Available online at www.fooddynamics.org

Int. J. Food System Dynamics 4 (2), 2013, 117-129

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Improving Food Safety within China's Dairy Chain: Key Issues of Compliance with QA Standards

Wei Geng, Jacques H. Trienekens, and Emiel F.M. Wubben

University of Wageningen, The Netherlands
wei.geng.cn@gmail.com; Jacques.Trienekens@wur.nl; Emiel.Wubben@wur.nl

Received October 2012, accepted July 2013, available online Oktober 2013

ABSTRACT

This study aims to gain insight in quality assurance (QA) activities along China's dairy chain, to assess the potential of meeting more demanding domestic and foreign consumers. The study reviewed QA literature and QA standards (HACCP, GlobalGAP, and BRC) to formulate indicators for QA. Based on this framework 31 indicators have been operationalized for a questionnaire. Altogether 33 respondents have filled out the questionnaire, and six in-depth expert-interviews elaborated on the challenges, their causes, and the suited strategies. Following the analysis the study arrived at 12 key challenges, and strategies to cope with them. The findings can be used as a guide for reorganizing current food safety programs, to improve food safety and quality of China's dairy chain to comply with QA standards.

Keywords: food safety and quality, quality assurance, dairy chain

1 Introduction

In September 2008 the poorly regulated food safety and quality controls in China led to the so-called Melamine-crisis. To profit from higher measured protein content, companies used to add nitrogen-rich melamine to watered-down (baby) milk. This illegal practice led to the death of six infants and the hospitalization of nearly 53,000 children. A further 250,000 children were estimated to have suffered mild kidney and urinary problems (Pei et al., 2011). The melamine-crisis indicated major, widespread quality control problems in China's dairy industry. It was claimed that mechanisms for controlling the numerous private milk collection stations were weak, with limited resources, for dairy chain control, and responsibilities not clearly assigned to a single governmental department (Chen, 2009). Moreover, large dairy processors were formally labeled "exempt of inspection" (China Food Industry, 2004, according to Xiu and Klein, 2010). The melamine-crisis resulted in a confidence-crisis among Chinese consumers, and exports practically coming to a stop.

Already in 2009, the Chinese government implemented a new Food law to stipulate regular inspections, leaving no exemptions for any company involved in the food business. However, so far, control systems focus mainly on end-product testing, rather than on risk prevention at the different steps of the dairy chain. In this respect, China's dairy chain lacks the implementation of quality assurance (QA) systems. At present, China faces the challenge to upgrade its safety and quality control along the dairy chain to meet increasing demands from domestic consumers, but also to catch up with level Western standards, to enable the exploration of export opportunities. To what extent do advanced Chinese dairy companies catch up with international QA standards? This study aims to benchmark the QA level of Chinese dairy companies against QA activities as proposed by literature, and required by the 3 major Western Food Safety and Quality standards: HACCP, GlobalGap and BRC. The focus of this study is on modern large scale diary companies in China, because they are closest to compliance with Western standards.

Following this introduction, next section will first provide a short description of the Chinese dairy chain, followed by an identification and selection of indicators, to assess food safety and quality in the Chinese dairy chain. The third section of this paper presents the methods and procedures for data collection and analysis. The main findings are presented and analyzed in the fourth section, which is followed by the concluding section

2 Indicators to assess food safety and quality of the Chinese dairy chain

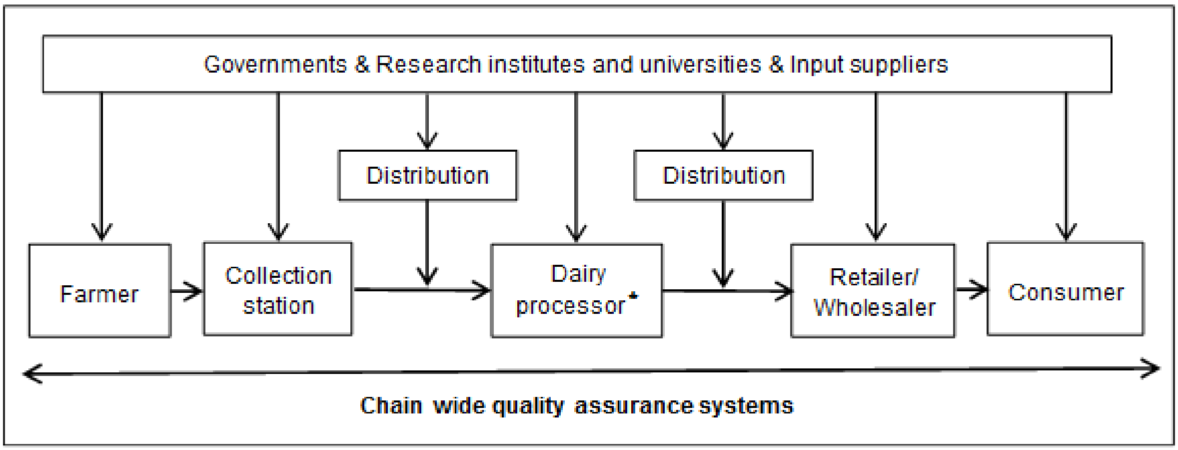

Figure 1 Dairy supply chain in China (*the modern processors)

2.1 China's dairy chain

The rapid growth of China's dairy industry over the last decades makes China the third largest milk producer in the world. The milk processing companies source the raw milk mostly from contracted suppliers. Milk collection stations, a typical Chinese link in the dairy chains, are locations with cubicle cattle sheds, where small dairy farmers milk their cows. Regular activities of milk collection stations are cleaning the cow's udders, milking, milk storage, and shipment. Most milk collection stations are owned by private business investors who have contracts with large dairy processors (Xiu and Klein, 2010). Governmental organizations play an important role in the dairy industry. Preferential policies and strategies have been designed to promote growth, because the dairy industry is regarded an important industry for developing local economies (Xiu and Klein, 2010). In guaranteeing a greater food safety level, regional and national governments put the control of food safety throughout all the actors of the dairy chain high on their agenda (Valeeva et al., 2005). Figure 1 presents the dairy chain in China. It is important to notice that the dairy processor in this study only refers to modern processors, which have modern equipment and use advanced technologies and managerial methods in their dairy operations (Xiu and Klein, 2010).

