Kussaga, Rovira, & Marcelis, 2008; Motarjemi & Käferstein, 1999; Motarjemi & Mortimore, 2005). Moreover, food quality is increasingly managed along the whole chain from feed and seed suppliers to final consumption of food (e.g. Beulens, Broens, Folstar, & Hofstede, 2005; Knura, Gymnich, Rembialkowska, & Petersen, 2006; Raspor, 2008; Sauli, Danuser, Wenk, & Stark, 2003). Food quality management has been typified as rather difficult due to the dynamic and complex character of perishable food products in combination with the dynamic and often unpredictable behaviour of people involved in food production chains (Luning, Marcelis, & Jongen, 2002). A techno-managerial (TM) research approach was, therefore proposed to deal with the complexity of food quality management (Luning & Marcelis, 2006, 2007). This TM approach shows that food quality is dependent on food and human behaviour, and involves an integrative use of theories from technological and managerial disciplines to analyse both the food and human systems involved in food production. *Although this techno-managerial approach indicates which factors contribute to food quality and which theories should be used to analyse them, there is not yet a well-defined methodology that explains how to realise such a techno-managerial research approach.*

This paper presents a research methodology to support a techno-managerial approach when analysing complex food quality management issues. First, the characteristics of food quality management are described and consequences for a research methodology are discussed. Next, the research methodology is depicted. Implications for applied scientists and practitioners in the area of food quality management are discussed in 'Conclusion'.

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## Characterising food quality management

Before developing the research methodology it is necessary to characterise food quality management, its objective, its activities, and the supply chain wherein it operates.

The primary objective is to realise food quality that meets or even exceeds customer and consumer requirements. Food quality is affected by both food and human systems, and the outcomes of these systems over time reflect their behaviour, i.e. food and human behaviour, respectively. Food behaviour depends on food dynamics (i.e. variability in properties due to, e.g. variable compositions, enzyme activities, and contamination levels) and applied technological conditions (like, process conditions, equipment, and buildings). Likewise, human behaviour is dependent on human dynamics (i.e. variability in decisions due to, e.g. variable perceptions, attitudes, or choice intentions) and administrative conditions (like, information systems and procedures). These influencing factors are reflected in the food quality relationship as*: food quality = f (food behaviour, human behaviour), wherein food behaviour = f (food dynamics, technological conditions) and human behaviour = f (human dynamics, administrative conditions)* (Luning & Marcelis, 2006)

In order to realise food quality a broad range of goal-oriented activities through the whole organisation is necessary. From a techno-managerial perspective the necessary activities are summarised in technological and managerial functions. The technological functions concern the technology dependent activities necessary to achieve a product with certain physical properties. They include the actual production activities (e.g. heating, storing, transporting, etc.) and measuring activities to provide information about the status of products and processes (e.g. taking samples, analysing, measuring, etc.). The managerial functions are the necessary decision-making activities to activate the food production system as well as the management system, to give it the right direction, and to ensure that it meets consumer and customer requirements. The managerial functions include, besides, quality control and assurance, quality design, improvement, and quality policy and strategy (Luning & Marcelis, 2007).

