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Performance assessment of food safety management system in the pork slaughter plants of China

Chuanwu Xiong [a, b], Changhong Liu [a], Feng Chen [c], Lei Zheng [a, *]

[a] College of Food Science and Engineering, Hefei University of Technology, Hefei 230009, China
[b] Star Farm, METRO Jinjiang Cash & Carry Co., Ltd., Shanghai 200333, China
[c] Department of Food, Nutrition and Packaging Sciences, Clemson University, Clemson, SC 29634, United States

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ABSTRACT

The aim of this study was to investigate the status of food safety management system (FSMS) implemented at the pork slaughter plants in China, based on a detailed profile of both announced assessments carried out in 60 companies and unannounced assessments in 25 ones, with the checklist covered 29 indicators. The results from the study indicated several factors had an effect on the status of FSMS, associated with company size, location, target market, and valid certificates. The results also revealed a weakness of FSMS on good manufacture practices, including contamination control, pest control, clean and disinfection, facility environment and personal hygiene. In order to precisely measure implementation performance and better identify insufficiency, unannounced assessment was shown to be more efficient than announced assessment.

1. Introduction

Pork is one of the most commonly consumed meats worldwide, and is also one of the foods with the fastest growing consumption rate. The growth rate of global pork consumption has increased by 10.71% over the past decade (Wu, Wang, Zhu, Hu, & Wang, 2015). Pork has historically been primary animal protein source in Chinese diets. For many years China is the biggest producer and consumer of pork (Verbeke & Liu, 2014). In 2014, China had a pork production of 56.71 million tons, which accounted for approximately half of the total production in the world (CSY, 2014). Simultaneously, food safety problems linked to pork products have been repeatedly reported, for instance, illegally added clenbuterol, excessive antibiotic residues, and hygiene contamination issues (Bolton et al., 2002; Liu et al., 2016; Spescha, Stephan, & Zweifel, 2006; Verbeke & Liu, 2014).

To address food safety issue, every company in the global food chain needs to implement a food safety management system (FSMS) (CAC, 2009; Kirezieva et al., 2015). Each FSMS is company specific because it is a result of the implementation of various quality assurance and legal requirements into a company's unique production, organization and environment (Jacxsens et al., 2011). Hazard analysis and critical control point (HACCP) has long been internationally recognized and accepted as the system for effective food safety management (CAC, 2003). HACCP is a common-sense systematic approach to the identification, evaluation, and control of hazards in those steps in food manufacturing that is critical to food safety (Ropkins & Beck, 2000; Sampers, Toyofuku, Luning, Uyttendaele, & Jacxsens, 2012). Generally, the use of hygienically designed equipment and prerequisite programs (PRPs) as good manufacturing practices (GMP), good hygiene practices (GHP) and sanitation standard operational procedures (SSOP), need to be there prior to HACCP implementation (Jacxsens, Devlieghere, & Uyttendaele, 2009; Kök, 2009; Panisello & Quantick, 2001; Roberto, Brandão, & da Silva, 2006; Walker, Pritchard, & Forsythe, 2003). Studies also indicated an increase in the adoption of additional food safety standards, like British retail consortium (BRC), international featured standards (IFS), and ISO22000, to upgrade the FSMS; especially when companies aimed for export markets (Chen, Flint, Perry, Perry, & Lau, 2015; Chu, Feng, & Chen, 2014; Herzfeld, Drescher, & Grebitus, 2011; Kök, 2009; Varzakas & Arvanitoyannis, 2008).

In China, the FSMS was introduced and extended by the government to enhance the safety of foods and to close the gap between Chinese and international food safety standards since 1990s

* Corresponding author. Tel.: +86 551 62919389; fax: +86 551 62919389.
E-mail addresses: lzheng@hfut.edu.cn, lei.zheng@aliyun.com (L. Zheng).

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(Jin, Zhou, & Ye, 2008). With the support of government, increase of consumer's expectations, and growth of international food trade, the number of certified FSMS had significantly grown in the past decades. Bai, Ma, Yang, Zhao, and Gong (2007b) reported about 4600 food enterprises obtained third party certification of FSMS in 2004. According to the statistic data of Certification and Accreditation Administration of China, 11,272 food companies adopted ISO22000 and 4422 food companies were certified of HACCP in June of 2016 (CNCA, 2016). In pork slaughter industry, the first HACCP certificate was issued in 2001. After that, in the highly competitive market, more and more slaughter plants have adopted the FSMS to strengthen its competitiveness.