In the following subsections a framework of quality assurance indicators will be designed to benchmark China's dairy chain quality assurance (QA) against QA in Western countries, according to standards used by their companies.

2.2 Indicators from literature on Quality Assurance (QA) systems

In this subsection indicators will be extracted from academic literature. Luning et al (2006) developed the techno-managerial approach to recognize both technological and managerial aspects that can influence the performance of QA systems with respect to food safety and quality assurance. Technological factors involve QA in all links of the dairy chain. Decision-making, quality behavior, auditing and certification are elements to manage QA issues. Management has to decide on safety and quality control, such as the extent of sampling and the number of critical control points (Luning et al., 2006). Quality behavior is how people act on QA issues and is influenced by two factors (Luning and Marcelis, 2009): first, disposition, which refers to people's intentions and awareness of QA standards, such as the investment in education and training; second, ability, which refers to physical conditions and personal skills to meet the requirements. Various QA standards describe detailed procedures for auditing specific standards (Luning and Marcelis, 2009). Internal audits are carried out by the company itself for management purpose, while external audits usually involve an independent auditor to assess the implementation of a QA standard and to provide a certificate that records the auditing results (Luning and Marcelis, 2009).

To evaluate the adoption of QA activities, one should also evaluate some of the major pre-requisites of

QA. QA pre-requisites can be understood as barriers that may prevent compliance with QA systems. Therefore, they can be added as indicators to evaluate the adoption of QA activities. Barriers and constraints can be grouped into two categories (Kupper and Batt, 2009): internal barriers and external barriers. Figure 2 lists the possible internal and external barriers during the adoption of QA systems. Lack of training and reliable advice from leadership can impact adversely on the ability to adopt new programs (Kupper and Batt, 2009). Problems in the management of QA were more likely to occur with managers who were not trained for QA responsibility (Holt and Henson, 2000). A typical business has a busy, day-to-day existence without long term planning activities (Kupper and Batt, 2009). Even when the manager can be convinced of implementing QA systems, he may hold the allocation of sufficient time as another constraining resource barrier.

More in general, documentation and record keeping are essential for QA, because it supports a transparent system for evaluation (Duxbury, 2005; Jacxsens et al., 2009; Walker and Jones, 2002, according to Luning et al., 2009). Holt and Henson (2000) found, however, that documentation and records can easily be falsified; even large companies with fully documented hygiene systems can have low standards of cleanliness. With respect to external barriers, support schemes, with a formal and forward-looking QA program, are often lacking (Holt and Henson, 2000). Furthermore, QA standards developed against a European background miss the capacity to be adapted to local conditions (Herzfeld et al, 2011).

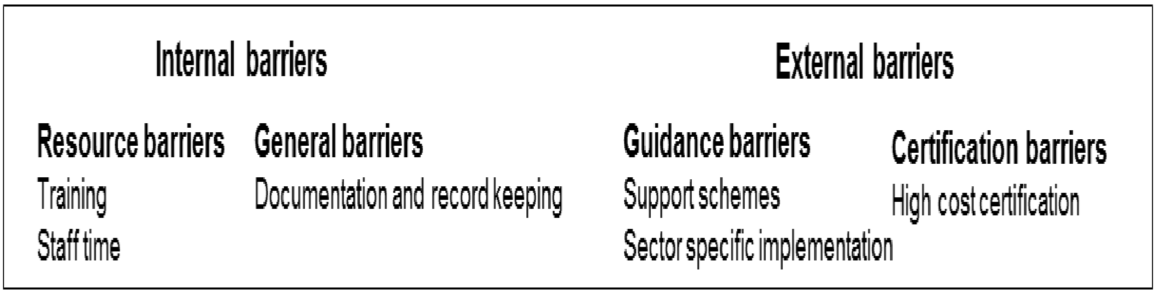

Figure 2. Internal and external barriers

Therefore, it is challenging to tailor specific assurance activities for the Chinese dairy industry. Finally, besides these two guidance barriers, the cost for certification of QA systems increased over time in China (Song and Chen. 2010), apart from high compliance costs.

2.3 Indicators from Quality Assurance (QA) standards

In this subsection, we will extract QA indicators from three QA standards, widely used by Western companies. First, HACCP (Hazard analysis and critical control points), that focuses on (food) safety and is used by most (other) QA standards as a basis philosophy or foundation to assure safety and quality of products. Second, GlobalGAP (formerly known as EurepGAP), that refers to the pre-farm gate activities of agricultural production and is a standard initiated by a group of leading global retailers. Third, BRC (British Retail Consortium) standard, also initiated by retailers, refers to post-farm gate activities, in particular focusing on food processing and food distribution. These standards cover QA from farm level to retail level including transportation and storage (see Figure 3).

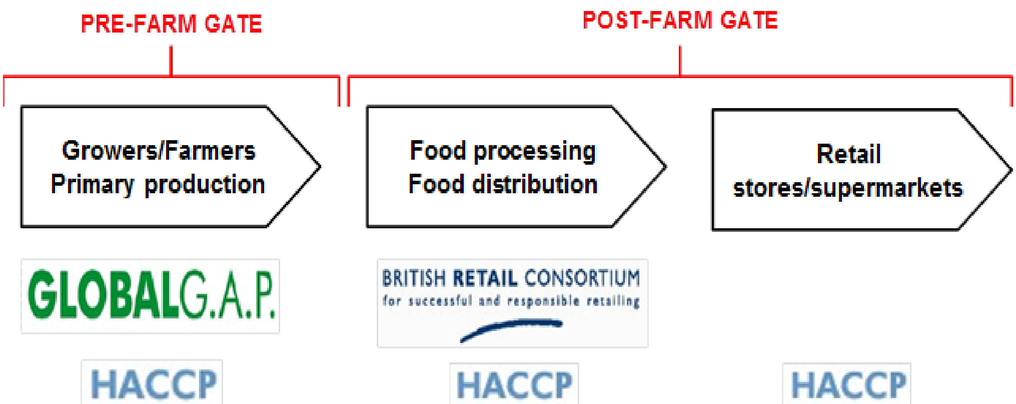

Figure 3. QA systems: classified based on stage of the supply chain (based on Chia and Lee, 2006)

