Conception of integrated models for quality management in production chains in the Agri-Food sector

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Abstract

Thinking about quality management started in the fifties. Until now many different quality management systems have been developed. Deficits in food safety and the globalisation were reasons for the development of quality systems in the agribusiness and food industry. Sometimes several quality systems are relevant for firms. However, it is more efficient for firms to analyse different requirements of quality management systems to eliminate double requirements. The result would be an integrated quality management system. The aim of this project is to develop an instrument that reduces this work and which gives an insight into the effectiveness of quality systems.

Keywords: quality management systems, cost/benefit, integrated description model

1 Introduction

Quality management is of paramount importance in all stages of the agri-food production and process chain. The approach of quality management has been changed in the past years due to the effects of globalisation, numerous deficits in food safety and the legislative such as the new European regulation 178/2002 concerning food safety. A challenge was and is the integration of these changes into the sector and the design and development of appropriate information and communication systems. A trend is the development of several quality systems and norms in response to this challenge. Therefore, programmes will be developed and improved in the agri-food-industry further on.

There are general quality systems, which are applied in different countries and sectors, country and product specific systems and programmes, which were developed by retail initiatives.

The formulation of production processes and documentation is a central dimension of these different quality systems. Normally, most of their requirements are not harmonized and an acceptance often does not exist between different quality systems. However, in some cases the requirements of different quality systems are nearly the same. The result of this development is that farmers or firms who have implemented different quality systems have to fulfil a lot of requirements for their certification. Without an integrated accomplishment, much double work would be done.

Due to the variety of different quality systems, firms select quality management systems by comparing the requirements against the benefits. Hence, the question arises for firms how important quality management systems are and which advantages/disadvantages do they get with or without the certification.

The aim of the “QUALINT” project is the development of an integrated description model to simplify the management of different quality systems. The formulation of this model is supported by a databank, which automatically generates operational system descriptions.
The goal of this model is the minimization of costs in firms by reducing double work. The steps of the project realization are:

1. Literature review
2. Analysis of quality systems
3. Development of a conceptual management model
4. Request of dates with an analysis of cost/benefit for firms, which will be the focus of this paper and
5. The next step will be the developing of an optimal strategy in implementing quality systems for firms.

First this paper considers the initial situation of the changes in the food legislation, the development of quality systems and costs and benefits of quality systems (section 2). Section 3 includes the explanation of the developed instrument “Qualint Sys” and analysis methods of different quality management systems to acquire the effectiveness of an integrated quality management system. These methods are used as a basis for a critical analysis of the efficiency of an integrated quality system (section 4).

2 Initial Situation

2.1 Changes in the food safety legislation

Food legislation has changed during the past years. For example, in the year 1990 the product liability law was published. A key element of this law is that producers have to fulfil the due diligence of the product, what simply means that firms must taken all relevant steps to assure the safety of the products. In the year 2000 the law redefined the legal meaning of due diligence (Krieger, 2002).

Another development was the publishing of the white book in the year 2000 by the EU. The new EU regulation 178/2002 with paragraph 18 concerning traceability of food is one result of the 84 actions of the white book (EU Commission, 2002). This regulation started in the year 2005 as the new subsidy payments did. Till last year the farmers got their payments according to the agricultural land size, since January 2005 farm subsidy payments have been linked to compliance with basic standards relating to environmental management, animal health and welfare and so on (Verbraucherministerium, 2004).

The Regulation 852/2004 aims to harmonize food hygienic legislation across Europe. This regulation lays down general requirements relating to food hygiene, clarifying the existing responsibilities of food businesses and is effective from January 2006. In a true ‘farm to fork’ approach, primary producers are now subject to the hygiene requirements (EU Commission, 2004). This legislations and changes of their requirements are also reasons for the development of quality systems

2.2 History of quality management systems

An important development is that in line with the principles established in the Codex Alimentarius food safety management systems based on Hazard Analysis and Critical Control Point (HACCP) principles will be mandatory for all food businesses.

At the beginning of the sixties, the FAO and WHO developed the Codex Alimentarius regulation because of the expansion of the food trade. Moreover, until now this regulation has
influences on quality and safety in the global food supply chain and is a basis for a ‘fair’ international trade.

In the eighties the development of systems with regard to process management (‘Good practice’) started.

Good practice (especially the good agricultural (GAP), good hygienic (GHP), good manufacturing (GMP) and good trade practice (GTP)) is a basis for a quality management. GAP is a guideline for the reduction of chemical, physical and biological hazards. GHP is obligatory for preventive hygienic arrangements in the firm and GMP is a basis for ensuring that products are consistently produced and controlled according to quality standards. GTP is a guideline for adequate transport of animals, raw materials and food (Krieger, 2002).