Considering the current situation in the food supply chain reveals that various technological and organisational changes put high requirements on food quality management. Typical technological changes, such as the trend towards less intensively processed food, higher level of preparation (like, ready-to-eat components and meals), incorporation of active health improving compounds, and replacement of products and ingredients put high demands on quality control and assurance (Boom, Dekker, & Esveld, 2003; Carle & Schieber, 2006; Jun, Jeong, & Ho, 2006; Sandrou & Arvanitoyannis, 2000; Senorans, Ibanez, & Cifuentes, 2003; Sonesson, Mattsson, Nybrant, & Ohlsson, 2005). To illustrate, the application of mild preservation techniques results in products that are more vulnerable to spoilage bacteria and pathogens (e.g. Fonberg-Broczek *et al.,* 2005; Guentert, Mohtar, Linton, Tamplin, & Luchansky, 2006; Selby *et al.,* 2006), which puts higher demands on control and assurance of processing, packaging, storage and distribution conditions. Inclusion of active ingredients requires that the functionality of these compounds are maintained along the whole chain up to consumption (Desai & Park, 2005; Kunzek & Vetter, 2001), which puts high demands on controlling and assuring of this food production chain. Also various organisational changes in the supply chain, such as more flexible supply chains, higher frequency of supply, new requirements on tracking and tracing, and increasing number of food outlets (Grunewald, 2004; Opara & Mazaud, 2001; Pettinger, Holdsworth, & Gerber, 2008; Wright & Lund, 2003) impact food quality management. The trend towards ‘fresh on demand’ with higher supply frequencies and specific requirements on tracking and tracing also increased requirements on quality management systems along the whole food supply chain (Froder *et al.,* 2007; Trienekens & Van der Vorst, 2006; Van der Vorst, Beulens, & Van Beek, 2003). The raise in food outlets selling prepared, and therefore more vulnerable food products, puts increasing demands on hygienic behaviour, hygiene knowledge, and compliance to safety control procedures (Guida, Marino, Buonaguro, & Melluso, 2006; Jones, Parry, O’Brien, & Palmeri, 2008; Legnani, Leoni, Berveglier, Mirolo, & Alvaro, 2004; Martinez-Tomé, Vera, & Murcia, 2000; Sun & Ockerman, 2005). Moreover, the increased concern of public and government on food safety and wholesome food production put increasing demands on food quality management as well (Rohr, Luddecke, Drusch, Muller, & Von Alvensleben, 2005; Van der Meulen & Van der Velde, 2004, 2006; Wang, Mao, & Gale, 2008).

In conclusion, food quality management deals with dynamic food and human systems, it requires technological and managerial activities to realise food quality, and it must deal with high requirements on food quality due to technological and managerial changes in the agri-food chain, and increased consumer and governmental concerns.

## Food quality management paradigm and research type

In order to develop a methodology one should first recognise the paradigms beyond the researcher’s philosophical assumptions and one must consider the type of research (Mingers & Brocklesby, 1996). Food quality management research is rather specific because it deals with paradigms from natural (food technology) and social sciences (management), and it deals with two research types, respectively managerial problem solving and fundamental scientific research.

### Paradigms

Above described characteristics underpin that food quality management issues need to be analysed from a technological and managerial perspective using theories from both disciplines. As a consequence, paradigms from food technology and management sciences must be acknowledged. One should realise that both disciplines represent different worlds of science. Paradigms of technological disciplines basically fit with a positivistic viewpoint, wherein the world is external and objective, the observer is independent, and science is value-free. On the other hand, paradigms of managerial disciplines essentially fit with a phenomenological viewpoint, wherein the world is socially constructed and subjective, the observer cannot detach him/herself from what is observed, and human interests drive science (Teale, Dispenza, Flynn, & Currie, 2003).

However, the positivistic and phenomenological viewpoints are not strictly connected to, respectively, natural and social sciences, but also both viewpoints are used in the same science. In social sciences, both qualitative and quantitative research approaches are used. Creswell (2003) discussed that the phenomenological viewpoint is common in qualitative research, whereas the positivistic viewpoint is common in quantitative research. He also described mixed methods approaches, wherein a pragmatic viewpoint – he called it knowledge claims – results in both open and closed-ended questions, both emerging and predetermined approaches, and both qualitative and quantitative information and analysis. More recently, Creswell and Plano Clark (2007) elaborated a step-by-step guideline for the decisions that must be made in designing a mixed methods research study.

