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How to improve food quality management in the bakery sector

M. Van Der Spiegel^{1, 2, *}, P.A. Luning¹, W.J. De Boer³, G.W. Ziggers⁴ and W.M.F. Jongen¹

¹ Product Design and Quality Management Group, Wageningen University, P.O. Box 8129, NL-6700 EV Wageningen, The Netherlands

² Institute of Food Safety (RIKILT), Wageningen, The Netherlands

³ Plant Research International, Wageningen University and Research Centre, Wageningen, The Netherlands

⁴ Nijmegen School of Management, Radboud University, Nijmegen, The Netherlands

*Corresponding author (e-mail: marjolein.vanderspiegel@wur.nl)

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Abstract

In the food industry, quality assurance (QA) systems are applied to ensure food safety and food quality to prevent liability claims and to build and maintain trust of consumers. Bakeries apply QA systems such as Hygiene code, HACCP (Hazard Analysis Critical Control Points), ISO (International Organization for Standardization) and BRC (British Retail Consortium), but for them to be able to decide which system suits their specific situation (i.e., context) most and how this system should be implemented, they lack the necessary insight into the interdependence of contextual factors of bakeries and the quality management level at which these bakeries operate. This article reports on these aspects. The contextual factors that were studied include QA system, size of organization, degree of automation and type of product group. The level of food quality management between groups of bakeries differing in these contextual factors was analysed. Differences between groups of bakeries were found in the level of the quality management activities, control of strategy, allocation of supplying raw materials, supply control, planning of production and control of execution of production tasks. Bakeries that applied BRC, bakeries with 150 employees or more, industrial bakeries, and confectionery and biscuit bakeries performed some of these activities at a higher quality level than the other groups of bakeries. The study shows that by using the instrument IMAQE-Food, bakeries can select suitable quality management activities and QA systems for their specific situation to achieve effective quality management.

Additional keywords: quality assurance system, organizational size, degree of automation, type of product group, product quality, IMAQE-Food

Introduction

Food quality management has become increasingly important in the agri-food sector due to various food incidents in the last decade: more food-borne diseases, higher-risk products and an increased quality awareness of consumers (Van Der Spiegel *et al.*, 2004). Because of consumer demands, the end linkages of the supply chain (e.g. retailers) require guarantees of an appropriate production quality. Therefore, a suitable food quality management has to be performed, which requires the application of quality assurance (QA) systems. To achieve an appropriate food quality management level the implementation of QA systems has to be adjusted to the different contexts of the organizations. However, the influence of contextual factors on food quality management is still unknown.

The context of bakeries differs in aspects like organizational size, number and type of suppliers and outlets, degree of automation, degree of co-operation, type of bakery products and type of QA systems (Anon., 2000; Diepstraten, 2000). Bakery products are characterized by a restricted shelf life, heterogeneity of (raw) materials, and seasonal variability in product quality due to production and harvesting conditions. The production quality of bakery products is designed, controlled, assured and improved by food quality management, the level of which can differ among bakeries. For example, some bakeries always purchase the same raw materials from the same suppliers and do not extensively control their quality, whereas other bakeries always select and evaluate suppliers and raw materials by audits, receiving control and analyses.

To improve quality management and to assure food production quality in the bakery sector, four QA systems are used: (1) the Hygiene code for bread and confectionery, (2) HACCP (Hazard Analysis Critical Control Points), (3) ISO 9000-series (International Organization for Standardization), and (4) BRC (British Retail Consortium). These systems focus on different aspects of a quality system (Dalen, 1996; Hoogland *et al.*, 1998; Luning *et al.*, 2002; Van Der Spiegel *et al.*, 2003; 2004; 2005a).

The Hygiene code describes production processes and guidelines to assure food safety and is based on HACCP-principles.

HACCP aims to assure the production of safe food products by using a systematic approach (i.e., a plan of steps) to the identification, evaluation and control of the steps in food manufacturing that are critical to food safety (Leaper, 1997; Anon., 1998). HACCP focuses on technological aspects of the primary process.

The ISO 9000-series aims to achieve uniformity in products and/or services, preventing technical barriers to free trade throughout the world. ISO consists of a checklist to assure managerial aspects. It requires the establishment of procedures for all activities and handling, which must be followed by ensuring clear assignment of responsibilities and authority (Hoogland *et al.*, 1998).

BRC aims to assure product quality and food safety (Damman, 1999; Loode, 2000). It is a technical standard for companies supplying retail branded food products. BRC consists of a checklist that combines HACCP with specific parts of Good Manufacturing Practice (GMP) and parts of ISO (Damman, 1999; Smit, 1999a, b; 2000). It focuses on both technological and managerial aspects.