Since the nineties, the international norm ISO 9000ff. has become popular. ISO (International Organisation for Standardisation) norms are international standards in order to achieve uniformity and to prevent technical barriers to trade throughout the world.

The reason for the development of ISO 9000 was the publication of a consistent norm, which formulates the framework for quality management.

The DIN EN ISO 9000:2000 norm includes basics and definitions of quality management (ISO 9000), makes demands on the quality management (ISO 9001) and formulates a guideline for the improvement of the quality system (ISO 9004). It is a sector independent standard (Pfeifer, 2001).

Since the middle of the nineties, more and more systems with reference to the HACCP system are implemented in the agri-food sector.

The main point of the HACCP-concept is the identification of health hazards during the production. It includes the seven HACCP principles. Conduct hazard analysis and identify control measures, identify critical control points (CCP), establish critical limits, monitor each CCP, establish corrective action to be taken when a critical limit deviation occurs, establish verification procedures and establish a record-keeping system (Luning et al., 2002)

On account of increasing different national certification standards for HACCP (e.g. the DS 3027 in Denmark, an HACCP standard in the Netherlands, an Australian norm) the international norm DIN EN ISO 22000 is directed for the standardization of these different systems. The system’s main point is the control of hazards with specific measures (SSM). The definition of the SSM is: “Supportive safety measures: specified activities, other than critical control points, which affect food safety by preventing, eliminating or reducing the probability of hazards occurrence.” (Bureau Veritas, 2002).

Furthermore, quality systems have been developed with specific demands for the agri-food industry and with a view on supply chains.

Examples for systems of the agri-food industry are the quality and safety system (Q+S), the quality management milk (QM) in Germany and the integrated chain control system (IKB) of the Netherlands; these are vertical oriented quality systems. Horizontal quality systems are for example the International Food Standard, the British Retailer Consortium, the European Food Safety Inspection Service, which were developed by retailers, the ISO 9000 standard and the HACCP (Krieger, 2004a).

2.3 Costs and benefits of quality management systems

2.3.1 Costs of quality systems

To measure the effectiveness of quality management systems, cost and benefits are important aspects.
In April 2003, questionnaires were sent out to the 300 biggest companies of the German food industry and 85 responses were received. The goal was to determine and analyse costs of quality management systems.

Figure 1 shows costs, which are interesting for the internal work of a firm. Documentation and the high cost of entry checking and process analysis got the most criticism by the firms. Fault analysis cause 14%, quality checking 11% and training 10% of quality costs in firms. (Beyer & Krieger, 2004).

![Figure 1: Internal costs of a quality system in firms: result of a survey (Beyer und Krieger, 2004)](image)

### 2.3.2. Background of benefit dimensions

Benefits of quality management have very different dimensions. Results from expert interviews and literature reviews present that some benefit aspects are more important and actual than others. Therefore, the following benefit aspects have been selected to evaluate the quality concepts:

1. **Market entry**
   
   In some cases, a quality system certification is an entry to markets. The reason is that without a certification it is not possible to sell on this market. Standards can also be a barrier to trade for poorer developing countries because the cost of meeting them is assumed prohibitively high.

2. **Product liability**
   
   Since the year 2000, product liability has been a catchword not only in the food and agri industry. A key example is the legal standard to meet the due diligence requirements of the product liability law. The requirements that firms practice due diligence simply means that a firm must have taken all necessary steps to assure the safety of the products.
3. Cross Compliance

Cross Compliance has been relevant for farmers since this year. The subsidy payments will now be paid according to the fulfilment of 19 EU-Regulations. In addition, in some cases the demands of those regulations have intersections with the demands of quality management systems.

4. Process quality

Process quality is the organisation of the internal process and the transactions between firms. An optimal organisation of a process means lower costs. Moreover, the requirements of different quality systems have a special focus on the optimal organisation of the processes in firms.

5. Product quality

Product quality concerns on the one hand physical product attributes (taste, shelf life, etc.) and on the other hand the safety of a product with regard to health aspects.

6. Traceability

The EU regulation 178/2002 contains general provisions for traceability (applicable from 1. January 2005), which cover all food and feed business operators, without prejudice to existing legislation on specific sectors such as beef, fish, GMOs etc. (EU Commission, 2002). Importers are similarly affected, as they will be required to identify from whom the product was exported in the country of origin. Traceability has to be done one step back and one step forward.

The evaluation of quality concepts is based in this study on the six above-mentioned benefit dimensions.

In the eighties the HACCP-Concept became popular in the USA and later on in Europe. HACCP is widely recognised in the food industry as an effective approach to establishing good production, sanitation, and manufacturing practices that produce safe foods (Pierson & Corlett, 1992).

