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Types of food control and application of seven basic quality tools in certified food companies in Serbia

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Abstract

Types of control and application of basic quality tools in the food industry have been analysed in 49 certified food companies in Serbia. The results showed that all sampled companies have some type of incoming and final control, while a third of the sampled companies do not have any process control. Analysis of control also showed that there was an independent control sector in 34.7% of the sampled companies while 40.8% of the companies have their own plant laboratories. One or two quality tools are being used by 63.27% of sampled companies while less than 13% use more than 4 tools. Companies mostly use flow charts (98.0%), followed by check sheets (75.5%) and histograms (32.7%). Other quality tools are used in below 10% of sampled companies, with the average number of 2.5 quality tools used per company. The strongest business drivers are the customers, confirmed by correlation analysis showing high correlation between companies having control as a sector and the ones performing external analysis beyond legal requirements (r=0.729), or being an exporter of food (r=0.639). Results confirmed that there is a correlation between the maturity of quality management system and control as an independent sector (r=0.486) or the number of quality tools (r=0.350).

Keywords: control, food safety, quality tools

1. Introduction

In order to build and maintain the trust of consumers in food safety and quality throughout the food chain, quality assurance and food hygiene are of major importance in the food sector (Aggelogiannopoulos *et al.*, 2007). Control is a part of both quality assurance and food hygiene focused on fulfilling quality and/or food safety requirements (ISO, 2005a,b). It is not possible to generalize the impacts of a set of incentives on the level and/or type of food control that is adopted by companies since they have different characteristics that vary according to the product type and environment in which they operate (Herath *et al.*, 2007). Increased international trade and travel has increased the risk of cross-border transmission and the need for strengthening methods of food control (Van der Spiegel *et al.*, 2004). Control aims at keeping product properties, production processes and human processes within defined acceptable tolerances (Luning *et al.*, 2009).

The development of quality assurance systems and the use of different tools to improve quality are the foundations upon which quality management is developed in companies (Bayo-Moriones and Merino-Díaz de Cerio, 2001). Quality movement introduced various quality tools that help companies improve different aspects of their business performances, including control. Ishikawa (1986), one of quality gurus, determined seven basic quality tools that should be implemented in every company: (1) flowcharts; (2) check sheets; (3) histograms; (4) Pareto diagrams; (5) cause and effect diagrams; (6) scatter diagrams; and (7) control charts (Tarí and Sabater, 2004). The American Society for Quality refers to them as 'the old seven', 'the first seven' or 'the basic seven' (Tague, 2004). Since then, a great variety of quality tools have been developed but they will not be discussed in this paper.

Numerous small and medium sized suppliers in the food industry are faced with the challenge that the complexity of food safety and quality requirements increases while their organizational knowledge decreases and time for fulfilling the requirements shortens. The majority of audit findings in certified companies in three Western Balkan countries were in the process of control regardless of type, size and product provided (Djekic *et al.*, 2011). This raised a question as to how companies performed their controls (for both quality and food safety systems), when the majority of nonconformities were in this process. With this in mind, and since quality tools are not presented enough in the food industry in comparison with other industries, this paper presents the results of a field study about the level of food control and implemented quality tools in certified food companies in Serbia.

The objective of this paper is to analyse the level of control in sampled companies, application of quality tools, identification of main drivers for application of various control mechanisms and tools and the relationship between maturity and type of management system, level of control and use of the tools.

2. Materials and methods

In order to achieve the objective of this paper, a survey was performed in Serbian food industry companies holding both quality (ISO 9001) and/or food safety system certificates (ISO 22000 or HACCP). The survey was performed in the period January-June 2011 through on-site visits and by interviewing members of the companies (management representatives and/or HACCP team leaders). A structured questionnaire was developed to enable processing and analysis of data. Results were processed using Microsoft Excel 2007.

The total sample was 49 companies operating in the food chain. The structure shows that 77.6% (38 companies) of the companies held quality management system (QMS) certificates, 95.9% (47) were certified for hazard analysis and critical control point/food safety management system (HACCP/FSMS) and 71.4% (35) were certified for both schemes. Among the sampled companies, 44.9% (22) were small companies with less than 50 employees, 34.7% (17) medium sized companies with 50-250 employees and 20.41% (10) large companies. Seven of the sampled companies were multinational companies, 34.7% (17) exporters and 24.5% (12) companies suppliers within the multinational food supply chain. Depending on the position in the food chain, 83.7% (41) of the companies could be considered as production plants and 16.3% (8) as servicing organizations. The structure of the audited companies per scope, presented as NACE codes (Eurostat, 2008), is shown in Table 1.