Most QA systems are too generic in nature to be applicable for each company. They only describe *what* level the quality system should achieve (i.e., descriptive), but not *how* to arrive at that level (i.e., normative) (Barendsz & De Groote, 1994; Anon., 1996; Dalen, 1996; Krause, 1996; Stanley, 1998; Van Der Spiegel *et al.*, 2003; 2004; 2005a 2006). So bakeries have several options to apply the QA systems. Each bakery has to interpret the systems by adapting the generic aspects to their specific situation.

Inappropriate management of food production operations can cause problems with aspects like food safety, customer satisfaction and product availability. For example, inadequate temperature control of confectionery containing e.g. cream, fresh fruit or meat causes growth of micro-organisms, which can result in safety problems, product failures and customer complaints. Inadequate planning of production and distribution causes either overproduction, resulting in loss of materials, or products not being available, requiring additional production and deliveries and leading to customer complaints and failure costs. To avoid failures due to inappropriate management of food production operations and inappropriate methods of design, implementation and improvement, procedures should be available to make QA systems suitable for specific situations.

Bakeries have to make decisions on what aspects of food quality management and what QA system(s) are most suitable for their specific situation and how the QA system(s) should be implemented. To apply QA systems to specific situations, insight is needed into the interdependence of contextual factors of bakeries and the quality management level at which these bakeries operate.

A quantitative study by Van Der Spiegel *et al.* (2005b) among 48 bakeries showed that a higher level of quality management was related to a higher production quality. On the other hand, a larger complexity of contextual factors was related to a lower production quality, but quality increased when the level of quality management improved. However, the study did not judge how groups of bakeries that differ in contextual factors perform their food quality management. Therefore, a second analysis is necessary that studies the level of food quality management performed by bakeries differing in contextual factors.

The objective of our study was to investigate how contextual factors of bakeries are related to the level of food quality management. Contextual factors comprise the complexity of the organization, the production process and the product assortment. This study will make a contribution to the body of knowledge in the field of food quality management by providing insight into the interdependence of contextual factors of bakeries and the quality management level at which these bakeries operate. Bakeries can use this insight to apply QA systems for their specific situation.

Materials and methods

Interdependence between contextual factors and level of food quality management

The interdependence between contextual factors and level of food quality management

Table 1. Mean levels of quality management activity that differ between subgroups of bakeries. Subgroups of bakeries classified on the basis of the contextual factor type of quality assurance (QA) system, organizational size, degree of automation and type of bakery. n = number of bakeries.

Contextual factor	n	Quality management activity							
		Control of strategy	Allocation of supplying raw materials	Supply control	Planning of production	Control of production	Control of execution of production tasks	Control of receiving orders	Planning of distribution
<i>QA system</i>									
No QA system	3	5.8	2.6	10.0b ¹	3.1a	4.8	2.5a	5.5	6.4
Hygiene code	8	4.4	2.3	9.1b	3.9a	7.9	4.0b	6.1	6.1
HACCP	17	4.6	3.0	9.4b	5.3a	6.5	4.4b	6.3	6.7
ISO	5	5.5	3.0	5.1a	7.6b	7.6	5.9b	6.3	7.2
BRC	15	5.7	4.6	8.3b	7.4b	7.4	6.6c	5.4	6.6
<i>Organizational size</i> ²									
10-49	13	4.4a	1.9a	9.1	3.7a	6.3	3.7a	5.7	5.7
50-99	14	4.8a	3.7b	9.2	5.7b	6.7	4.7a	6.3	6.4
100-149	11	4.5a	3.2b	7.6	7.1b	7.8	5.7a	4.9	7.6
≥150	10	7.1b	5.0b	8.1	7.4b	7.4	6.6b	6.8	7.1
<i>Degree of automation</i> ³									
Non-industrial	22	4.3a	2.3a	9.2	4.2a	6.8	3.9a	5.6	6.7
Industrial	26	5.7b	4.3b	8.1	7.2b	7.2	6.0b	6.2	6.6
<i>Type of bakery</i>									
Bread	10	5.1	3.9	6.6a	7.0	8.0	7.2b	5.7	6.2
Confectionery	11	5.7	4.0	9.3b	5.5	6.9	5.3b	6.5	5.2
Mixed	22	4.7	2.5	8.8b	5.1	6.9	3.7a	5.4	7.9
Biscuits	5	5.4	4.9	10.0b	7.5	5.8	6.4b	7.4	5.0

¹ Means in the same column, followed by the same letter are not statistically different (Student's t-test; $P < 0.05$).

² Based on number of employees.