It establishes process control through identifying points in the production process that are most critical to monitor and control. HACCP’s preventive focus is seen as more cost-effective than testing a product and then destroying or reworking it. The system can be applied to control any stage in the food system, and is designed to provide enough feedback to direct corrective activities. Like figure 2 shows the main focus of HACCP is product quality of food. Food borne illness has been decreased since the integration of HACCP, which studies show (Unnevehr & Jensen, 1998).

However, product quality can only be guaranteed if the process organisation is in a good order.

Adoption of HACCP as a regulatory standard has been motivated first by food safety concerns, and only second by a desire to facilitate trade (Caswell & Hooker, 1996). But the process of facilitating trade required mutual recognition of HACCP regulations across
national boundaries, which shows that HACCP is internationally necessary for the market entry (Unnevehr & Jensen, 1998). In addition to greater food industry concentration, HACCP regulations may also create incentives for greater vertical coordination to control food safety throughout the production process. There is no necessary control if the product deliver and it is less expensive to contract or control production processes upstream (Mazzocco, 1996). A better vertical coordination can be guaranteed. Another benefit is seen in product liability. HACCP formulates no special requirements which does fulfil Cross Compliance requests (Figure 2).

![Figure 2: Benefits of HACCP](image1)

![Figure 3: Benefits of ISO](image2)

In the nineties the ISO 9000 norm was developed. ISO 9000 is a set of international, voluntary quality management standards that ensure a consistent production process. The result is an improving in the efficiency (Böcker et al., 2004). The ISO 9000 is a framework for a quality management system and the integration in a firm is very flexible. Therefore, the accomplishment of the ISO 9000 is not a guarantee of good product quality. This standard has an international acceptance and it was relevant for the market entry. A survey presents that international marketing aspects of the ISO 9000 certification and access to other markets have been regarded as one of the most important reasons to seek certification (Capmany et al., 2000). A vertical traceability is not the main focus of the ISO 9000 like the product liability. The ISO 9000 has also no special requirements which are important to fulfil Cross Compliance demands. However, it is possible to create the ISO 9000 on the farm with focus on their fulfilment (Figure 3).

Retailer initiatives developed quality systems for the food industry in the past years. On the one side there are quality systems like the International Food Standard (IFS), the British Retailer Consortium (BRC) and the European Food Safety Inspection Service (EFSIS) for the supplier to the retail and on the other hand, there is EurepGAP, a system for the farmers (Krieger, 2004b). These quality systems are often important for the market entry. Retailers ask for this system also due to product liability. Interventions exist between the requirements of the EurepGAP System and Cross Compliance. The requirements of horizontal quality systems are mainly recording process quality (Krieger, 2002). Product quality is also in focus of these quality systems. An interaction between
different QS systems over the stages of the agri-food supply chain would raise traceability. For example a combination of EurepGAP for farmers and of IFS for the supplier could increase a higher tracking and tracing between the stages of the agri food industry (Figure 4).

The main focus of vertical oriented quality systems is traceability. The intensity of the cooperation between the different stages of the supply chain can be different. The supply chain can have an open character (e.g. Q+S), a semi closed character (e.g. IKB) and a closed character (e.g. regional quality systems). The result is that cooperation and traceability have a different intensity. Vertically oriented quality systems have problems to be accepted by the retail, because the retail stage has designed their “own” quality systems. The result was that only a few retailers ask for vertical oriented quality systems because they also have to fulfil special demands. Product liability plays also a rule like Cross Compliance. The directives, included in the Cross Compliance demands, are often addressed by farm assurance schemes. Process quality is characterized by management routines that support the organisation and control of processes to assure desired process output (Schiefer, 2004). Points with this focus are also implemented in vertically oriented quality systems but more important is the preservation of product quality and safety (Figure 5).

3 Methodology

To answer the question about the optimal combination and integration of quality management systems in a firm, an instrument was developed. This instrument demonstrates the requirements of quality management systems. The model utilizes a databank, which automatically generates operational system descriptions. Benefits can be shown if a firm does an integrated quality system. Advantages of an integrated quality system are the use of synergies, reduction of time and cost in the application of quality systems and an easier integration of new quality systems (Schlüter & Petridis, 2000).
An important cost-value-analysis about special quality management scenarios in companies is the next step of this project. These scenarios will be analysed after a selection of marginal cost and benefit theories.

Marginal cost is the additional cost from increasing an activity. In production, marginal cost is the additional cost of producing one more unit of output (Varian, 1995).