Despite the efforts to develop FSMS, food poisoning and accidents were still reported and remained an important source of human disease (EFSA, 2014; Griffith, 2006). Many of these incidents could be traced back to food handler errors and/or non-compliance with food hygiene or food safety procedures (Powell, Jacob, & Chapman, 2011; Wright, Leach, & Palmer, 2012). Therefore, food business operators need to have clear insight in which aspects of the FSMS they should further improve (Bai, Ma, Gong, & Yang, 2007a; Cormier, Mallet, Chiasson, Magnússon, & Valdimarsson, 2007; Fraser & Monteiro, 2009; Tsalo, Drosinos, & Zoiopoulos, 2007). Meanwhile, stakeholders as the government, food safety agencies and sector organizations are interested in precisely measuring the implementation performance of FSMS, in order to identify bottlenecks for further improvement (Fraser & Monteiro, 2009). Our group has previously developed real-time food quality monitoring systems designed to control food manufacturing process implemented with FSMS requirements (Liu et al., 2016; Ma et al., 2014, 2016; Xiong et al., 2016). To our knowledge, few studies have been published regarding performance measurement of FSMS (Jacxsens et al., 2010; Kafetzopoulos, Psomas, & Kafetzopoulos, 2013), and there is no published results concerning the implementation performance of FSMS in Chinese pork industry.

In order to fill this gap, this study aims at developing an instrument to investigate the status of FSMS implemented at pork slaughter plants, to explore the factors, and to examine the differences between announced assessment and unannounced assessment. The results from this study will help food business operator as well as the consultants to improve the performance of FSMS. The official control should also benefit from the result by better understanding of the problems in pork companies when carrying out the FSMS system. In summary, this study should make a substantial contribution to the continuous improvement of the performance of FSMS.

2. Data and methods

2.1. Characterization of the Chinese pork companies

This research was carried out between 2014 and 2015. To identify the potential pork companies and to facilitate data collection, assistance was sought from METRO Jinjiang Cash & Carry Company, which had very successful pork business in China. Only the slaughter plants implemented FSMS was selected to participate this study. As a result, 60 pork slaughter plants were randomly investigated, which are distributed in 56 cities, covering 19.7% prefecture-level cities of China.

As seen from Fig. 1, those companies were classified into different regions of China that included: East China (45.0%), Central China (20.0%), North China (10.0%), Northeast China (10.0%), Southwest China (8.3%) and South China (6.7%). The reason for such high percentage in East China in this research was that East China is the most important food production area. The demographic information related to characteristics of investigated companies was presented in Table 1. This information can be used later on to perform secondary analysis; for example to investigate the impact of certification, company size, turnover, and so on.

2.2. Assessment methods

A questionnaire and checklist with scoring system were prepared specifically for this research. The assessors employed the questionnaire and checklist by face-to-face communication, documents review, and onsite inspection to assess the status of FSMS system in pork slaughter plants. The total assessment duration for each company was from 6 to 8 h, and the onsite inspection time is not less than 4 h.

2.2.1. Questionnaire and checklist design

The questionnaire was designed to attain the characteristics of investigated companies, e.g. turnover, employee number, location, certification, and target market etc. The checklist was obtained from the GFSI Global Markets Programme, which has been launched in 2008 by the Global Food Safety Initiative (GFSI) for small or less developed companies to help them achieve certification of GFSI recognized food safety scheme.

The full checklist comprises two levels to assess the compliance performance, basic level and intermediate level. Basic level matches 35% of the GFSI guidance document requirement, and intermediate level matches 65% of the GFSI guidance document requirement (GFSI, 2011). The checklist consists of different indicators to analyse Food Safety Management System (14 indicators), Good Manufacturing Practices (11) and Control of Food Hazards (4). Table 2 shows the complete list of indicators to analyse an implemented FSMS. Each indicator has different checking points which can individually analyse the compliance.

Prior to the start of the using of questionnaire and checklist, five plants were subsequently selected to test the validity. The guideline of the assessment toolkit was developed to ensure the reliability.