Moreover, in social sciences research has been characterised on its fundamental differences in the principal orientation to the role of theory (deductive vs. inductive, testing theory vs. generation of theory), the epistemological orientation (positivism vs. interpretivism, phenomenology being a part of it), and the ontological orientation (objectivism vs. constructivism) (e.g. Bryman, 2004; Johnson & Duberley, 2000). Although Bryman (2004) acknowledged these fundamental differences in quantitative and qualitative research approaches, he stated that they are perhaps not so opposite. He discussed that there is no agreement about the positivistic viewpoint to be the only epistemological base of natural sciences, and that realism is an alternative option. Realism involves the viewpoint that there is a difference between reality (world as it is) and perception (how we see the world), and that we give a subjective interpretation of it. At the other hand, in social sciences, in quantitative research elements of the positivistic viewpoint are included.

Summarising, we may conclude that at the same time different paradigms may serve as a starting point for research.

### Research types

Commonly two distinctive research types are distinguished based on the different ways they deal with theory and practice, i.e. managerial problem solving and fundamental scientific research (Gill & Johnson, 1997; Teale *et al.,* 2003). In managerial problem solving the researcher starts in practice with a problem and stays there, mainly unconsciously using theory. Information is gathered to analyse the situation and to develop alternative solutions in a process of continuously matching goals and ways to reach them. It is a process of selection out of alternative choice options, resulting in a decision at a certain moment, and it is thus finite. In fundamental scientific research the researcher starts in theory and basically stays there. It starts with a question, driven by a feeling of curiosity or amazement. Then more and more information is gathered (e.g. by analyses and observations), followed by continuous matching objective facts and creative ideas. It is a process of cognition resulting in knowledge, and it is more or less infinite. Problem solving and fundamental scientific research can be characterised as, respectively, decision-oriented and conclusion-oriented (Bos, 1974; Luning *et al.,* 2002). Food quality management research should be positioned between both types of research. It must result in solutions for the problem situation, while at the same time high requirements are put on the dependability of the provided solutions, due to customer, public, and or governmental concerns. Food quality management research differs from managerial problem solving in consciously using theory, and it differs from fundamental scientific research in being aimed at solving problems in practice.

From this characterisation of food quality management research we may conclude that out of the different knowledge claims, described by Creswell (2003), the pragmatic knowledge claim fits most with this type of research, more than positivism (knowledge claim in most quantitative research) or interpretivism (the knowledge claim in many qualitative research projects) alone. Pragmatic knowledge claims arise out of actions, situations, and consequences, rather than antecedent conditions. Instead of methods being important, the problem is most important, and researchers use all approaches to understand the problem (Creswell, 2003).

## Food quality management research methodology

In our study, we have attempted to translate the different paradigms and research types into a systematic methodology. Mingers (1997a,b, 2003) studied research processes solving complex multidimensional problem situations. He argued that a research or intervention, which is aimed to change such a situation, is often a process that typically proceeds through a number of phases. The first phase concerns *appreciation* of the situation as experienced by researchers and as expressed by actors in the problem situation. In the second phase, underlying structures of relationships and constraints that have generated and or maintain the experienced problem situation are *analysed*. The third phase concerns *assessment* of alternative ways to change the situation and considering to which extent structures and constraints can be changed within limitations of the research intervention. Finally, *action* must be undertaken to realise agreed changes and to evaluate their effectiveness. Both types of research in food quality management fit with these phases. Managerial problem solving requires a range of problem definition, analysis, solution development, choice and implementation. Fundamental scientific research requires recognition of different problem perceptions, analysis of underlying structures and mechanisms, studying and predicting the effect of different ways of changing situations, and evaluation on hypotheses and effects.

Mingers (1997a,b, 2003) also discussed that multidimensional problems should be analysed from different viewpoints, using theories from different paradigms. He underpinned that each research phase requires other theories and developed a framework to analyse and solve complex problem situations. The framework is based on two features, i.e. multidimensionality of the problem content (material, personal, and social) and the different research phases (i.e. appreciation, analysis, assessment, and action phase). We used such a framework as the basis for the development of a food quality management theory-selection grid (Table 1). To typify the multidimensionality of the problem content we used the food quality relationship model, which recognises the technological and managerial factors influencing food quality, i.e. dynamics and conditioning of, respectively, the food and human systems. The theory-selection grid shows for each research phase, which type of technological and managerial theories should be searched to analyse the problem situation from a techno-managerial perspective. It indicates that for each phase other types of models should be searched to answer the different questions, which will be explained and illustrated in more detail in the next section. The actual research process of using different theories is a continuous cycle of reflection, judgment, and action. It will bring in certain theories at certain moments depending on as well the content of the problem as the stage of intervention. Therefore, the intensity of combining different theories will vary (Mingers, 1997a,b, 2003).