³ Based on type of oven used.

in the bakery sector was studied using IMAQE-Food, a diagnostic Instrument for Management Assessment and Quality Effectiveness in the Food sector. IMAQE-Food, which was developed and validated for the bakery sector by Van Der Spiegel *et al.* (2005a; 2006), includes both a questionnaire and a classification system that measures effectiveness of food quality management. The questionnaire was used for measuring the level of contextual factors, food quality management and production quality.

Data were collected from a sample of 48 (quality) managers of bakeries, using open questions with field coding and absolute answers. The data were quantified using scores in the range of 0-10 to measure differences within the sample. The score totals of each validated construct of IMAQE-Food were computed for each bakery stud-

ied by averaging (without weight factors) the scores of the indicators that comprise one construct. The following indicators of quality management activities were assessed: (1) control of strategy, (2) allocation of supplying raw materials, (3) supply control, (4) planning of production, (5) control of production, (6) control of execution of production tasks, (7) control of receiving orders, and (8) planning of distribution.

Classification of contextual factors

The 48 bakeries were classified on the basis of four contextual factor groups: (1) type of QA system applied, (2) size of organization, (3) degree of automation, and (4) type of product group (Table 1). Specific subgroups were distinguished within each group (Table 1).

The subdivision of the group *type of QA system applied* was based on the situation common in the bakery sector. Bakeries were classified according to their most comprehensive QA system. For example, bakeries using both the Hygiene code and HACCP were classified in the subgroup HACCP, bakeries using HACCP in combination with ISO 9001:1994 or ISO 9002:1994 were classified in the subgroup ISO, and bakeries with BRC combined with other systems were classified in the subgroup BRC. Most bakeries without HACCP applied the Hygiene code. The bakeries that used ISO and HACCP, first applied ISO because of requirements by customers and next HACCP because of legislative requirements. Bakeries with BRC first applied HACCP and some also performed ISO.

A subdivision of the group *size of organization* has not been explicitly used in literature or in practice. Therefore, the 48 bakeries were classified in four subgroups on the basis of numbers of employees per bakery, using the following ranges: 10–49, 50–99, 100–149 and 150 employees or more. Subdivision of the groups *degree of automation* and *type of product* was based on classifications used in practice (Anon., 2000; Diepstraten, 2000). Two subgroups of *degree of automation* are distinguished: industrial bakeries, which use ovens in which the products are mechanically moved, and non-industrial bakeries, which use ovens requiring the manual removal of products.

Subgroups of *type of product* comprised bakeries that produce bread, confectionery, a mix of bread and confectionery (i.e., mixed bakeries), or biscuits.

Statistical analysis

The relations between contextual factors and level of quality management activities were analysed per subgroup, using analysis of variance from the statistical programme GenStat. Differences in level of quality management activities between subgroups were analysed for statistical significance ($P < 0.05$), using Student's t-test. These differences were investigated in detail by a qualitative analysis. Within the subgroups, statistically significant differences in the level of a quality management activity were studied at indicator level to explain relations between contextual factors and quality management activities.

Results

The differences in level of quality management activities for the subgroups of contextual factors are presented in Table 1. The results of the qualitative analyses of the relations between contextual factors and quality management activities are listed in Tables 2–5.

Quality Assurance systems

Most bakeries performed HACCP or BRC. Five bakeries applied ISO and only three applied no quality assurance system. In spite of this variation in sample size, differences were shown to be statistically significant. The subgroups of bakeries differed significantly in the level of *supply control*, *planning of production* and *control of execution of production tasks*. Bakeries applying BRC performed these quality management activities at a higher level. In the case of *supply control* this level was higher than for bakeries applying ISO, in the case of *planning of production* it was higher than for bakeries with Hygiene code, HACCP or no quality assurance system, and in the case of *control of execution of production tasks* it was higher than for bakeries applying other systems or no quality assurance system. Bakeries that applied ISO performed *supply control* at a lower level than the other bakeries, and *planning of production* at the same higher level as BRC. Moreover, bakeries applying Hygiene code, HACCP and/or ISO performed *control of execution of production tasks* at a higher level than bakeries without a quality assurance system and at a lower level than bakeries with BRC.

Most bakeries applying BRC selected suppliers on the basis of criteria (Table 2). Other suppliers were selected only when failures were noticed or when the same persons noticed no improvements after making agreements. These bakeries mainly evaluated raw materials by a random check. Bakeries applying BRC always used the same design of production plan and fixed their product order. They used margins for quiet days and took failures and unexpected orders into account in the planning. Most bakeries applying BRC scheduled the tasks of employees per day or per week. Their instruction consisted of information, demonstration and supervision. When shifts changed, they communicated through consultation. Product quality was evaluated by registration and control. Most bakeries gave feedback of results by consultation, and improved their procedures following evaluation.