2.2.2. Defining FSMS performance

Previous studies have been published concerning that the performance of FSMS focused on the extent to which the objectives were met (Kafetzopoulos et al., 2013; Redshaw, 2000). In this study the research methodology of the FSMS performance assessment was developed. Firstly, assessor evaluated the compliance of each checking item of checklist by different ratings: A, B, C, D and Major were used. The rating (A) corresponded to full compliance of the requirement; the rating (B) corresponded to almost full compliance with the requirement; the rating (C) corresponded to only a small part of requirements implemented; the rating (D) corresponded to the requirement not implemented; and the rating (Major) could be given to any requirement when there are a substantial failure to meet requirement, which included food safety or the legal requirements. Secondly, different points were awarded for each rating: A (20), B (15), C (5), D (−20), and Major (15% of the possible total amount is subtracted) were used (IFS, 2012), and the final score can be expressed as:

$$\text{Score} = \frac{N_A \times 20 + N_B \times 15 + N_C \times 5 - N_D \times 20}{(N_A + N_B + N_C + N_D + N_M) \times 20} \times 100\% - N_M \times 15\% \quad (1)$$

where N_A is the number of rating with "A", and N_B, N_C, N_D, N_M is the number of rating with "B", "C", "D" and "Major", respectively.

2.2.3. View calibration of assessors

The assessments in this study were conducted by assessor

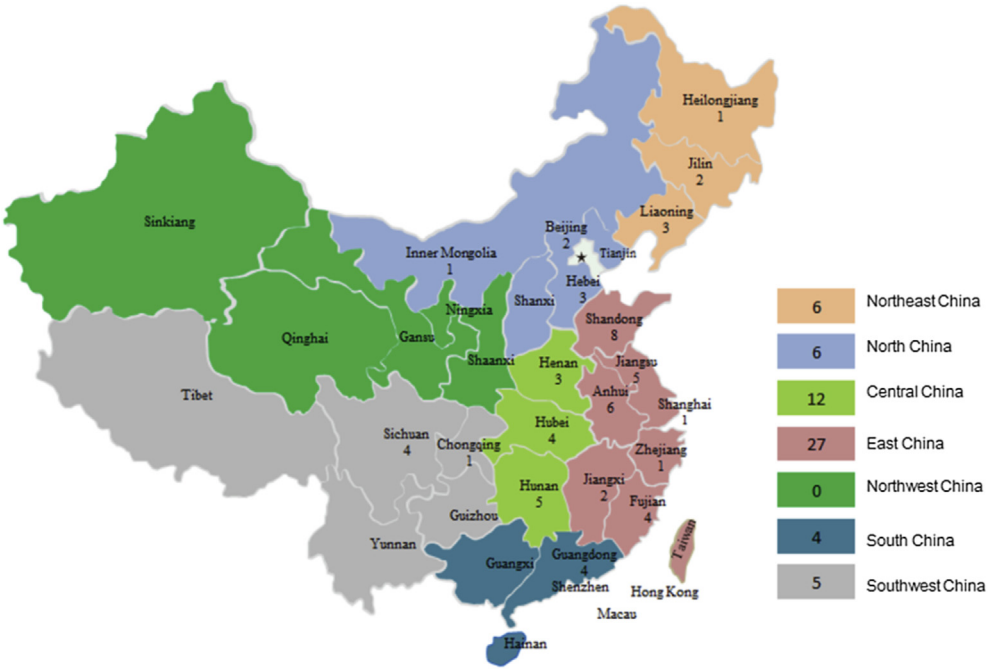

Fig. 1. Investigated pork slaughter plants distributed in China. Different colors means region of China and the figure in each province shows the number of food companies investigated. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Characteristic of pork slaughter plants for announced assessments (n = 60).

Category		Frequency	Percentage (%)
Year of establishment	~1990	3	5.0%
	1991–2000	10	16.7%
	2001–2010	43	71.7%
	2011~	4	6.7%
Location	East China	27	45.0%
	Central China	12	20.0%
	North China	6	10.0%
	Northeast China	6	10.0%
	Southwest China	5	8.3%
	South China	4	6.7%
Turnover by million (USD)	~10	6	10.0%
	11–100	34	56.7%
	101–1000	18	30.0%
	More than 1000	2	3.3%
Staff No.	~50	7	11.7%
	51–250	21	35.0%
	251–1000	28	46.7%
	more than 1000	4	6.7%
Target market	Export	5	8.3%
	Domestic	55	91.7%
Certification	No	5	8.3%
	ISO9001	47	78.3%
	ISO22000	47	78.3%
	HACCP	9	15.0%

employed by METRO Jinjiang Cash and Carry Company, who had an educational background in food safety and extensive experience in implementation of FSMS. Additionally assessor had at least two years of working practical experience as an auditor of HACCP or ISO22000 in pork industry. Before assessing the pork company, each assessor was trained by the assessment guideline of toolkit and was also calibrated on the view of assessment judgment by the pilot test.