European legislation prescribes the use of HACCP throughout the whole dairy chain, but dairy producers are not yet obliged to introduce a full HACCP program (Vilar et al., 2012). Moreover, the identification of CCPs is an individual decision of enterprises and very much depends on the basic level of hygiene that is being established and common in a country. Schothorst and Kleiss (1994) discussed in detail the implementation of a HACCP system in the dairy industry. They highlighted a critical control point (CCP) in pasteurization, which is an essential preventive measure for potential hazards in raw milk. Heating time and temperature are the parameters to accomplish this step. Next, cooling pasteurized milk is a CCP, because leaks in the barrier between the milk and the cooling fluid can occur and cannot always be predicted. A slight over-pressure on the pasteurized milk side can control the recontamination hazard. Other CCPs in the dairy production are the reception of milk, filtration, etc., (Arvanitoyannis and Mavropoulos, 2000). Furthermore, WHO and FAO (2008) emphasized the establishment of HACCP-based traceability systems for wholesalers, central distribution centers and retailers,: each wholesaler, central distribution center, or retailer should at least be able to ensure that foodstuffs in their control are traceable to the supplier. Expiration date is a CCP for milk powder products related to the growth of Salmonella and mould (Gesundheit and Frauen, 2006, according to Pei et al., 2011).

Second, the general regulations of GlobalGAP-certification of pre-farmgate dairy companies requires compliance with the “Dairy Base”, “All Farm Base”, “Livestock Base” and the “Ruminant Base” modules (General regulations, 2011). Each module provides control points on dairy health, milking and milking facilities. Some criteria are Major Must- control points, that require 100% compulsory compliance. The standards provide a series of main control points. The identification system requires that all dairy cattle have individual identification marks (tags/chips/tattoos/batch ID) and transport records. The veterinary health plan (VHP) shows routine preventative treatments, such as foot care, mastitis prevention, vaccination, and worming programs. The VHP should be formulated, implemented, reviewed and updated at least annually. Handling prescribes that dairy cattle at all times should be treated and handled in such a way that they are protected from pain, injury and disease. Milk cows must be milked regularly. Milk from cows within withdrawal periods for any medicine should be disposed of and must not enter the food chain. Clean running water for cleaning of dirty cows, rump bars and floors during milking, and potable water for cleaning of milking machines are needed. Milking facilities must be tested annually on records that ensure the temperature, adequate potable water and the cleaning chemicals being used. The requirements for milking parlors are (1) no evidence of vermin, birds or domestic pets; (2) no potential hazard of glass contamination from vulnerable lights; (3) easily cleanable walls, doors and floors; (4) sufficient lighting for cows; (5) sound and weather-proof external doors and windows; (6) no mess or rubbish as harborage for vermin; (7) clean equipment; (8) no excessive dust, no smoking; (9) well drained floors. Finally, GlobalGAP requires chemicals and medicines to be registered by the official bodies for use on a dairy farm.

The norms of the BRC standard take a HACCP system-based approach, but in the dairy chain emphasize managerial aspects and transportation for dairy processing companies. (Global Standard for Food Safety, 2011). Figure 4 depicts major BRC norms for QA. The outsource process requires the company to establish inspection and test procedures for raw milk from contracted suppliers. The item corrective action means that the company shall be able to use failures in the food safety and quality management system, to make necessary corrections and prevent recurrence. Also the norms on layout, process flow and segregation are important in dairy processing. Measures to control the hazard of recontamination are tight barriers between the product and its environment, as well as hygienic practices (Schothorst and Kleiss, 1994). Inspection prior to or during transportation (e.g., on duration, temperature, and acidity) is required. Documented cleaning procedures must be maintained for all vehicles and equipment used for loading and unloading. At the milk reception, the company shall undertake or subcontract inspections and analyses to confirm product safety and quality.

Senior management commitment
Meeting programme. The senior management shall ensure that all employees are aware of their responsibilities.

Food safety and quality management system
Quality manual
Documentation control and maintenance
Management of outsourced processing
Corrective action
Control of non-conforming product
Traceability
Complaint handling
Management of incidents, product withdrawal and product recall

Site standards
Security (protect the products from theft or malicious contamination)
Layout, process flow and segregation

Dispatch and transport
Documented procedure
Traceability
Inspection on vehicles and containers with records
Temperature control
Cleaning procedure
Security during transport
Third party contractors

Product and process control
Laboratory product testing
Control of operations
Calibration and control of measuring and monitoring devices

Figure 4. Main norms of BRC standard

2.4 Selection of indicators for QA assessment

Following the identification of QA indicators in the previous sections, this subsection describes the selection of indicators for QA assessment in the dairy chain. The selection was based on the following criteria:

(1) Indicators representing responsible factors for the melamine crisis. The raw milk collection station was the crime site of melamine adulteration. No single government agency had clearly identified responsibilities for the control of private raw milk collection stations (Chen, 2009). Moreover, Sanlu Company (main responsible company in the melamine crisis) officials knew about the problem for months without taking corrective actions (Xiu and Klein, 2010).

(2) Indicators representing core assurance activities in QA concepts. Management should take decisions on the extent of sampling and the number of critical control points (Luning et al., 2006).

(3) Indicators representing key CCPs (cf. HACCP-system). Schothorst and Kleiss (1994), Arvanitoyannis and Mavropoulos (2000), and Vilar et al (2011) identified key CCPs in the dairy industry and specifically in milk powder processing lines, oriented at ensuring food quality and safety.

(4) Areas and indicators that are pre-farm gate Major Must control points in the modules “Dairy Base” and “Livestock Base” of the GlobalGAP standard.

(5) Areas and indicators that are Fundamental requirements of the BRC standard.

(6) Areas and indicators that are barriers to the adoption of QA systems. These barriers are key problems in China’s dairy industry. E.g. dairy farmers are not trained properly and no detailed national standards exist that cover specific aspects of the dairy chain (Xiu and Klein, 2010).

Based on the stated criteria table 1 lists the main criteria for assessment of QA standards in China, used in this study. The methodology of the empirical research is further detailed in section 3.