The grid is the basis for the FQM research methodology, which is schematically presented in Fig. 1. It shows that food quality management research should pass the four distinct research phases, in each phase identifying, selecting, and applying useful technological (T) and managerial (M) models from theory, and collecting useful T and M data and information from practice. The theory-selection grid supports in the *identification* of relevant models from theory by indicating which technological and managerial topics should be concerned in each phase. The *selection* of models is supported by the use of three criteria (i.e. relevance, validity, and reliability) to systematically evaluate usefulness of models. Relevance refers to which extent they are really related to the problem situation, understandable for people to work with, and available at the time they are needed. Validity concerns rightness and precision, and reliability includes consistency and ability of verification (De Leeuw, 1999). Similar to the theory evaluation, data and information from practice must be critically evaluated on relevance, validity and reliability, before using them. One should realise that the selected models affect how one observes the problem situation in practice and in this way affects the collection of practical data and information. At the same time, data and information from practice influence the specific search for additional theories.

More in detail we have described the methodology in terms of objectives and typical questions for each research phase.

The *appreciation phase* is aimed at defining the problem by selecting appropriate technological and managerial models, which help to perceive the problem situation from the viewpoint of food and human behaviour. It starts with typifying the problem situation, which means recognising which attributes (or dimensions) of food (production) quality are of concern (e.g. physical attributes like safety, shelf life and/or organisational quality dimensions like flexibility or service), and identifying which FQM activities are involved (e.g. quality control or assurance at production and/or distribution) (Luning & Marcelis, 2007; Luning *et al.*, 2002). The next step is to select useful (i.e. relevant, valid, and reliable) models that give answers to questions like, *which* food properties and processes (e.g.

**Table 1. Food quality management theory-selection grid**

| Food quality influencing factor | Research phase | | | |
|---|---|---|---|---|
| | **Appreciation** | **Analysis** | **Assessment** | **Action** |
| Food dynamics | Product composition and reaction processes | Product properties andunderlying reaction mechanisms | Alternative product compositions | Implement/adjust alternative specifications |
| Technological conditions | Operational practices, technological interrelations | Technological infrastructure and measurement systems | Alternative technological arrangements | Change technological conditions or implement new resources |
| Human dynamics | Employee characteristics, competencies and commitment | Knowledge, perceptions, attitudes, interests, and conflicts | Alternative employee requirements | Implement training and re-orientation |
| Administrative conditions | Organisational practices, power relations, and mutual dependencies | Organisational structure, procedures, and information | Alternative organisational structures and procedures and alternative information systems | Change responsibilities/ authorities, procedures, and information supply |