2.3. Unannounced assessment

Powell et al. (2013) pointed out that more effective assessment

Table 2
Characteristic of pork slaughter plants for unannounced assessments (n = 25).

Category		Frequency	Percentage (%)
Year of establishment	~1990	1	4.00%
	1991–2000	4	16.00%
	2001–2010	18	72.00%
	2011~	2	8.00%
Location	East China	9	36.00%
	Central China	6	24.00%
	North China	2	8.00%
	Northeast China	4	16.00%
	Southwest China	3	12.00%
	South China	1	4.00%
Turnover by million (USD)	~10	4	16.00%
	11–100	12	48.00%
	101–1000	9	36.00%
	More than 1000	0	0.00%
Staff No.	~50	3	12.00%
	51–250	10	40.00%
	251–1000	10	40.00%
	More than 1000	2	8.00%
Target market	Export	2	8.00%
	Domestic	23	92.00%
Certification	No	1	4.00%
	ISO9001	23	92.00%
	ISO22000	21	84.00%
	HACCP	3	12.00%

systems incorporate unannounced visits along with supplemental information into their framework. In addition, unannounced assessment omits the notification process, therefore, should increase the probability of discovering the relevant non-compliance due to the fact: (1) there is no opportunity to hide facts before the assessment and (2) records and other documentation cannot be falsified quickly (Bravo, Ramírez, Neuendorff, & Spiller, 2013). However, there are also some disadvantages associated with the use of unannounced assessments such as the risk of absence of the client and production shutdown when the visit is carried out.

In this research, of total 60 participating pork companies, a total of 28companies were randomly sampled for the unannounced respondents, 3 companies stopped because they were not during production status when unannounced assessment, the remaining 25 were calculated as the number for the unannounced assessments. In Tables 1 and 2, we can observe the characters of respondents for announced and unannounced assessment are similar.

During the unannounced assessment, only when the assessor reached the entrance of the investigated pork slaughter plants, he could contact the responsible person to start the assessment. In order to make the comparative analysis, the unannounced assessment was carried out within one month after announced assessment.

2.4. Data analysis and statistic

In order to distinguish groups of companies with distinct characteristics (Fig. 2), the differences in the individual scores of plants were analysed by using Kruskal-Wallice non-parametric test, with significance of results established at $p \leq 0.05$. Additionally, by using the same method the differences were analysed between announced assessment and unannounced assessment (Fig. 4).

3. Results and discussion

3.1. Factors to implementation of FSMS

The previous studies pointed out that there are different factors as important for implementation of FSMS (Arpanutud, Keeratipibul, Charoensupaya, & Taylor, 2009; Bai et al., 2007b; Macheka, Manditsera, Zgadze, Mubaiwa, & Nyanga, 2013; Yapp & Fairman, 2006). In this research, Fig. 2 indicates how different factors to influence the implementation performance of FSMS system.

3.1.1. Company size by turnover and staff number

According to Yapp and Fairman (2006), the size of the enterprises determined the characteristics such as financial, expertise and staffing capabilities. The distribution of the investigated companies by size, in terms of turnover and number of staff, was the following: micro and small enterprises (≤10 million USD or ≤50 employees), medium-size firms (11–100 million USD or 51–250 employees), large firms (101–1000 million USD or 251–1000 employees), and macro enterprises (more than 1000 million USD or more than 1000 employees). The vast majority of the participated companies in the present study were small and medium-sized enterprises (SMEs). While, similarly, Panigyrakis, Kapareliotis, and Ventoura (2009) stated that the size of the Greek manufacturing companies in general were quite small. The SMEs tended to have a poor understanding of food safety management system and insufficient finance support resulting in limited adoption of FSMS (Fielding, Ellis, DrBeveridge, & Peters, 2005). The smaller enterprises needed more incentives and faced more difficulties in allocating resources to food safety systems (Taylor & Kane, 2005; Trafiałek, Lehrke, Lücke, Kołozyn-Krajewska, & Janssen, 2015). It means that, we can say with certainty that size of enterprises has an effect on effectiveness of HACCP implementation (Bai et al., 2007b; Jin et al., 2008).