Table 1.
Target indicators in relation to food safety and quality

Area	Indicator	Criteria (nr)
Managerial aspects		
Decision-making on QA	Identify critical control points; Validation;	(2)
	Traceability	(6)
Quality behavior	Training; Supervision and support schemes	(3)
Auditing and certification	Sampling & laboratory testing	(2)
	Documentation & record	(3); (6)
	Corrective actions	(1); (6)
Technological aspects		
Farming practices	Identification system; Animal health	(5)
Collection stations	Regularly milking; Withdrawal period; Worker hygiene; Milking; Chemicals; Parlor condition; Clean potable water; Milking/cooling equipment hygiene	(1); (5)
Distribution	Quality control prior to/during transportation	(6)
	Cleaning procedure	(4)
Milk reception	Inspection; Hygiene condition; Filtration; Storage	(4)
Transformation	Heating time & temperature; Cooling pasteurized milk; Pasteurization equipment design; Equipment cleaning; Factory layout	(4)
Retail practices	Traceability	(4)
Final food preparation	Expiration date	(4)

3 Methodology

This study focuses on the modern dairy industries in China, which stand the best chance to comply with international QA standards. Therefore, for data gathering the researchers targeted regions around the following four cities: Hohhot in the Northeast & Inner Mongolia area, and the areas surrounding modern cities, such as Beijing, Tianjin and Shanghai. These areas can be considered as representative for the modern dairy industry in China.

To examine the extent to which China's dairy chains are able to comply with QA systems, a combination of quantitative (questionnaire) and qualitative (in-depth interview) methods is used in this research. Both a questionnaire and an interview were designed on the basis of Table 1. The aim was to, first, have the respondent fill out the questionnaire, and then, when feasible, have an in-depth interview, clarifying the answers given and discussing opportunities for the industry and implications for policies.

3.1 Questionnaire design

The questionnaire was developed in accordance with target indicators referring to both managerial and technological aspects of quality assurance (See Table 1). We follow the techno-managerial approach, that has been successfully applied in several studies to measure the food safety performance in agri-food chains (Jacxsens et al., 2010) and, in particular, in milk processing plants (Sampers et al., 2012). In those studies, indicators were scored using four different levels: Score 0 (*no indication of food safety activity*) refers to absence, not present, not conducted; Score 1 (*low level of application*) is associated with: not standardized, unstable, problem driven, scarcely reported, no independent positions, and regular problems; Score 2 (*medium level of application*) refers to the use of (sector, governmental) guidelines, based on expert knowledge, standardized, regular reporting, and restricted problems; Score 3 (*high level of application*) refers to activities that use specific information/criteria, scientific knowledge, systematic activities, independent positions, and absence of safety problems. A score 4 (*Don't know*) indicates no answer to the question, due to non-applicability or lack of information.

The questionnaire was developed in English and translated in Chinese. It was sent out with an explanation of the survey, and a short guidance. We stratified four groups in the four stated regions (1) Researchers from university and research institutes (n=23); (2) Government staff members (n=6); (3) Members of dairy associations (n=5); (4) Staff members in modern dairy companies (n=16). Altogether 50 persons were contacted to participate in this investigation.

3.2 Interview design

When feasible, the filing out of the questionnaire was followed by an in-depth interview, clarifying the answers given and discussing opportunities for the industry, and implications for policies. The interview guide covered the following topics: first, key challenges to upgrade food safety and quality in China's dairy chain; second, the industry strategies and public policies , that can be developed to improve food safety and quality in China's dairy chain.

Six respondents accepted to do an additional interview after filling out the questionnaire. The interview started with the clarifying question why the respondents had given certain scores to specific indicators in the questionnaire. Next, the interviewee was invited to raise possible solutions for each lower scored indicator, to improve food safety and quality performance. The interview ended with a question on whether the interviewee has anything more to add to the study.

3.3 Data collection

Table 2 presents the participation of 34 respondents, out of 50 contacted persons. In total 33 questionnaires were received which means a 66% response rate. One person was only interviewed in depth. The 33 respondents who filled out the questionnaire came from the four subgroups. The four participating dairy companies are large modern dairy companies from within the four targeted regions. The response rate of each subgroup is presented in Table 2. Interestingly, the study managed to have almost half of the filled out questionnaires coming from staff-members of dairy companies.

Table 2.
Detailed participation of the respondents

Activity/Group	University/ Institute	Govern-ment	Associa-tion	Dairy companies (4 companies)
E-mail questionnaire	9	5	-	7
On-site questionnaire	-	-	-	7
On-site questionnaire + In-depth interview	-	-	1	2
Pre-test questionnaire + In-depth interview	1	-	1	-
In-depth interview	-	1	-	-
Questionnaire response rate (%)	43	83	40	100
Total (34)	10	6	2	16

4 Results

This section presents the aggregated results of the questionnaire and analyses the data together with the information gathered from the interviews and secondary sources.

4.1 Questionnaire results

The aggregated data gathered on the application of QA activities in China's modern dairy industry is presented in Table 3. No respondent marked a score 0 (*No indication of activity*), meaning that all QA indicators are considered somehow present in the dairy chain. The scores on managerial indicators were on average lower than those related to technological indicators. There was a number of score 4 answers (*incomplete information*) because not all the respondents had a complete overview of food safety and quality aspects along the entire dairy chain. Most answers were scores 2 and 3. Score 3 would indicate that no safety problems exist (*high level of application*), while score 1 and score 2 imply respectively major or moderate levels of QA challenges for the dairy chain.