Bakeries applying ISO selected and evaluated suppliers (as part of *supply control*) at a lower level than other bakeries. They selected suppliers from a list of the purchase organization. Forty per cent of these bakeries had their suppliers selected and evaluated by persons who every time differed. However, they evaluated raw materials at a higher level than the other bakeries by receiving inspection reports, analyses and audits. For *control of execution of production tasks*, bakeries applying ISO differed from bakeries applying BRC because they used mainly demonstration and supervision for instruction. Moreover, to give feedback of results, they used a paper on a bulletin board.

Bakeries applying HACCP or Hygiene code performed *planning of production* at a lower level than bakeries applying BRC or ISO (Table 1). They based their production plan and product order also on experience (Table 2) and did not include time for unex-

pected situations in the planning. As for *control of execution of production tasks*, 41% of the bakeries applying HACCP and 38% of the bakeries applying Hygiene code performed the same tasks every day in contrast to the bakeries applying BRC or ISO. Bakeries applying HACCP or Hygiene code used mainly demonstration and supervision for instruction, and not all bakeries used shifts. Bakeries applying HACCP or Hygiene code evaluated product quality by supervision but did not improve their procedures following evaluation.

In conclusion, HACCP and Hygiene code scored lower on *planning of production* due to less flexibility and because planning was based on experience. ISO scored lower on *supply control* due to a less extensive and ambiguous selection and evaluation of suppliers. Considering these findings and the higher level of quality management when BRC was applied, a combination of HACCP and ISO appears to result in a higher level of quality management.

Size of organization

The four subgroups of bakeries classified according to size only differed significantly in level of *control of strategy*, *allocation of supplying raw materials*, *planning of production*, and *control of execution of production tasks*. Bakeries with 10–49 employees performed these four quality management activities at a lower level than bakeries with more than 150 employees (Table 1). Bakeries with 50–149 employees also performed at a higher level of *allocation of supplying raw materials* and *planning of production* than bakeries with 10–49 employees. But they performed at a lower level on *control of strategy* and *control of execution of production tasks* than bakeries with 150 employees or more.

Most of the bakeries with 150 employees or more had a relatively long-term strategy in contrast to the smaller bakeries, which mainly used a simple plan (Table 3). Besides long-term aspects, they evaluated their long-term strategy for aspects like certification and market situation, in contrast to the smaller bakeries, which evaluated their strategy for amount of produced products. Only the larger bakeries used the evaluation for improvement of their long-term strategy and integrated the data in an information system. Furthermore, the larger bakeries improved their procedures following evaluation, whereas the smaller bakeries did not always use evaluation for improvement.

The bakeries with more than 50 employees purchased raw materials and selected suppliers either themselves or via their trading company (Table 3). They mostly used the same design of production plan whereas the bakeries with 10–49 employees based their production plan also on experience. The bakeries with more than 50 employees adjusted their production plan on the basis of realization and used it for improvement of the long-term plan, in contrast to the smaller bakeries. The bakeries with more than 100 employees fixed the product order, whereas the smaller bakeries based the product order also on experience. Most of the bakeries evaluated product quality by product and process control in contrast to the smaller ones, which evaluated mainly by supervision.

In conclusion, the bakeries with 150 employees or more performed at a higher level of quality management because of a long-term perspective and improvement. Due to less evaluation and improvement and because of planning of production based

Table 2. Differences in quality management activity between subgroups of bakeries classified on the basis of type of quality assurance (QA) system. % = $a/b \times 100\%$ where a = number of bakeries that perform the level of quality management activity, and b = number of bakeries that use the QA system.

Quality management activity	Quality assurance system	
	Hygiene code	HACCP
Supply control	No selection of suppliers (50%) or selection on criteria (25%): product quality, price, delivery time. Other suppliers are selected if failures are noticed (38%) or if improvements after making agreements (50%). Selection by one person who is always involved (88%). Raw materials are evaluated by a random check (75%).	No selection of suppliers (35%) or selection on criteria (65%): product quality, price, delivery time, application of QA system. Other suppliers are selected if no improvements after making agreements (65%). Selection by one (29%) or more persons (47%) who are always involved. Raw materials are evaluated by a random check (71%).
Planning of production	Design of production plan is always the same (75%) or based on experience (25%). Product order is based on experience (38%) or fixed (55%) by: possibilities of contamination, types of dough, temperature of the oven, baking time, cooling, delivery time of products, capacity. Failures and unexpected orders are not included (50%) or are included in margins for only quiet days (50%).	Design of production plan is always the same (65%) or based on experience (24%). Product order is based on experience (47%) or fixed (41%) by: possibilities of contamination, number of times of cleaning, temperature of the oven, baking time, types of dough, packaging, amount of products. Failures and unexpected orders are not included (59%) or are included in margins for only quiet days (29%).
Control of execution of production tasks	Tasks of employees were scheduled per week (38%), per day (25%), or the tasks per day were the same (38%). Instruction by demonstration and supervision (75%) and information (25%) or only demonstration (25%). No shifts (63%). Communication for changing shifts by consultation (38%). Product quality evaluated by supervision (88%). Feedback of results by communication and evaluation (63%) or written (25%). Procedures are improved (50%) following evaluation (25%) or are not improved (50%).	Tasks of employees were scheduled per week (18%), per day (41%), or the tasks per day were the same (41%). Instruction by demonstration and supervision (83%) and information (24%) or only demonstration (18%). No shifts (29%). Communication for changing shifts by consultation (65%). Product quality evaluated by supervision (59%) or registration and control (29%). Feedback of results by communication and evaluation (47%) or ad hoc (41%). Procedures are improved (59%) following evaluation (41%).