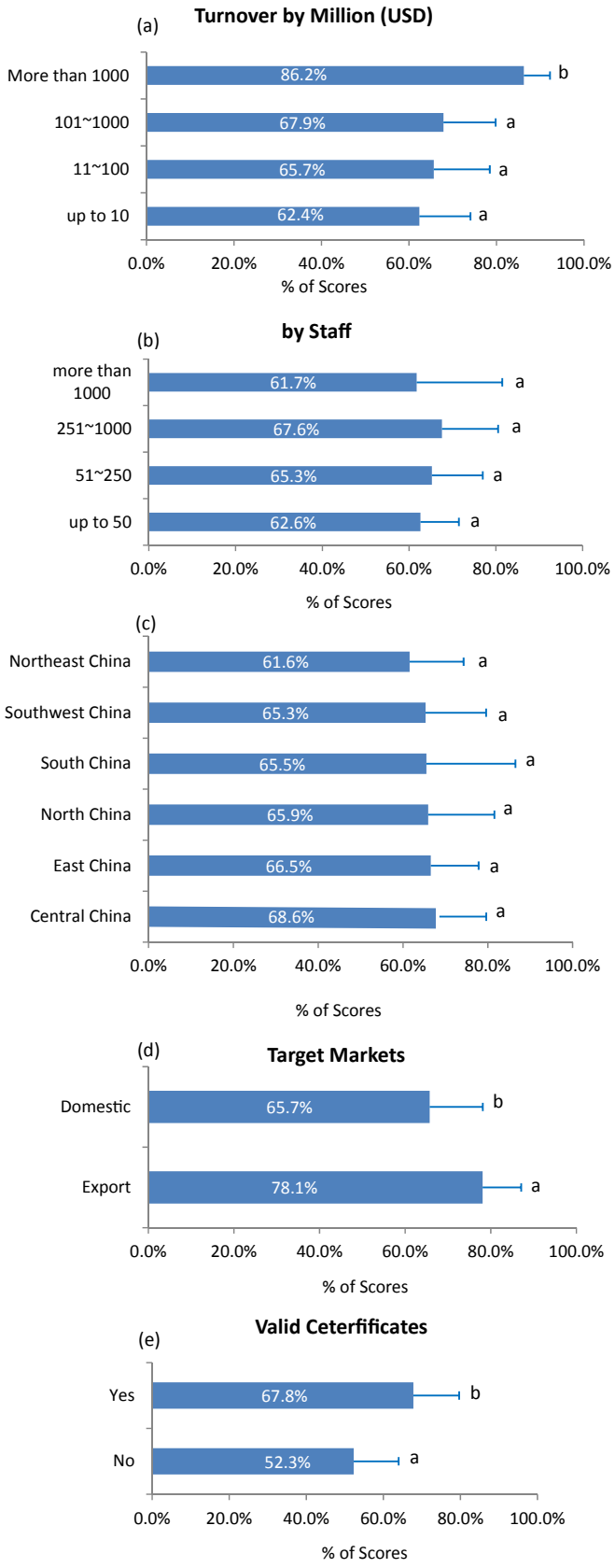

Fig. 2. Analysed the performance of FSMS system by different factors. (a) turnover by million; (b) staff number; (c) region; (d) target market; (e) valid certificates.