Table 3.
Frequency of individual scores and average scores on quality assurance (Score 0, 1, 2, and 3 represent no, low, medium, and high level; score 4 (shaded) stands for no answer)

Areas	Indicators	Frequency					Mean score
Managerial aspects		**0**	**1**	**2**	**3**	**4**	
Decision-Making	Identify critical control points	0	1	4	22	6	2.8
	Validation	0	0	5	24	4	2.8
	Traceability	0	2	11	12	8	2.4
Quality behavior	Training	0	2	13	17	1	2.5
	Supervision and support schemes	0	4	11	15	3	2.4
Auditing and certification	Sampling & laboratory testing	0	0	3	30	0	2.9
	Corrective actions	0	3	12	16	2	2.4
	Documentation & record	0	2	13	13	5	2.4
Areas	**Indicators**	**Frequency**					**Mean score**
Technological aspects		**0**	**1**	**2**	**3**	**4**	
Farming practices	Identification system	0	1	11	16	5	2.5
	Animal health	0	1	11	14	7	2.5
Collection stations	Regularly milking	0	0	1	27	5	3
	Withdrawal period	0	0	6	18	9	2.8
	Worker hygiene	0	0	8	21	4	2.7
	Milking	0	0	2	24	7	2.9
	Chemicals	0	1	4	20	8	2.8
	Parlor condition	0	0	15	13	5	2.5
	Clean potable water	0	0	6	19	8	2.8
	Milking/cooling equipment hygiene	0	0	7	20	6	2.7
Distribution	Quality control prior to/during transportation	0	2	10	17	4	2.5
	Cleaning procedure	0	1	10	19	3	2.6
Milk reception	Inspection	0	0	1	30	2	3
	Hygiene condition	0	0	6	23	4	2.8
	Filtration	0	1	3	25	4	2.8
	Storage	0	0	4	27	2	2.9
Transformation	Heating time & temperature	0	0	5	21	7	2.8
	Cooling pasteurized milk	0	1	1	19	12	2.9
	Pasteurization equipment design	0	0	1	26	6	3
	Equipment cleaning	0	0	3	25	5	2.9
	Factory layout	0	0	0	25	8	3
Retail practices	Traceability	0	1	10	14	8	2.5
Final food preparation	Expiration date	0	1	6	23	3	2.7

When we turn to the distribution of scores from the four subgroups (see table 2) we find that staff-members of dairy companies, almost half of the received questionnaires, scored all indicators relatively high. Their high scores can be explained by the focus of the research on large modern dairy processing enterprises, expected to show above industry-average performance on safety and quality. Also the common-method bias may provide part of the explanation. Nevertheless, this subgroup revealed two problems in particular, namely: Corrective actions and Parlor conditions. They experience the rejection of corrective proposals, and witness unclean parlors. Furthermore, all these company-respondents gave the highest score (3) for Inspection, and all but one gave this score for Sampling & testing. This may indicate that the government and dairy enterprises have made radical improvements in the inspection of raw milk, since the melamine crisis.

Figure 5 depicts in different colors the investigated indicators and their sources (literature, HACCP, GlobalGap, and BRC). The indicators that are highlighted (yellow) represent a relative large number of low (1 or 2) scores, indicating (major) challenges that have to addressed, by the Chinese diary industry, to meet international QA-standards.

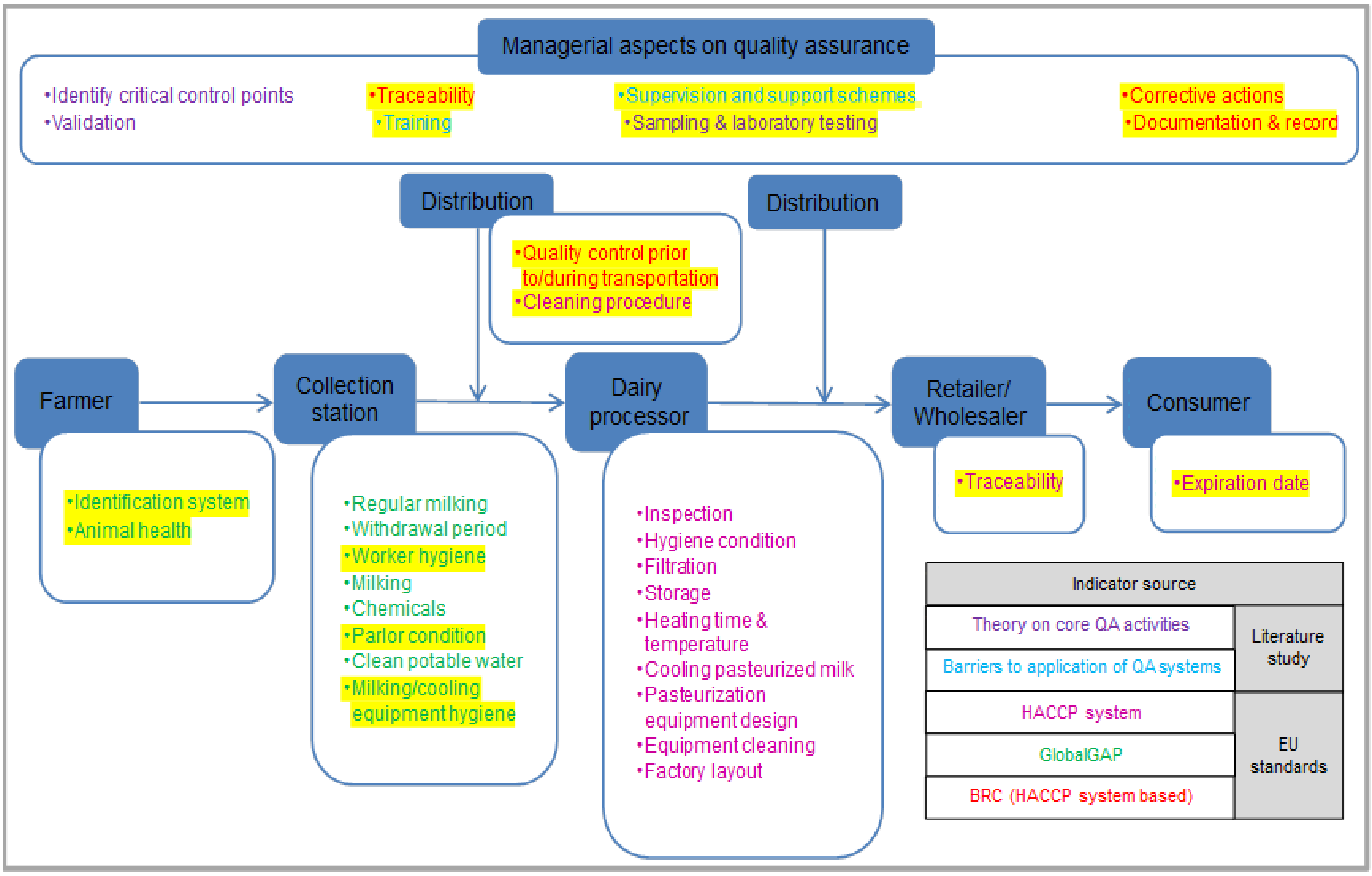

Figure 5. Source of indicators and challenges (highlighted yellow).