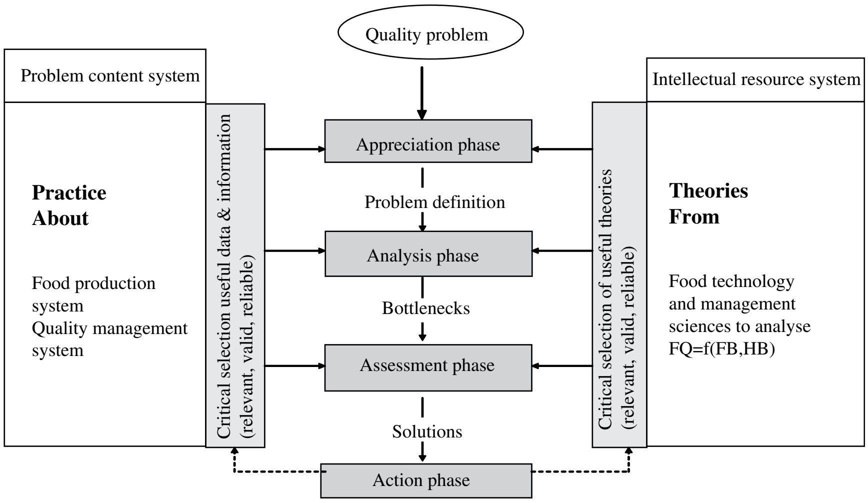


**Fig. 1**. Food quality management research methodology.

composition, microbial or physical–chemical processes), *which* technological conditions (e.g. processing equipment, and storage rooms), which aspects of people (e.g. competences and commitment), and which administrative conditions (e.g. procedures and working conditions) may affect the problem situation. The theory-selection grid supports in deriving such models and questions (Table 1). Answers to these questions are translated into a detailed problem definition and the hypothetical assumptions upon which it is based.

The *analysis phase* is aimed at getting insight in the underlying technological and managerial mechanisms, and to what extent they may affect the problem. It continues with selection, by using the grid, of theories from technological and managerial sciences to find more in-depth models to answer questions, like *where* and *how* specific technological conditions affect variation in certain product properties. *Where* and *how* may food handlers (or food managers) influence these properties (e.g. due to inappropriate risk perception and conflicting interests), and *how* may administrative conditions (e.g. organisational structure, procedures, and information systems) influence food handlers' behaviour when executing a specific activity (like, e.g. procedures to influence control behaviour at CCPs). The analysis phase consists of two distinct parts, i.e. development of a techno-managerial (TM) research model and analysis of the actual problem situation. A TM-research model is a conceptual model, which is based on the selected useful models. For crucial elements of the model indicators are derived that reflect the technological and managerial factors and mechanisms that are assumed to contribute to the problem. In the second part these indicators are systematically translated into questions, which are used to gather data and information from the actual problem situation. Both the research model and the data/information need to be evaluated on relevance, validity and reliability in order to draw useful conclusions about bottlenecks (i.e. what is really going wrong?).

The *assessment phase* is aimed at developing scenarios of solutions for the problem within the constraints of the situation. It starts with searching new technological and managerial literature to find methods, tools, strategies, etc. that could be useful (i.e. relevant, valid, and reliable) to change the problem situation. Scenarios should be formulated considering as well the technological as managerial aspects. Criteria to judge the scientific (does it contribute to solving the problem) and practical appropriateness (does it fit with the company policy) of scenarios are formulated to select the best one.

The *action phase* is aimed at changing the actual problem situation. In this phase concrete solutions are specified and analysed on potential technological and managerial implementation problems, and the actual usefulness of the implemented solution must be judged. Finally, one should critically reflect on the whole research process as will be discussed in 'Conclusion'.

The FQM research methodology will be illustrated with a research example.

## A research example

The research project, used here as an example, starts with a question of the Dutch Celiac Disease Society: is it possible to create a safe chain for oats bread to be consumed by celiac disease (CD) patients? Celiac disease is currently the most occurring food intolerance. It is a chronic inflammatory disorder of the small intestine resulting from the ingestion of gluten found in wheat, rye, barley, and products thereof (Garsed & Scott, 2007). About one in 200 people in the Netherlands is suffering from CD and the only remedy is a lifelong gluten-free diet. Oats are basically free from gluten, but due to contamination with gluten of wheat, rye, and barley along the oats production chain, oats products are not safe for CD-patients. The actual problem is thus how to build up an oats production chain, wherein gluten contamination is reduced to an acceptable level.