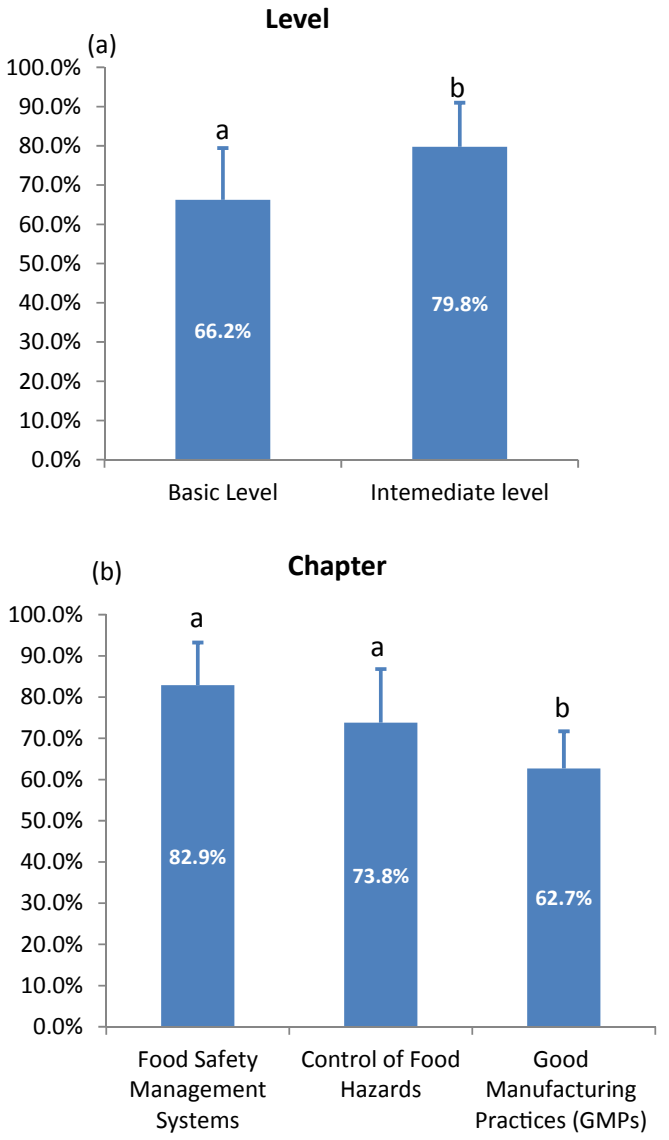

Fig. 3. Analysed the performance of FSMS system implementation. (a) by level of Basic Level and Intermediate Level; (b) by Chapter of Good Manufacture Practices, Food Safety Management Systems, and Control of Food Hazards. Different letters indicate significant differences ($p < 0.05$).

It was shown in Fig. 2a and b that the same trend during the assessment was observed by turnover and staff number. Our results indicated when the company size increased in terms of turnover and staff number, their performance in FSMS practices also increased. However, in macro enterprise with more than 1000 employees, the main difficulties encountered for implementation of HACCP were related to the need for constant staff training and the complex of product line, the average score even reduced compared with SMEs. In addition, no significant differences in score existed for turnover and staff numbers.

3.1.2. Region of location

As illustrated in Fig. 2c, the regions of northeast and southwest had the lowest score, the average score increased slightly related to the economic development level. However, no significant differences were found in different region. Escanciano and Santos-Vijande (2014) found similar trend in the Spanish firms.

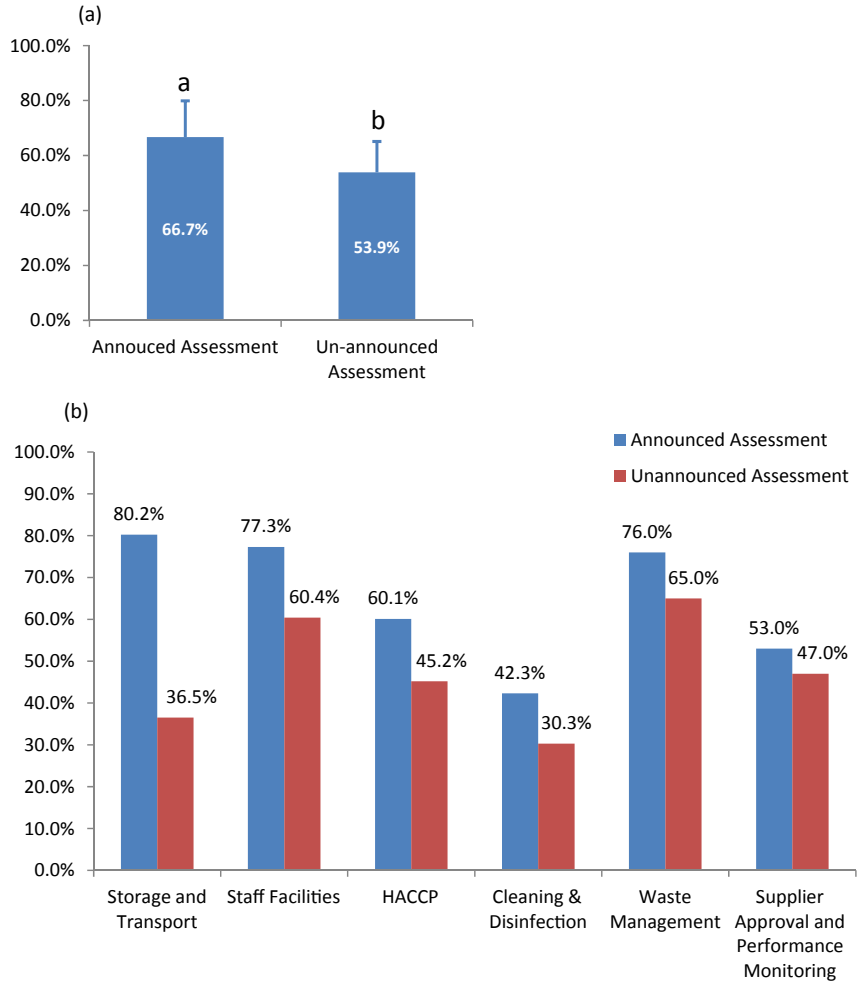

Fig. 4. The performance comparison of FSMS between announced and un-announced assessment (n = 25). (a) by the average score; (b) the biggest difference in indicators. Different letters indicate significant differences ($p < 0.05$).