4.2 Analysis

We will analyse the data by relating them to the information from interviews and other sources. The survey was supported by six interviews, discussing main challenges for the Chinese dairy industry. In figure 5, derived from table 3, “Supervision and support schemes” and “Training” turn out to be two major barriers. Regarding “supervision and support”, the responsibilities from different government departments overlap, weakening effective supervision of QA standards. Also, no specific dairy processing standards exists to provide a formal framework for quality management. “Training” is problematic because of the low education level of dairy farmers. Even though the government is active in training dairy farmers, many farmers still have no clue how to take care of food safety problems. Besides, there is no incentive for small farmers to invest in food safety activities.

Figures 6 and 7 further detail the specific challenges of the Chinese dairy industry differentiated according to GlobalGap, BRC and HACCP requirements.

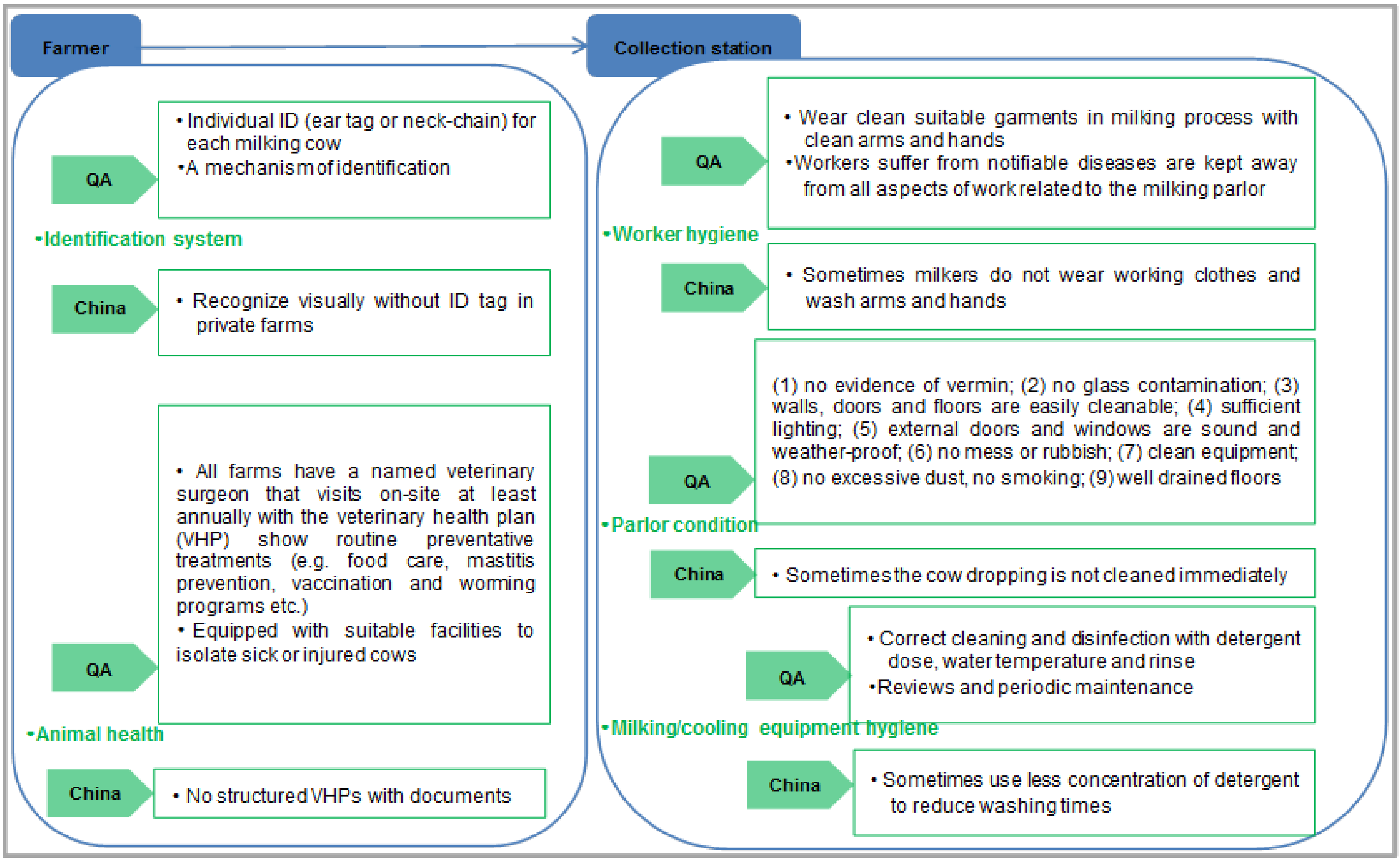

Figure 6. Comparison between QA activities in China's modern dairy industry and QA requirements of GlobalGap

Figure 6 may explain why China's modern dairy industry fails to meet GlobalGAP requirements. The major problems occur at the stage comprising of farmer and milk collection stations. At the farmer stage, "Identification system" performed well in dairy companies' own pastoral parks. However, in contracted private farms there were typically no ID tags as the farmers recognize their cows visually. With regards to the challenge "Animal health", all farms can always reach veterinarians for free, and necessary preventative treatments is performed. But there are no structured veterinary health plans (VHP). In the stage of the milk collection stations, "Worker hygiene" is not assured even in dairy companies' own parks. Sometimes milkers do not wear working clothes or did not wash arms and hands because they use milking equipment without touching cows' udders directly (source: quality controller of a dairy company). The indicator "Parlor condition" scored poorly, because sometimes cow droppings are not removed immediately (source: inspector of a dairy company). The requirement of "Milking/cooling equipment hygiene" is not satisfied, because sometimes lower concentrations of detergent is used to reduce washing times during cleaning procedures (source: quality controller of a dairy company).