Table 1. Structure of the companies by scope.

	n[1] (%)
Production of meat products	10 (20.4)
Processing and preserving of fruit and vegetables	5 (10.2)
Manufacture of dairy products	6 (12.2)
Manufacture of grain mill and bakery products	3 (6.1)
Manufacture of confectionery products	5 (10.2)
Beverages	11 (22.4)
Food and beverage service activities (catering, hotels)	3 (6.1)
Wholesale of food, beverages and tobacco	4 (8.2)
Other	2 (4.1)
Total	49 (100.0)

[1] n represents the number of sampled companies.

3. Results and discussion

Control in sampled companies

Control presents one of the most important processes in the food industry; quality and food safety systems both strongly rely on it. Food processes are difficult to control due to the variability in raw materials, lack of developed methods for monitoring key food process variables, food quality and food safety attributes, especially in small and medium-sized enterprises (SMEs) (Linko and Linko, 1998). Food chain complexity relates to six factors: (1) number of chain participants; (2) number of processing steps; (3) number of raw materials; (4) number of suppliers of raw materials; (5) logistics; and (6) destination of products, influencing the necessity of a higher level of control (Van Asselt *et al.*, 2010).

To provide evidence and confidence to stakeholders that quality and safety requirements will be met, the performance of the control system must be evaluated on its principal effectiveness and proper execution (Luning *et al.*, 2009). Since there is no legal requirement for defining the types and levels of internal controls, among the sampled companies only 34.7% (17 companies) had control as an independent sector. Plant laboratories where various types of analyses are performed existed in 20 companies (40.8%) and among them, 80.0% had control as sectors.

Food characteristics are affected by the composition of individual raw materials, the recipe of the product, and the processing conditions (Van der Spiegel *et al.*, 2003). Table 2 shows the types of controls and analyses that companies performed. All sampled companies had both incoming and final control systems. Within the sample, quantitative control of incoming goods was part of the incoming control. However, process control was present in

Table 2. Types of control and analyses in sampled small, medium and large companies.

Type of control and analyses	n[1] (%)	Small n (%)	Medium n (%)	Large n (%)
Incoming control	49 (100.0)	22 (100.0)	17 (100.0)	10 (100.0)
Quantitative control	49 (100.0)	22 (100.0)	17 (100.0)	10 (100.0)
Microbiological analysis	13 (26.5)	2 (9.1)	5 (29.4)	6 (60.0)
Physical-chemical analysis	21 (42.9)	4 (18.2)	7 (41.2)	10 (100.0)
Sensory analysis	14 (28.6)	3 (13.6)	6 (35.3)	5 (50.0)
Process control	32 (65.3)	14 (63.6)	8 (47.1)	10 (100.0)
Microbiological analysis	10 (20.4)	0 (0.0)	1 (5.9)	9 (90.0)
Physical-chemical analysis	29 (59.2)	11 (50.0)	8 (47.1)	10 (100.0)
Sensory analysis	12 (24.5)	4 (18.2)	2 (11.8)	6 (60.0)
Final control	48 (98.0)	22 (100.0)	16 (94.1)	10 (100.0)
Microbiological analysis	14 (28.6)	1 (4.5)	6 (35.3)	7 (70.0)
Physical-chemical analysis	36 (73.5)	14 (63.6)	12 (70.6)	10 (100.0)
Sensory analysis	40 (81.6)	19 (86.4)	11 (64.7)	10 (100.0)

[1] n represents the number of sampled companies.

only 65.3% of the companies. There should be a concern as to how some process steps are controlled, especially critical control points (CCPs), since the majority of companies have certified HACCP/FSMS. The effectiveness of the CCP depends on the accuracy and reliability of the control and monitoring systems (Doménech *et al.*, 2008). Within the supply chain, only 24.5% (12 companies) reported the performance of any type of on-site supplier audits.

Microbiological analyses that were performed in-house were reported for 34.7% (17 companies). Among the sampled companies, less than 30% had any microbial control (incoming, process or final). Only 10 companies had documented laboratory methods for these analyses with an average of 7.4 documented methods per company.

Physical and chemical analyses were performed in 85.7% (42) of the sampled companies in all three stages of control, with the greatest emphasis in the final control stage. Documented methods for physical-chemical analysis were registered in 24 companies with an average of 5.8 documented methods per company.