Economic constraint was one of aspect holding back the spread of food safety management system, perceiving its implementation as complex and costly in terms of material and human investment. It was also pointed out by Karaman, Cobanoglu, Tunalioglu, and Ova (2012) in the study made in the Turkish dairy industry, where problems were due to insufficient funds, plant conditions, and knowledge about FSMS practices.

3.1.3. Target markets

The results (See Fig. 2d) indicated that the companies with export markets had higher score than those with only domestic market, with 78.1% and 65.7%, respectively ($p < 0.05$). These findings were consistent with results from a similar survey conducted where a relationship between the amount of export products and level of food safety management system adoption was studied (Arpanutud et al., 2009; Bai et al., 2007b; Jiang & Batt, 2016; Macheka et al., 2013). Food-exporting countries were intricately bound to comprehensive HACCP-based food control systems because they were obligated to assure food safety in international trade and meet the requirements of an increasing number of importing countries. It was critical for food in international trade to increase bilateral and multilateral recognition of the legitimacy of different approaches to the design of FSMS in different countries (Maldonado-Siman, Bai, Ramírez-Valverde, Gong, & Lara, 2014).

3.1.4. Valid certificates in food companies

Table 1 shows that 78.3% of Chinese pork slaughter plants were certified by ISO22000 and ISO9001, 15.0% were certified by HACCP, while 8.3% were not certified by any quality or food safety standard. The results (See Fig. 2e) revealed that the average score as the performance of FSMS system was significant different in companies: 52.3% by non-certified company; 67.8% by ISO9001, ISO22000, or HACCP certified company. Similar to the present study, Psomas and Kafetzopoulo (2015) evaluated the FSMS performance differences between ISO22000 certified and non-certified companies and revealed that the dairy companies certified by ISO22000 significantly outperformed the non-certified companies with regard to the FSMS performance.

3.2. Performance of FSMS

Table 3 shows the level of compliance of different indicators in the assessed companies. The indicator with the lowest score was product contamination control (28.3%), followed by pest control (31.7%), clean and disinfection (44.6%), facility environment (48.7%) and personal hygiene (55.1%). The major problems of these indicators (see Table 4) were further analysed during the assessment. Indeed, all these indicators belonged to the chapter of good manufacture practices (GMPs) in the checklist. As a result (Fig. 3b), the average score of GMPs achieved by 60 pork companies was only

Table 3
Implementation performance by score with the whole checklist.

Chapter	Item	Requirement	Check points	Score
A. Food safety management systems				
Basic level	B.A1	Specifications including product release	6	95.3%
	B.A2	Traceability	5	60.3%
	B.A3	Food safety incident management	4	83.1%
	B.A4	Control of Non-conforming Product	1	90.8%
	B.A5	Corrective action	2	84.2%
Intermediate level	I.A1	Management responsibility	2	99.2%
	I.A2	General documentation requirements	2	90.4%
	I.A3	Procedures	2	97.8%
	I.A4	Complaint handling	2	83.5%
	I.A5	Control of measuring & monitoring devices	2	65.4%
	I.A6	Product analysis	2	86.9%
	I.A7	Purchasing	1	100.0%
	I.A8	Supplier approval and performance monitoring	2	55.8%
	I.A9	Training	4	67.6%
B. Good manufacturing practices (GMPs)				
Basic level	B. B1	Personal hygiene	6	55.1%
	B. B2	Facility environment	6	48.7%
	B. B3	Cleaning & disinfection	3	44.6%
	B. B4	Product contamination control	2	28.3%
	B. B5	Pest control	3	31.7%
	B. B6	Water quality	2	86.7%
Intermediate level	I.B1	Facility layout and process flow	3	74.2%
	I.B2	Facility and equipment maintenance	5	92.9%
	I.B3	Staff facilities	4	70.2%
	I.B4	Waste management	2	68.5%
	I.B5	Storage and transport	9	88.4%
C. Control of food hazards				
Basic level	B. C1	Control of food hazards – General and specific	5	86.1%
	B. C2	Control of allergens	5	NA
Intermediate level	I.C1	HACCP	13	60.2%
	I.C2	Food defense	3	65.4%

Note: NA means not applicable.

Table 4
Key findings for weakest indicators.