Next, Figure 7 visualizes on what indicators China's modern dairy sector fails to comply with requirements of BRC and HACCP norms. Regarding the HACCP system requirements, uncontrolled CCPs were found in the stages distribution, retailer/wholesaler, and consumer. In distribution, "Cleaning procedure" performs poorly in winter. In the winter washing water easily friezes in the trucks, to become difficult to handle (source: quality controller of a dairy company). In the retailer/wholesaler stage, the "Traceability system" is not common practice. Only some large retailers in modern cities use sound traceability systems. In the consumer stage, occasionally consumers buy expired products (mainly yoghurt products) even before the "Expiration date" stated on the package. One explanation, stated by a dairy association expert, could be that the bacteria count in raw milk, the "National Food Safety Standard — Raw Milk" requires max. 2,000,000/ml (vs 100,000/ml in Europe), cannot guarantee good raw milk quality. Although modern enterprises have the ability to produce higher quality raw milk, they are not willing to strive for better, because of the extra costs involved. Another cause could be ultra-high-temperature processing, the main sterilization method in China. The necessary extreme heat temperature causes significant losses in protein.

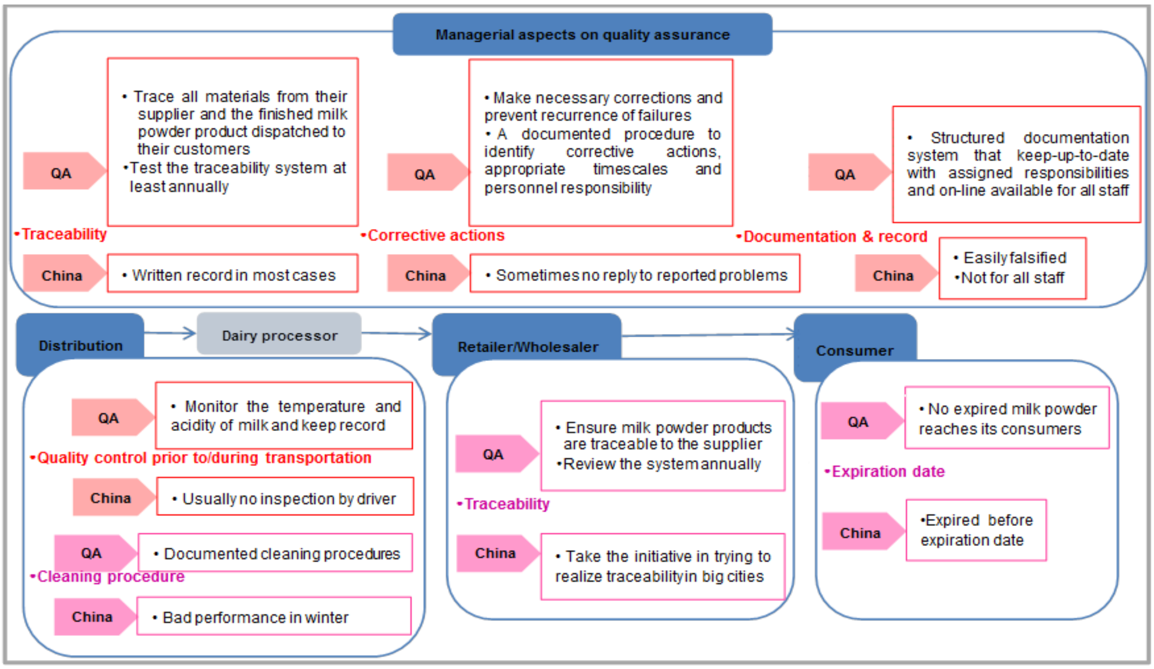

Figure 7 .Comparison between QA activities in China's modern dairy industry and QA requirements of HACCP and BRC

distribution stage of the dairy chain. With respect to managerial aspects, "Traceability" is a challenge for entire dairy chains; typically the sourcing of materials is only recorded by hand. The registration of raw milk batches, which requires samples of individual cows, is also performed by using only written records (source: quality controller of a dairy company). Only a small number of enterprises in modern cities use traceability systems. The limited application of "Corrective actions" is due to the neglect or slow reaction to reported problems in dairy companies. The "Documentation and record" is easily falsified by workers who have the responsibility to record. Documents are not available on-line for all staff. Next, in the distribution stage, "Quality control prior to/during transportation" cannot be guaranteed. Private milk collection stations typically outsource raw milk transportation to uneducated truck drivers. However, these drivers are not able to ensure the monitoring of temperature and acidity of raw milk. Regular inspection is said to be conducted by dairy processors, after arrival at the milk reception facility (source: quality controller of a dairy company).

5 Conclusions

This study evaluates the extent to which China's (modern) dairy chain is able to comply with international QA standards. An evaluation framework that presents both managerial and technological practices for achieving QA has been developed as benchmark. It integrates QA literature and important norms of the international QA standards HACCP, GlobalGAP and BRC. 31 indicators that relate directly to food safety and quality were selected and applied to the China's dairy chain. Four cities (Hohhot, Beijing, Tianjin and Shanghai), that have developed sophisticated dairy production with relatively high quality and safety, were selected for empirical research. The key challenges and strategies to upgrade food safety and quality of China's dairy chain were analyzed.

The survey revealed that over half of the assessed QA activities are performed at an advanced level. The lower scored QA activities indicate possible challenges for China's (modern) dairy chain. The findings can be used as a guide for reorganizing current food safety programs to improve food safety and quality of China's dairy chain.

The previous sections identified the challenges for the modern Chinese dairy industry. The causes of the identified challenges are summarized in Table 4, that also lists directions for improvement.

Table 4.
Challenges, causes, and directionsfor China's dairy chain

Challenges	Causes	Directions for improvement
Traceability	•Only a few enterprises in modern cities use traceability systems	•Improve traceability systems and technology
Supervision and support schemes	•Overlapping of responsibilities of government departments •No specific dairy processing standards	•Clear-cut responsibilities of different departments of government •Lay down dairy processing standard
Corrective actions	•Neglects/slow reaction to report	•Managers should be able to engage employee involvement •Accomplish electronic records
Documentation & record	•Documents are easily falsified •Not for all staff	
Expiration date	•High bacteria tolerance	•Encourage enterprises to reduce bacteria tolerance
Animal health (Farmer)	•No structured documented VHPs	•Design VHPs at dairy farms
Training (Farmer)	•Small farmers are not well trained •No profit motivation	•Establish standards for quality assurance activities with a system of rewards and punishments •Strengthen the supervision and inspection
Identification system (Farmer)	•No ID system in private farms	
Parlor condition (Milk collection station)	•Cow dropping is not removed immediately	
Milking/cooling equipment hygiene (Milk collection station)	•Use less concentration of detergent	
Cleaning procedure (Distribution)	•Bad performance in winter	
Quality control prior to/during transportation (Distribution)	•No inspection by truck driver	

To develop and improve traceability, technology is necessary and integrated traceability in the complete dairy chain should be indicative of a general trend towards transparent dairy chains. The prime recommendation for the government is that, at national, regional and local level, there should be clear-cut responsibilities of different departments for comprehensive supervision. At local level this is essential for supervision control of collection stations. Next, government should announce dairy processing standards. The relevant existing national food safety standards are deficient, because they only refer to end products, raw milk and milk powder.