Quality assurance system

ISO

Selection of suppliers selected by purchase organization (80%): product quality, price, delivery time, flexibility, application and no implementation of QA system. Suppliers are always selected and evaluated (40%). Other suppliers are selected if no improvements after making agreements (60%). Selection by more persons who are always (60%) or sometimes (40%) involved. Raw materials are evaluated by receiving inspection, analyses and audits (60%).

Design of production plan is always the same (100%). Product order is fixed (100%) by: temperature of the oven, types of dough, cutting, number of changing of equipment, possibilities of contamination, baking and rise time, packaging, specific product requirements, number of times of cleaning, delivery time of products. Failures and unexpected orders are included in margins for only quiet days (60%) or in the planning (20%).

Tasks of employees were scheduled per week (60%) or per day (40%). Instruction by demonstration and supervision (100%) and information (20%). Communication for changing shifts by consultation (60%). Product quality evaluated by registration and control (80%). Feedback of results by communication and evaluation (20%), written (60%) or ad hoc (20%). Procedures are improved following evaluation (80%).

BRC

Selection of suppliers on criteria (73%): product quality, price, reliability, information about specifications, application and implementation of QA system. Other suppliers are selected if failures are noticed (27%) or if no improvements after making agreements (53%). Selection by more persons who are always involved (87%). Raw materials are evaluated by a random check (53%) or by receiving inspection, analyses and audits (40%).

Design of production plan is always the same (87%). Product order is fixed (80%) by: possibilities of contamination, number of times of cleaning, number of changing of equipment, capacity, temperature of the oven, baking time, types of dough, specific product requirements, packaging. Failures and unexpected orders are included in the planning (40%), or in margins for only quiet days (33%) or are not included (27%).

Tasks of employees were scheduled per week (53%), per day (20%), or the tasks per day were the same (27%). Instruction by demonstration and supervision (80%) and information (53%). Communication for changing shifts by consultation (93%). Product quality evaluated by registration and control (87%). Feedback of results by communication and evaluation (60%) or written (27%). Procedures are improved following evaluation (80%).

Table 3. Differences in quality management activity between subgroups of bakeries classified on the basis of organizational size. % = $a/b \times 100\%$ with a = number of bakeries that perform the level of the quality management activity, and b = number of bakeries within the range of organizational size.

Quality management activity	Number of employees per bakery	
	10-49	50-99
Control of strategy	A simple long-term plan (< 1 week) based on production process (62%), comparable with production plan. Evaluation on the amount of produced products (54%).	A relatively long-term strategy (1-5 years) (50%) or a simple long-term plan (< 1 week) based on production process (36%). Evaluation on long term aspects like capacity and sales (57%).
Allocation of supplying raw materials	Purchase of raw materials and selection of suppliers by bakery itself (100%).	Purchase of raw materials by bakery itself (86%), selection of suppliers by bakery itself (93%).
Planning of production	Design of production plan is always the same (50%) or based on experience (29%). Product order is based on experience (50%) or fixed (43%) by: possibilities of contamination, temperature of the oven, baking time. Production plan is adjusted on the basis of realization (43%) or not adjusted (43%).	Production plan has always the same design (64%) or is always newly designed (36%). Product order is based on experience (50%) or fixed (50%) by: possibilities of contamination, temperature of the oven, packaging, capacity, delivery time. Production plan is adjusted on the basis of realization (91%), and used for adjustment of the long-term plan (57%).
Control of execution of production tasks	Product quality evaluated by supervision (100%). Procedures are improved if necessary (54%) following evaluation (31%).	Product quality evaluated by supervision (57%) and product and process control (36%). Procedures are improved if necessary following evaluation (50%).

 Number of employees per bakery

100–149

A simple long-term plan (< 1 week) based on production process (73%), comparable with production plan.

Evaluation on long term aspects like capacity and sales (55%).