Indicators	Key findings
Product contamination control	Insufficient foreign body control; Deficiencies in process flow and design; Lack of competent person; No good condition of facility;
Pest control	Lack of inspection records; Insufficient monitoring and action taken; Lack of competent person; Not starting of pest control equipment;
Cleaning & disinfection	Insufficient implementation of procedures; Lack of verification activities; Deficiencies in chemical storage; Lack of qualified personnel;
Facility environment	Drainage Issue; Insufficient ventilation and extraction; In sufficient condition of floors and walls;
Personal hygiene	No suspect illness; Lack of documented communication procedures in the case of an infectious disease; Lack of implemented hygiene requirements;

62.7%, which was significantly lower than control of food hazards (73.8%) and food safety management systems (82.9%). Doménech, Amorós, Pérez-Gonzalvo, and Escriche (2011) found similar problems to those in the Spanish industry were associated with facility structure & design, and hygiene & cleaning. It was also pointed out by Karaman et al. (2012) in the study made in the Turkish dairy industry, where problems were due to insufficient plant conditions, and lack of competent staff.

Another interesting finding was that intermediate level compared to basic level had significantly higher score (Fig. 3a). It indicated basic level had even worse performance than intermediate level during FSMS implementation for the pork slaughter

Table 5
7 Principles of HACCP implementation performance.

Rating	Hazard analysis	Determine CCP points	Establish critical limits	Monitoring procedures	Corrective actions	Verification procedures	Documents & records	Total
A	50	56	51	24	58	30	50	319
B	6	1	4	2	0	2	2	17
C	4	2	4	9	0	11	5	35
D	0	0	1	11	1	14	3	30
Major	0	1	0	14	1	3	0	19

plants. From the checklist, we could see that indicators in basic level are more related to GMPs. However, indicators in intermediate level are more related to documents. The main reason was that Chinese companies were strong on document preparation, but not willing to invest money to improve the GMPs. Zhang et al. (2015) concluded that the self-discipline of certified enterprises was weak, they preferred to buy the certificate from certification body by setting up series of documents, instead of implementation for long term.

3.3. Performance of HACCP principles

As shown in Table 5, the total rating of seven HACCP principles implementation was analysed. The weakest point identified during the assessment of HACCP principles was Principle 4 (monitoring procedures), which had got 11 'D' and 14 'major'. A lot of deviations or nonconformities were found during assessment. The main reason was that the company failed to follow the monitoring frequency, and also failed to implement the monitoring record on time according to the procedures. The second weakest point was Principle 6 (verification procedures), which had 14 'D' and 3 'Major'. It was found that the verification frequency was not implemented effectively, especially when there was new process, new production line, new product, and other important change. Wallace, Powell, and Holyoak (2005) classified HACCP plan by design, implementation, control, and manage. The weak points on Principle 4 and Principle 6 in this study were highly related to control and manage. It suggests that the control and management of HACCP plan should be taken more attention.

3.4. Performance of unannounced assessment

Unannounced assessments had significantly lower scores compared to the announced ones (Fig. 4a). It could be explained that announced assessments allow an assessed company to prepare its operations and to organize its records for review. Generally, announced assessments evaluate a company's best efforts and uncover what it does not know. By contrast, unannounced assessments offer insight into normal operating conditions. In line with findings of this study, Bravo et al. (2013) and Zorn, Lippert, and Dabbert (2012) revealed there was a strong and significant positive correlation between unannounced inspections and number of non-compliance.

Moreover, Fig. 4b shows the performance level of the different indicators by announced and unannounced assessment. The major problems encountered during unannounced assessment were temperature control in storage and transports, deficiencies in staff facility using, insufficient monitoring frequency and lack of monitoring record in HACCP plan, lack of records in cleaning and disinfection, not clear handling record of waste management, not well followed the procedure of supplier approval and performance monitoring.

4. Conclusions

This study provides a practical assessment of the facts associated with the status of FSMS in Chinese pork slaughter plants. It provides useful quantitative methodology by using checklist with scoring system. Results indicated that China was a bit weak on GMPs, and monitor and verification process of HACCP plan due to inadequate procedure execution. Moreover, the results demonstrated that unannounced assessments had significantly lower scores compared with the announced ones. And revealed the several factors had an effect on the status of FSMS implemented.

From the analysis of weakness and factors of FSMS system, we can help food business operator as well as the consultants to understand the status, and make the improvement action accordingly. Therefore, it is interesting and valuable to assess the status of FSMS system in China, which is considered as an important safety assurance by many countries.

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