The *appreciation phase* starts with searching for typical technological and managerial aspects related to the problem situation. Typical technological aspects include characteristics and dynamics of oats and oats products, process characteristics of production, technological dependencies in the production chain, and sources of gluten contamination. Typical managerial aspects include characteristics of people involved in oats processing and handling, collaboration in the chain, and quality assurance systems. From theory, technological (T) and managerial (M) models and concepts are selected to support a more in-depth understanding of the problem situation. Typical models that have been selected using the theory-selection grid are:

- concepts on quality assurance systems (M) (e.g. Luning, Marcelis, & Van der Spiegel, 2006),
- models on quality control (M) (e.g. Bertolini, Bevilacqua, & Massini, 2006),
- models on chain relationships and partnerships (M), (e.g. Zuurbier, Trienekens, & Ziggers, 1996),
- models on compliance to procedures (M), (e.g. Azanza & Zamora-Luna, 2005),
- concepts on prerequisite programs and CCPs (T, M), (e.g. Arvanitoyannis & Traikou, 2005),
- models on production of oat and oats products (T), (e.g. Gallagher, Gormly, & Arendt, 2004),
- models on product/process variation and risk (T), (e.g. Voysey & Brown, 2000),
- concept on effect of gluten-level on CD-patients (medical studies) (T), (e.g. Fasano & Catassi, 2001), and
- concepts on factors determining gluten contamination, like seed, equipment, and air (T), (e.g. Størsrud, Malmheden-Yman, & Lenner, 2003).

Using these models and concepts it was concluded that producing low-contaminated oats bread is not specifically a technological problem or a people problem, but the critical issue is to let both people and technology work at a very high quality level. It was also concluded that CD-patients want to be absolutely sure about non-contamination. After this first theory analysis the appreciation phase resulted in a more focused problem definition: is it possible to develop a quality assurance system for the oats production chain, assuring oats bread to be safe for consumption by celiac disease patients? From the same models it was concluded that probably much attention has to be paid to preventive measures, because once oat or oats flour or bread is contaminated with gluten, they cannot be removed. Therefore, the resulting hypothesis is ‘a quality assurance system in the oats production chain only can assure a lower than 20 ppm gluten-level when it is based on a high level of prevention of gluten contamination’.

In the *analysis phase* first a conceptual research model needs to be developed (Fig. 2), including the following:

- An outcome factor: in this case assured oats bread, indicated by the level of gluten in parts per million.
- The basic processes resulting in the outcome: in this case the oats production process (farming and cleaning), oats flour production (hulling and milling), and baking process of oats bread. Both people (taking decisions and handling products) and products and technological infrastructure are included as factors to be assured in each production step.
- Factors influencing the processes and the outcome: in this case the quality assurance system, that should assure gluten-free bread by putting requirements on capability of processes, equipment and buildings (technological conditions), on product properties and process parameters (food dynamics), on responsibilities and procedures (administrative conditions), and on people decisions and actions (human dynamics).

These factors are indicated by, respectively, the *level of separation* (is the production physically separated from production of gluten containing products), the *level of dedication* (are product tolerances and process parameters designed for production of high-purity oats products), the *level of procedures* (do procedures exist, containing well considered and clear prescriptions of responsibilities and practices), *and level of compliance* (do people comply with the procedures). The model was validated by discussions with people involved in oat production chains, and with several experts in the field of oats processing, high quality (food) production, quality assurance, and risk analysis. Related to the conceptual model, the research objective is formulated as to find a relationship between quality assurance measures for the oats production chain and the level of gluten contamination in oats bread. The next step in the analysis phase is to translate indicators into questions as a basis for data and information gathering. Therefore, indicators are more specifically described in four levels, representing quality practices from no specific measures, to simple, medium, and advanced practices, as shown in Table 2. With questions, derived from these indicators, existing companies were analysed both in The Netherlands, where these companies possibly should be part of a future oats chain, and in Sweden, where fully separated companies already produce oats for CD-patients. In The Netherlands the scores for the four indicators in five chain phases (from farmer to bakery) resulted in a mean score 3, which is much too low for meeting the assurance requirements. Problems were summarised in three bottle-necks:

- contamination is possible due to open air (farmer) and dust (huller, miller, and bakery),
- equipment cannot always be cleaned (farmer and cleaner), and