The firms’ optimisation calculus can be represented as follows:

The firm’s marginal costs (MC) arise from the marginal costs of the fulfil of the demands of the new quality system (MC_N) minus the marginal costs of the existence quality system (MC_E) and the requirements which are not requirements of the new quality system. Another relevant parameter for the integration of a quality management system are the certification costs (MC_C).

\[
(1) \quad MC = MC_N - (MC_E - MC_{EA}) + MC_C
\]

Where

- \( MC \) = marginal costs
- \( MC_E \) = requirements of existence quality systems
- \( MC_N \) = requirements of new quality systems
- \( MC_{EA} \) = requirements of the existence quality system but not of the new one
- \( MC_C \) = costs for certification

The marginal benefit (MB) of a new quality system is the marginal sum of the advantages which arise from an implementation for a firm like a market entry (MB_M), more product liability (MB_P), fulfil of demands for Cross Compliance (MB_C), improving in the process quality (MB_Q), better product quality (MB_PR), enhance changes in the traceability (MB_T) and special benefits for a firm (MB_F).

\[
(2) \quad MB = MB_M + MB_P + MB_C + MB_Q + MB_PR + MB_T + MB_F
\]

Where

- \( MB \) = marginal benefit
- \( MB_M \) = benefits for market entry
- \( MB_P \) = benefits for product liability
- \( MB_C \) = benefits for Cross Compliance
- \( MB_Q \) = benefits for process quality
- \( MB_PR \) = benefits for product quality
- \( MB_T \) = benefits for traceability
- \( MB_F \) = benefits for firms

From this initial situation an optimal combination of quality systems (q_{opt}/c_{opt}) can be developed (see figure 6).

Figure 6: Relationship between the number of quality systems and cost/benefit
4 Results

4.1 Integrated models for the quality management in the production chain

The first result of this project was a computer based description model. This instrument is called Qualint Sys (Quality integration system), which is an instrument to measure the effectiveness of the integration of a new quality system in the agri-food sector. Qualint Sys contains the requirements of different quality systems. An example is given in table 1.

A mill has to fulfil four different quality systems: the Q+S, GMP13, IFS and BRC. These systems have a lot of intersections. HACCP is relevant for every quality system, a ISO 9000 or GMP certificate is also important for the Q+S system. A documentation of the HACCP-concept is a requirement of every quality system, and training and pest control is important for the GMP 13, IFS and BRC. This table shows that a integrated quality management system reduces work.

Table 1: Comparison of different quality systems

<table>
<thead>
<tr>
<th>Elements of quality systems</th>
<th>Quality systems</th>
<th>Q+S</th>
<th>GMP 13</th>
<th>IFS</th>
<th>BRC</th>
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</thead>
<tbody>
<tr>
<td>HACCP</td>
<td>required</td>
<td>required</td>
<td>required</td>
<td>required</td>
<td>required</td>
</tr>
<tr>
<td>ISO 9000</td>
<td>requirement (certification of ISO 9000 or GMP)</td>
<td>no requirement</td>
<td>no requirement</td>
<td>no requirement</td>
<td>no requirement</td>
</tr>
<tr>
<td>documentation</td>
<td>- HACCP-concept</td>
<td>- HACCP-concept</td>
<td>- HACCP-concept</td>
<td>- HACCP-concept</td>
<td>- HACCP-concept</td>
</tr>
<tr>
<td></td>
<td>- ISO 9000 or GMP+</td>
<td>- training</td>
<td>- training</td>
<td>- training</td>
<td>- training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- pest control</td>
<td>- pest control</td>
<td>- pest control</td>
<td>- documentation of a QM system</td>
</tr>
</tbody>
</table>

But how does exactly Qualint Sys works?
User could enter existing and new quality management systems into the description model. The additive documentation requirements are the result of the procedure.

The presentation of this documentation requirements act on different scenarios:
1. integrated into the ISO 9000
2. hinge on department
3. unstructured or
4. a combination of 1. and 2.

4.2 Cost and benefit of quality systems -Example-

A comparison of the British Retailer Standard (BRC) and the European Food Safety Inspection Service (EFSIS), two important standards on the Great Britain market, presents highly overlapping requirements.
A BRC higher level certified firm, which would like to integrate the EFSIS higher level requirements in their quality management system has to fulfil only some new requirements like table 2 shows. The firm has only to fulfil fifteen more requirements on a basic level and three new requirements on the higher level. The marginal costs are thirty four new requirements plus the certification costs.

Table 2: Integration of EFSIS in a BRC-certified firm

<table>
<thead>
<tr>
<th>level of requirements</th>
<th>additional requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>basic level</td>
<td>15</td>
</tr>
<tr>
<td>higher level</td>
<td>3</td>
</tr>
<tr>
<td>recommendations</td>
<td>18</td>
</tr>
</tbody>
</table>

5 Conclusions

In conclusion: This paper has given an overview of the variety of quality systems in the agribusiness and food industry in Europe. The main aspect was a cost/benefit analysis of quality management systems in firms and the description model for the integration of different quality systems in firms. The goal of this model is the minimizing of costs in firms in due to reduction of double work.

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