Sensory analyses were reported in 85.7% of the sampled companies with the greatest emphasis in the final control stage. However, only 1.9 on average documented sensory methods were present in 21 companies.

External analyses of final products in accredited laboratories are performed by all companies. However, only 34.7% (17 companies) performed any type of analysis beyond legal requirements, mainly as a customer requirement.

The complexity of the supply chain depends on the simplicity of the organization, of the production process and of the product. The diversity of these factors between companies may explain why controls differ in product quality and can be used for implementing and developing quality assurance systems (Van der Spiegel *et al.*, 2003).

Quality tools in sampled companies

All sampled companies used at least one tool, the majority of them used one or two, while 12.3% of the sampled companies used more than four (Figure 1). Further analysis of the type of quality tools used (Table 3), shows their distribution, where companies had the possibility to outline tools they use. This research showed that a flow chart was the most common quality tool, followed by check sheets, histograms, control charts, scatter diagrams, Pareto diagrams and cause and effect diagrams. In Spain, a similar survey (covering not only food industry) showed that the most widely used tools were audits and graphs, followed by statistical process control, flow charts, Pareto curves, cause-effect diagrams and correlation diagrams (Tarí and Sabater, 2004). A Portuguese survey revealed that control charts and scatter diagrams were not used among surveyed SMEs (Sousa *et al.*, 2005). In Sweden, below 30% of the companies used all seven tools, with flow chart being the most significant and most commonly used (Lagrosen and Lagrosen, 2005).

Flow chart is the leading tool, since its construction is outlined as one of 12 steps in implementing a HACCP based food safety system (CAC, 2009; ISO, 2005b; Ropkins and Beck, 2000). This implies that it is expected to find flow

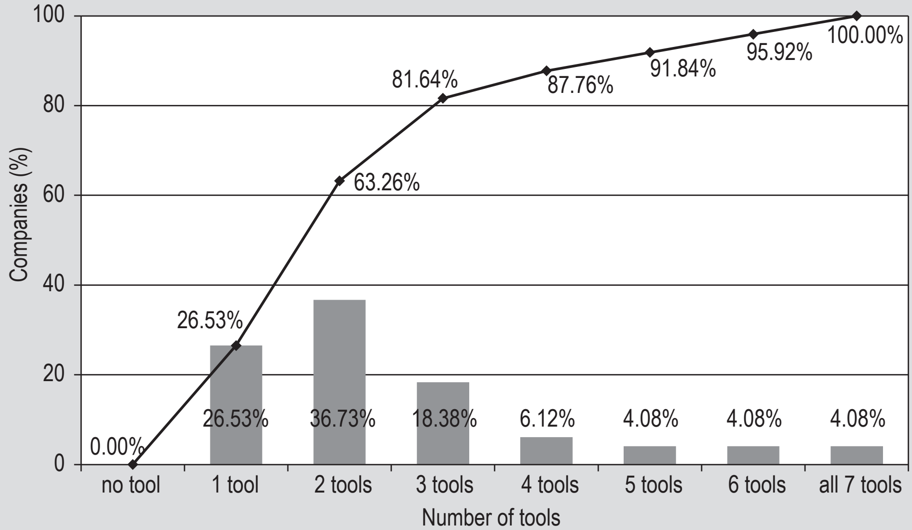

Figure 1. Pareto diagram of tools used by companies. The bars represent the percentage of companies using a number of tools and the line shows the cumulative percentage.

Table 3. Quality tools used by all companies and by size of companies.

Quality tool	n[1] (%)	Small n (%)	Medium n (%)	Large n (%)
Flow chart	48 (98.0)	21 (95.5)	17 (100.0)	10 (100.0)
Check lists	37 (75.5)	16 (72.7)	11 (64.7)	10 (100.0)
Histograms	16 (32.7)	3 (13.6)	4 (23.5)	9 (90.0)
Control charts	10 (20.4)	2 (9.1)	3 (17.6)	5 (50.0)
Scatter diagram	7 (14.3)	0 (0.0)	1 (5.9)	6 (60.0)
Pareto diagram	3 (6.1)	0 (0.0)	1 (5.9)	2 (20.0)
Cause and effects diagrams	3 (6.1)	0 (0.0)	0 (0.0)	3 (30.0)
Mean	2.5	1.9	2.2	4.5
Standard deviation	1.6	0.9	1.3	1.8

[1] n represents the number of companies that positively responded to the use of a specific tool.

charts in all HACCP/FSMS systems. On the other side, in the companies with mature and integrated systems, flow charts were used not only for the purpose of verifying HACCP but also for further deployment of quality characteristics within quality plans.