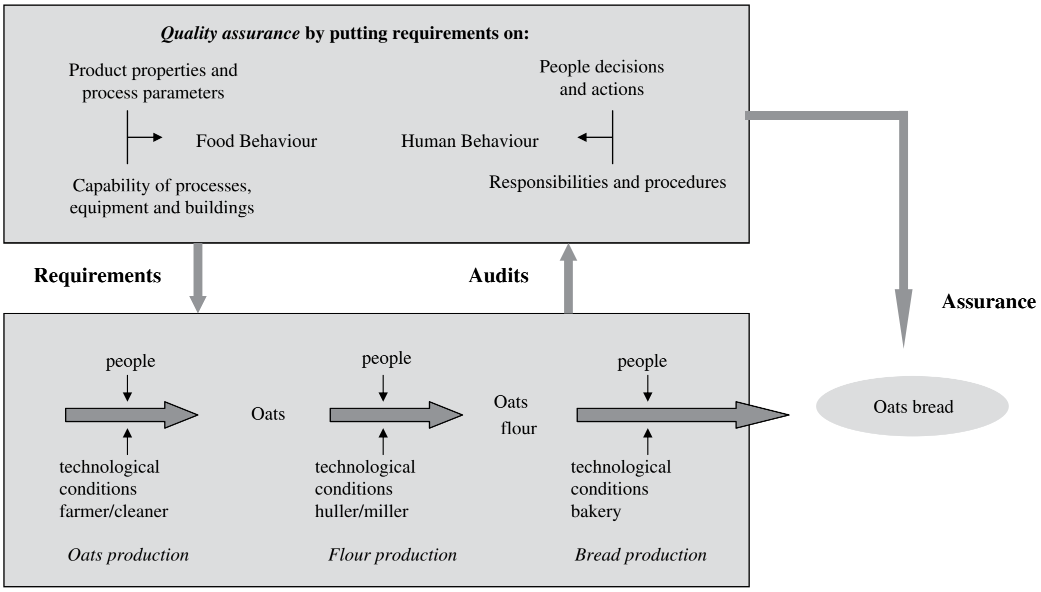


**Fig. 2**. Conceptual research model on quality assurance in oats bread production chain.

- compliance to procedures is low (in all parts of the chain).

The positive point is that production with full separation in Sweden is resulting in gluten levels <20 ppm.

In the *assessment phase* literature needs to be found that supports in solving above-mentioned bottlenecks. Besides full (indicator level 1) or partial separation (indicator level 2) of companies, typical control measures are found as possible solutions, ranging in difficulty from careful supplier selection, supplier certification to total chain control. Combining these possible measures results in six options: (A) partial separation, supplier selection, (B) partial separation, supplier certification, (C) partial separation, total chain control, (D) full separation, supplier selection, (E) full separation, supplier certification, and (F) full separation, total chain control. Analysing these options on their ability to assure a 20 ppm level, it was concluded that option B is minimally required for farmer and cleaner, and option E for huller, miller, and bakery. This minimum scenario was compared to a scenario with total chain control instead of supplier certification. Criteria for selecting the best alternative were formulated as:

- meet 20 ppm level, but preferably in combination with 20–200 ppm products for quantity of production (20–200 products are acceptable for the greater part of CD-patients),
- meet legal requirements,
- acceptable product prices, and
- full assurance.

Only the last criterion supports the total chain control alternative, therefore it was decided to first analyse the BE alternative in more detail on its feasibility.