Purchase of raw materials and selection of suppliers by bakery itself (64%) or via trading company (18%).

Design of production plan is always the same (100%).
 Product order is fixed (91%) by: temperature of the oven, baking time, types of dough, cutting, packaging, delivery time, number of changing equipment.
 Production plan is adjusted on the basis of realization (81%), and used for adjustment of the long-term plan (45%).

Product quality evaluated by product and process control (64%).
 Procedures are improved if necessary (91%) following evaluation (55%).

≥ 150

A relatively long-term strategy (1 month to 5 years) (80%).

Evaluation on aspects like quality policy, certification, investments, prognoses, market situation, product development, volumes, employees, and supply of raw materials (80%).

Improvement of long-term plan.

Purchase of raw materials by bakery itself (70%) or via trading company (20%).

Design of production plan is always the same (100%).
 Product order is fixed (80%) by: possibilities of contamination, temperature of the oven, baking time, types of dough, specific product requirements, cutting, packaging, capacity, number of times of cleaning, number of changing equipment.
 Integration of data in an information system.
 Production plan is adjusted on the basis of realization and used for adjustment of the long-term plan (70%).

Product quality evaluated by product and process control (80%).
 Procedures are improved if necessary following evaluation (80%).

on experience the bakeries with less than 100 employees performed at a lower level.

Degree of automation

The subgroups of industrial and non-industrial bakeries differed significantly in level of *control of strategy*, *allocation of supplying raw materials*, *planning of production*, and *control of execution of production tasks* (Table 1). The industrial bakeries performed these four quality management activities at a higher level than the non-industrial ones.

Industrial bakeries mainly used a long-term strategy, which was evaluated for long-term aspects or aspects like quality policy, certification and market situation (Table 4). They either purchased raw materials themselves or via their trading company. As for *planning of production*, industrial bakeries fixed their own product order. They used evaluation of the production plan for improvement of the long-term plan. They communicated by consultation when shifts changed. Industrial bakeries evaluated product quality by product and process control. They improved their procedures following evaluation.

Non-industrial bakeries performed the quality management activities at a lower level. They used a simple plan comparable to the production plan, which was evaluated for the amount of produced products. They purchased raw materials themselves. As for *planning of production*, they fixed their product order or based it on experience. Evaluation of the production plan was used for improvement of the production plan instead of the long-term plan. Most non-industrial bakeries produced without shifts. They evaluated product quality by supervision, and did not improve their procedures following evaluation.

In conclusion, industrial bakeries performed quality management activities at a higher level than non-industrial bakeries because of their long-term perspective and improvement. Non-industrial bakeries performed at a lower level due to less evaluation and improvement and because their quality management was based on experience.

Type of product

Most of the bakeries ($n = 22$) produced a mix of bread and confectionery (Table 1). Only five bakeries produced biscuits, with statistically significant differences between them. The subgroups differed significantly in level of *supply control* and *control of execution of production tasks*. Especially confectionery and biscuit bakeries performed these activities at a higher level. Bread bakeries performed *supply control*, whereas mixed bakeries performed *control of execution of production tasks* at a lower level.

Confectionery and biscuit bakeries performed both *supply control* and *control of execution of production task* at a higher level (Table 1). They mainly ordered raw materials at the same moment and frequently used contracts for delivering raw materials (Table 5). They mainly selected suppliers on the basis of criteria. The same one or more persons supervised the production tasks. Confectionery bakeries evaluated product quality by supervision, and biscuits and bread bakeries by product and process control. Most confectionery, bread and biscuit bakeries used evaluation to improve procedures.

Table 4. Differences in quality management activity between industrial and non-industrial groups of bakeries classified on the basis of degree of automation. % = $a/b \times 100\%$ where a = number of bakeries that perform the level of the quality management activity, and b = total number of industrial (n = 26) or non-industrial (n = 22) bakeries.

Quality management activity	Degree of automation	
	Industrial	Non-industrial
Control of strategy	A relatively long-term strategy (1 month to 5 years) (65%). Evaluation on long-term aspects (42%) or aspects like quality policy, certification, investments, prognoses, market situation, product development, volumes, employees, and supply of raw materials (35%). Improvement of long-term plan.	A simple long-term plan (< 1 week) based on production process (64%), comparable with production plan. Evaluation on the amount of produced products (60%).
Allocation of supplying raw materials	Purchase of raw materials by bakery itself (69%) or via trading company (16%).	Purchase of raw materials by bakery itself (95%).
Planning of production	Product order is fixed (81%) by: possibilities of contamination, temperature of the oven, types of dough, specific product requirements, packaging, number of times of cleaning, number of changing equipment. Production plan is adjusted on the basis of realization (92%) and used for adjustment of the long-term plan (65%).	Product order is based on experience (55%) or fixed (41%) by: possibilities of contamination, temperature of the oven, baking time, delivery time. Production plan is adjusted on the basis of realization (68%) and used for adjustment of the long-term plan (23%) or not adjusted (32%).
Control of execution of production tasks	Communication for changing shifts by consultation (90%). Product quality evaluated by product and process control (65%) or supervision (27%). Procedures are improved following evaluation (65%).	Communication for changing shifts by consultation (36%) or no shifts (55%). Product quality evaluated by supervision (86%). Procedures are improved following evaluation (32%) or are not improved (50%).