A check sheet is a structured, prepared form for collecting and analysing data and this tool can be adapted for a wide variety of purposes (Tague, 2004). The main intention of this tool is the gathering of the objective data needed to shed light on the problem at hand in a form appropriate for the analysis of the data (Juran, 1998). The results of this study revealed that 50% of the companies used it in checking housekeeping activities such as cleanliness of the premises, evidence of insect or rodent infestation, dusty surfaces, cobwebs, availability of soap and disinfectants, presence of unwashed utensils, which agrees with the results of Amoa-Awua *et al.* (2007) and Obadina *et al.* (2010). This tool was used for hygienic (food safety) rather than quality purposes.

Histograms were a tool used by almost a third of the sampled companies. This tool presents a graphic summary of variation in a set of data and analysis consists of identifying and classifying the pattern of variation (Juran, 1998). Results of findings from housekeeping check sheets were presented in histograms. The other use of histograms was in presenting quality characteristics used in statistical process control analysis (Brix, CO_2, various quality indexes), as well as all types of nonconformities from various food quality or safety audits grouped by processes or other categories. Companies with mature management systems and developed methodologies for monitoring quality indexes of their products presented their results in histograms.

The aim of using control charts in food business and further deployment through statistical process control is to increase knowledge about the process, to steer it to behave in the desired way and to reduce variation of final-product parameters, or in other ways improve performance of a process (ISO, 2006). In choosing the quality characteristics to be followed, the choice is either in analysing a characteristic that is currently experiencing a high number of nonconformities and Pareto analysis can be useful (Juran, 1998), or to control a parameter that is critical to quality or food safety. In the food industry typical use of this tool was dedicated to attributes such as dry matter content, CO_2 in carbonated soft drinks or net content due to its impact to quality costs or to analyse sensory attributes (Ennis and Bi, 2000; Grigg *et al.*, 1998; Ittzés, 2001). Control charts represented a tool used by 20.4% of the sampled companies (Table 3). They used this tool for the previously mentioned quality attributes as well as for monitoring viscosity, torque, density and pH value, depending on the type of product. The other use of control charts, as confirmed by the sampled companies was for analysing the concentration of chlorine in water after multi-barrier water treatment or analysis of cleaning practices in numerous outlets using post-mix syrups. Relatively little has been written on the successful application of control charts and statistical process control covering food safety (Grigg *et al.*, 1998). This tool is rarely used in the area that deals with microbial contamination (Augustin and Minvielle, 2008). Some work has been published on the introduction and application of statistical process control in HACCP systems and validation of CCPs (Hayes *et al.*, 1997; Ittzés, 2001; Srikaeo and Hourigan, 2002).

Scatter diagrams as a tool were confirmed by less than 15% of the companies. This is a tool for charting the relationship between two variables to determine whether there is a correlation between the two which might indicate a cause-effect relationship (or indicate that no cause-effect relationship exists) (Juran, 1998). In the food industry, such diagrams are used when correlating bacterial survival and temperature, or survival vs. time. Relating to food safety issues, this diagram is used when presenting correlation between time and temperature in heat processing, in analysing shelf-life (Corradini *et al.*, 2005; May and Chappell, 2002; Sirpatrawan, 2009) or analyzing structure changes of food products during heat transfer (Guerin *et al.*, 2004). Consumer acceptability of various quality characteristics or quality control are applications of this tools (Gallo *et al.*, 2011; Jayasena and Cameron, 2008; Ribeiro *et al.*, 2010). Amongts the sampled companies, those with various pasteurization and sterilization process used this diagram in terms of time and temperature, with data extracted from these diagrams. Another application was for the purpose of validating cleaning and sanitation as one of prerequisite programs in analysing effectiveness of sanitation solutions and microbial survival.

Pareto analysis is a tool that produces a bar chart organized from higher to lower levels of frequency and compares the importance of the different factors intervening in a problem and helping in identifying action priorities (ISO, 2006). The detection of the ingredients either at risk or at extremely significant risk can be properly displayed by depicting the results of a Pareto diagram or genetically modified organism (GMO) risk classification prior to corrective actions (Arvanitoyannis and Savelides, 2007). The use of Pareto analysis in the classification of failures that may lead to unsafe products (in bread production) were shown by Tsarouhas (2009), as well as for further analysis in various food safety risk classifications prior and after implemented corrective measures (Arvanitoyannis and Varzakas, 2007b). Less than 10% of the companies confirmed use of this tool (Table 3) and its main application was in analysing groups of typical risks or nonconformities.