For companies in the Chinese dairy industry a critical point in QA is the enhancement of employee involvement. Encouraging employee involvement regarding food safety and quality, and developing joint problem solving in the supply chain may drastically improve the performance and execution of corrective actions. For example, sharing documents with staff on-line can encourage employee involvement and arouse employee awareness of QA principles. Finally, the replacement of written records by electronic records, will reduce falsifications and support a more transparent work environment.

Finally, to ensure final product quality, the quality of raw milk is a prerequisite. Pasteurization, in contrast to the UHT-method for sterilization, may prevent extreme high temperature treatment, but it requires high raw milk quality. The old raw milk standard (promulgated in 1986) set four levels of bacteria count, from 500,000/ml, till 4,000,000/ml. Interestingly, bacteria count was already lower than 300,000/ml in various modern cities like Shanghai (source: investigations by an expert from the dairy association). In contrast, the raw milk standard that became effective in 2010 legally limits bacteria count at 2,000,000/ml. The rationale was that the new limit stabilizes raw milk supply and protects small dairy farmers. An option could be to encourage dairy enterprises to formulate their own private raw milk standards, with low limits on bacteria count. These are stepping stones identified in this study, in a long series to be realized by the Chinese modern dairy industry to catch up with international QA standards.

References

Arvanitoyannis, I.S., Mavropoulos, A.A. (2000). Implementation of the hazard analysis critical control point (HACCP) system to Kasseri/Kefalotiri and Anevato cheese production lines. *Food Control*, **11**: 31-40.

Chen, J. (2009). What can we learn from the 2008 melamine crisis in China. *Biomedical and Environmental Sciences*, **22**:109-111.

Chia, G., Lee, H. (2006). Private food standards and their impacts on developing countries. Available at: http://trade.ec.europa.eu/doclib/docs/2006/november/tradoc_127969.pdf (accessed 5 September 2012).

General Regulations (GlobalGAP). (2011). General Rules, part I ,Final version 4.0. Available at: http://www.globalgap.org/cms/upload/The_Standard/IFA/Version_4_2011/Final_V4/Documents_clean/110330_GG_GR_PART_I_IFA_ENG_Final_V4.pdf (accessed 18 September 2011).

Global Standard for Food Safety (BRC). (2011). Issue 6, available at: http://www.brcglobalstandards.com/globalstandards/GlobalStandards/Home.aspx (accessed 18 September 2011).

Herzfeld, T., Drescher, L.S., and Grebitus, C. (2011). Cross-national adoption of private food quality standards. *Food Policy,* **36**: 401-411.

Holt, G., Henson, S. (2000). Quality assurance management in small meat manufacturers. *Food Control,* **11**: 319-326.

Jacxsens, L., Uyttendaele, M., Devlieghere F., Rovira, J., Gomez, S.O., and Luning, P.A. (2010). Food safety performance indicators to benchmark food safety output of food safety management systems. *International Journal of Food Microbiology*, 141: 180-S187.

Kupper, G., Batt, P.J. (2009). Barriers to the adoption of quality assurance systems in the food and beverage sector, *Stewart Postharvest Review*, **5** (3): 1-5.

Luning, P., Marcelis, W. (2009). Food quality management: technological and managerial principles and practices. Wageningen, Wageningen Academic Publishers.

Luning, P., Marcelis, W., and Spiegel, M. (2006). Quality assurance systems and food safety, Safety in the agri-food chain. Wageningen, Wageningen Academic Publishers.

Luning, P.A., Marcelis, W.J., Rovira, J., Spiegel, M., Uyttendaele, M., and Jacxsens, L. (2009). Systematic assessment of core assurance activities in a company specific food safety management system. Trends in *Food Science and Technology*, **20**: 300-312.

Pei, X., Tandon, A., Alldrick, A., Giorgi, L., Huang, W., and Yang, R. (2011). The China melamine milk scandal and its implications for food safety regulation. *Food Policy*, **36**: 412-420.

Sampers, I., Toyofuku, H., Luning, P.A., Uyttendaele, M., andJacxsens, L. (2012). Semi-quatitative study to evaluate the performance of a HACCP-based food safety management system in Japanese milk processing plants. *Food Control*, **23**: 227-233.

Schothorst, M., Kleiss, T. (1994). HACCP in the dairy industry. *Food Control*, **5** (3): 162-166.

Song, H., Chen, K. (2010). Trade effects and compliance costs of food safety regulations: the case of China. *Agriculture and agricultural Science Procedia,* **1**: 429-438.

Trienekens, J.H., Zuurbier, P. (2008). Quality and safety standards in the food industry, developments and challenges. *International Journal of Production Economics*, **113**: 107-122.

Valeeva, N.I., Meuwissen, M.P.M., Oude Lansink, A.G.J.M., and Huirne, R.B.M. (2005). Improving food safety within the dairy chain: an application of conjoint analysis. *Journal Dairy Science*, **88** (4): 1601-1612.

Vilar, M.J., Rodriguez-Otero, J.L., Sanjuan, M.L., Dieguez, F.J., Varela, M., and Yus, E. (2012). Implementation of HACCP to control the influence of milking equipment and cooling tank on the milk quality. *Trends in Food Science and Technology*, **23**: 4-12.

WHO (World Health Organization) and FAO (Food and Agriculture Organization of the United Nations). (2008). Rome, Animal food production, 1st ed.

Xiu, C., Klein, K.K. (2010). Melamine in milk products in China: Examining the factors that led to deliberate use of the contaminant. *Food Policy*, **35**:463-470.