Table 5. Differences in quality management activity between subgroups of bakeries classified on the basis of type of bakery. % = $a/b \times 100\%$ where a = number of bakeries that perform the level of the quality management activity, and b = number of bakeries that produce bread, confectionery, biscuits or more types of product (i.e., mixed).

Quality management activity	Type of bakery	
	Bread	Confectionery
Supply control	<p>Raw materials are always ordered at the same time (50%).</p> <p>Selection of suppliers is done within selection by purchase organizations (40%) or selection on criteria (40%): product quality, price, delivery time, relation with suppliers, reliability, information about specifications, product quality and production method, flexibility, application and implementation of QA system.</p> <p>Raw materials are evaluated by receiving inspection, analyses and audits (70%).</p>	<p>Raw materials are always ordered at the same time (45%) or contracts are made (27%).</p> <p>No selection (36%) or selection of suppliers on criteria (64%): product quality, price, delivery time, reliability, variation in assortment, flexibility.</p> <p>Selection is based on evaluation of former deliveries, experience by other bakeries, results of tests, information by suppliers and purchase organization.</p> <p>Raw materials are evaluated by a random check (55%) or by receiving inspection, analyses and audits (27%).</p>
Control of execution of production tasks	<p>Supervision by 1 same person (30%), by more the same persons (30%) or by various persons (40%).</p> <p>Instruction by demonstration and supervision (100%) and information (50%).</p> <p>Product quality evaluated by product and process control (80%).</p> <p>Feedback of results by consultation (80%).</p> <p>Procedures are improved following evaluation (70%).</p>	<p>Supervision by 1 same person (45%) or by more the same persons (45%).</p> <p>Instruction by demonstration and supervision (91%) and information (27%).</p> <p>Product quality evaluated by supervision (64%).</p> <p>Feedback of results by consultation (73%).</p> <p>Procedures are improved following evaluation (55%) or are not improved (36%).</p>

Type of bakery

Mixed

Raw materials are always ordered at the same time (55%) or contracts are made (27%). No selection (36%) or selection of suppliers on criteria (50%): product quality, price, delivery time, application of QA system. Selection is based on evaluation of former deliveries, experience by other bakeries, results of tests, information by suppliers and purchase organization. Raw materials are evaluated by a random check (73%).

Supervision by 1 same person (36%) or by various persons (55%). Instruction by demonstration and supervision (45%) or only demonstration (36%). Product quality evaluated by supervision (68%). Feedback of results by consultation (41%), or written (23%) or ad hoc (36%). Procedures are improved (59%) following evaluation (32%) or are not improved (41%).

Biscuits

Raw materials are always ordered at the same time (20%) or contracts are made (40%). Selection of suppliers on criteria (100%): product quality, price, delivery time, reliability, information about specifications, product quality and production method, flexibility, application and implementation of QA system. Raw materials are evaluated by a random check (80%).

Supervision by 1 same person (60%) or by more the same persons (40%). Instruction by demonstration and supervision (100%) and information (40%). Product quality evaluated by product and process control (80%). Written feedback of results (60%). Procedures are improved following evaluation (80%).

Bread bakeries performed *supply control* at a lower level than other bakeries (Table 1). They mainly ordered raw materials at the same moment but used no contracts (Table 5). They mostly did not choose suppliers on the basis of criteria but chose from a selection made by a purchase organization. On the other hand, bread bakeries evaluated their raw materials by receiving inspection, analyses and audits in contrast to other bakeries that mainly used a random check.

Mixed bakeries performed *control of execution of production tasks* at a lower level than other bakeries (Table 1). More than one, always different person did the supervision (Table 5). They instructed their employees by supervision and/or demonstration but used no information. Mixed bakeries evaluated product quality by supervision. They did not improve procedures or evaluate procedures for the purpose of improving them.

In conclusion, confectionery and biscuit bakeries performed at a higher quality management level thanks to unambiguous supervision and more extensive selection, evaluation and improvement than bread and mixed bakeries. Bread bakeries performed *supply control* at a lower level than confectionery, biscuit and mixed bakeries because of less extensive selection of suppliers and ordering of raw materials. Mixed bakeries performed at a lower level of *control of execution of production tasks* than bread, confectionery or biscuit bakeries due to ambiguous supervision and less extensive evaluation and improvement.