Finally, evaluating the project as a whole, it was concluded that the T–M approach enables a simultaneous consideration of relevant technological and managerial aspects

**Table 2. Indicators to analyse factors influencing gluten level in oats bread**

| Levels of quality practices | Indicators | | | |
|---|---|---|---|---|
| | **Separation** | **Dedication** | **Procedures** | **Compliance** |
| 1. Advanced | Full separation and on different location | Tolerances and parameters are fully adjusted to production of high-purity oats products | Complete, precise, and understandable procedures | Full and conscious compliance |
| 2. Medium | Full separation, but on same location | Full adjustment, but only for contamination prevention at CCPs | Complete and understandable, but general procedures | Full but unconscious compliance |
| 3. Simple | Same production room, but hygienic designed infrastructure | Partial adjustment for contamination prevention | General procedures, but describing intentions, more than practices | Unconscious partial compliance |
| 4. No specific measures | No specific separating measures | No specific adjustment | No specific procedures | Conscious or spontaneous non-compliance |

involved in quality assurance in the oats chain. From a theoretical point of view, it is possible to realise an oats chain on a 20 ppm level. The hypothesis (high level of prevention) could not be confirmed nor rejected, and only a theoretical solution has been derived. So, more research is necessary to evaluate the implemented solution in a practical situation. Last but not least the research has been done in close cooperation with the Dutch Celiac Disease Society, which could have been led to a bias towards a positive solution.

## The critical role of the researcher in techno-managerial FQM research

In this section the role of the researcher in analysing complex food quality management research by a techno-managerial approach is considered. Mingers (1997b, 2003) discussed the importance of acknowledging the multidimensionality of a problem situation, but also emphasised that the use of various theories from different scientific disciplines increases the impact of the agent involved in a research process. He underpinned that the relationships between intervention system (agent) and intellectual resource system (theory), between intervention system and problem content system (practice), and between intellectual resources system and problem content system are unique to a particular intervention, and should be explicitly considered. For FQM research it means that researchers in relation to the technological and managerial theories deal with questions like, to what extent can I work in diverse paradigms, what is my level of critical awareness of possible theories, what are my skills/experiences in using them, and what is my personality, cognitive style? Researchers dealing with the problem situation should ask questions like, who do I see as problem owners, what is my commitment to them, what are expectations about my role (e.g. facilitator or expert), and what resources are available (access, time, participants). Finally, the researcher should critically analyse the relationship between practice and theory, dealing with questions such as, what is the culture of the organisation with regard to using certain theories, and what is the history of past theory use, and to what extent are certain values embedded in the theories appropriate to the situation. So, researchers themselves are the basic condition for critical FQM research. However, at the same time they are barriers for it. A techno-managerial approach includes working with different disciplines but usually agents have been educated in one of them. Since technological and managerial disciplines represent two different worlds of science (positivistic versus phenomenological), people will meet cognitive barriers when working with different paradigms. Brocklesby (1997) described four barriers in cognitive development required for multi-paradigm work: (1) becoming conscious of new paradigms, which includes realising that other theories could be involved, (2) committing oneself to a new paradigm, which is based on perceiving the advantages of using new theories, (3) acting effectively in a new paradigm, which includes getting used to work with new theories, and (4) moving easily between paradigms, which finally is necessary to really integrate different theories in one consistent approach. In an analysis on interdisciplinary working, Vedeld and Krogh (2005) concluded that it is a process that encompasses maturing and self-reflection on one's own perspectives, and a culture of learning and knowing. According to them it is crucial to select, translate and integrate knowledge from different disciplines within a coherent framework.

To be able to act effectively in interdisciplinary research work, researchers and practitioners need adequate education, which pays attention to important dimensions of interdisciplinary work such as: disciplinary grounding (is work grounded in carefully selected and adequately employed disciplinary insights), advancement through integration (are disciplinary insights clearly integrated, using integrative devices as conceptual frameworks and models), and critical awareness (does work exhibit clear purpose, reflection, and self-critique, like framing problems in ways that invite interdisciplinary approaches, and exhibiting awareness of how integration works and the limitations of integration) (Boix & Dawes, 2007).

## Conclusion

In this study we have developed a research methodology with a framework for selection of theories and information from practice from as well a technological as managerial disciplines, which will enable researchers and practitioners in analysing complex problem situations from a techno-managerial approach. The specific attention to the impact of the agent (researcher or practitioner) on the research process will stimulate his critical awareness to integrated research or analysis of food quality management issues.

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