Discussion and conclusions

Contextual factors and quality management

This study showed that contextual factors in the bakery sector affected the level of quality management activities. Literature on effects of contextual factors on quality management in the agri-food sector is scarce. But several studies have been done in other sectors. In the pot plant sector, Ziggers (1993) found that the number of non-temporary and part-time employees was related to the level of work performance. Benson *et al.* (1991) suggested that process and product contextual factors have little effect on quality management in manufacturing companies, although product complexity affected quality management in service companies. Others observed a positive relation between product complexity and vertical integration in the automobile industry (Novak & Eppinger, 2001), between number of products and work performance in the pot plant sector (Ziggers, 1993), and between type of industry and delegation, participation, and measurement in distribution (De Groote *et al.*, 1996). But in various industries Benson *et al.* (1991) found no relation between company size and quality management.

Although several studies also indicate that quality management is related to contextual factors, the specific characteristics of the agri-food industry contribute to a higher complexity of contextual factors. It therefore is expected that these factors have a larger effect on the level of quality management. Examples of such specific characteristics are: hidden safety risks, compound products, products that are still alive and change in time through several reactions, lower educated employees in comparison with the

knowledge required in the food production sector (Jongen, 1999; Luning *et al.*, 2002).

Because only a few studies investigated the interdependence of contextual factors and the level of quality management, more studies should be performed to obtain a good insight into this relation. Such insight is of major importance to know which quality management activities have to be improved in the specific situation of an organization.

Improvement of production quality

A previous study showed that the levels of quality management and production quality are interdependent (Van Der Spiegel *et al.*, 2005b). We assume that this relation will also hold for the differences within the groups, although we were not able to investigate this due to lack of data. The interdependence of level of quality management and production quality suggests that bakeries should improve their quality management activities to increase the level of production quality. On the other hand, the results of this study show that a lower level of food quality management does not necessarily lead to a lower production quality, because several companies with a low level of food quality management operated on the basis of experience.

Application of IMAQE-Food

In practice, established QA systems have a generic approach. They focus on processes, products, linkages of the supply chain, or company size. QA systems are often combined because each QA system covers different aspects of the complete quality system (Dalen, 1996; Hoogland *et al.*, 1998; Luning *et al.*, 2002; Van Der Spiegel *et al.*, 2003; 2004). But the implementation of QA systems is still not optimal (Green, 1993; Pallett, 1994; Krause, 1996; Mitchell, 1998; Motarjemi & Käferstein, 1999; Leblanc, 2000).

Because of the interdependence of contextual factors and quality management it is of major importance that contextual factors are integrated into the implementation methods of quality management. Also Van Der Bij & Broekhuis (1998) propose this contingency approach for contextual factors and quality systems.

A new QA system is not necessarily suitable for the specific situation of any organization. QA systems should be generic and transparent so that they can be inspected and certified in various organizations and sectors. So by selecting generic QA systems their implementation should be optimal for a group of companies and each company should adjust the systems to their specific situation. This would result in a better application, at the same time enabling unambiguous inspection and certification.

Because of their non-specialized functions in an informal organization, Jonker (1997) suggests to investigate the implementation of integrated QA systems in small and medium companies, whereas because of specialized functions individual QA systems could be more useful for large companies. In our opinion the classification of companies should be studied in a broader perspective, taking relevant contextual factors into account.

IMAQE-Food can be used to identify the contextual factors that need to be integrat-

ed into implementation methods. Moreover, the instrument can identify which of the quality management activities are important in a specific situation to obtain an optimal production quality. IMAQE-Food can also be used to analyse which of the quality management activities are improved by a specific QA system. Finally, the instrument can also be specified to measure effectiveness of established QA systems.

Future research

To measure the effectiveness of quality management activities for the subgroups, future research should analyse the interdependence of level of food quality management and production quality. This will show which quality management activities should be improved and/or added by the subgroups of bakeries. Moreover, more insight will be obtained into the improvement of effective quality management activities by applying a specific QA system.

Experience can replace the need for a high level of quality management to obtain an appropriate quality production. In IMAQE-Food, experience is part of food quality management. The relation between experience and production quality can be studied quantitatively by including experience as an indicator of contextual factors in IMAQE-Food. Scenarios can be used to measure experience.

Because of the interdependence of contextual factors and quality management, it is of major importance that contextual factors are integrated into implementation methods of quality management. In successive research implementation, methods can be developed that use a contingency approach. This will improve the applicability and can result in effective quality management and optimal production quality.

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