Cause and effect diagrams have been developed by Kaoru Ishikawa and for the purpose of organizing and displaying the interrelationships behind the root cause of a problem (Juran, 1998). In the context of food safety, cause and effects diagrams can be used for determining and analysing the critical control points in HACCP plans for all types of hazards (Arvanitoyannis and Varzakas, 2007a,b). This tool has also been used in identifying possible causes of problems or factors/parameters required to ensure success of effort against end product contamination with GMOs, which is in concurrence with the results of Arvanitoyannis and Savelides (2007). Other examples of the use of this tool are for resolving food safety issues if a physical hazard has occurred in final products where analysis of man, materials, machine, methods and environment (4M & 1E) is of significant help or in the process of the validation of control measures as required by new FSMS standard (ISO, 2005b). Less than 10% of the sampled Serbian companies confirmed use of this tool in solving quality or food safety issues such as analysing the occurrence of physical hazards in the final product and analysis of possible productivity problems on their production lines.

The average number of quality tools used per company was 2.5 within the range of 1.9 in small companies and 4.5 in large companies (Table 3). This confirms the findings of Herath *et al.* (2007) that smaller firms are less likely to adopt enhanced food safety and quality assurance practices than larger firms and limited use of basic quality tools in Spanish companies (Tarí and Sabater, 2004).

Drivers, control mechanisms and quality tools

In order to analyse the correlation between some of the results, the Pearson's correlation coefficient was calculated (significant at the 0.05 level) and presented in Table 4. Nine categories were chosen, as follows:

- Is the company a production plant?
- The maturity of certified HACCP/FSMS in relation to the number of years holding certificates.
- Maturity of certified QMS in relation to number of years holding certificates.
- Number of quality tools used.
- Does the company have control as an independent sector?
- Does the company perform external laboratory analysis for more parameters than minimal legally required?
- Is the company within the multinational supply chain?
- Is the company an exporter?
- Does the company have any type of cooperation with scientific institutions?

Critical values for Pearson's correlation coefficient for this size of sample is 0.2816 for a two-tailed test with P=0.05 level of significance.

In order to analyse business drivers that promote control and quality tools it is obvious from the results that customers from abroad are a greater driving force compared to operating in multinational food chain. The highest correlation was observed between exporters and their need to perform external analysis beyond legal requirements (r=0.729). A high correlation exists between companies having control as a sector and performing external analysis above legal requirements (r=0.549), as well as having control as a sector and being an exporter (r=0.639). The results also show that there was a correlation between the number of implemented quality tools and whether the company was an exporter (r=0.684). On the other hand, the results did not confirm a correlation between companies being in the multinational supply chain and the use of quality tools (r=0.171). This is in concurrence with surveyed Polish companies where almost all of the companies were involved in improving internal control measures of quality and food safety of the manufactured foodstuffs, in the process of adapting to the EU requirements (Konecka-Matyjek *et al.*, 2005). Serbia has been granted official candidate status for EU membership by the European Council in March 2012 and this implies the necessity of improving control in order to implement EU food safety and quality requirements. Scientific cooperation can influence improvements in the quality sector and the use of various quality tools since there is a correlation between exporters and companies with scientific cooperation (r=0.490). Also, companies that have scientific cooperation are the ones having more quality tools than exporters (r=0.696 compared to 0.684).

Maturity and type of management system, control and use of tools

Some papers indicate that the level of implementation of quality tools is related to the maturity of the management system, regardless of the industry (Lagrosen and Lagrosen, 2005; Sousa *et al.*, 2005). Our results show that the correlation between having control as a sector and maturity of certified management system is almost twice as high as in the case of being QMS certified (r=0.486) than HACCP/FSMS certified (r=0.296). There was also a correlation between the number of quality tools implemented and having the company perform external analysis beyond legal requirements.

Table 4. Pearson's correlation (r) between nine selected control categories[1].

	Production	Years HACCP/ FSMS	Years QMS	Number of Q tools	Control a sector	Above legal analysis	In MN supply chain	Export	Science
Production	1.0000								
Years HACCP/FSMS	0.3587	1.0000							
Years QMS	0.2507	0.5569	1.0000						
Number of Q tools	0.1849	0.0896	0.3502	1.0000					
Control a sector	0.3220	0.2957	0.4859	0.4648	1.0000				
Above legal analysis	0.3220	0.1851	0.3603	0.6017	0.5496	1.0000			
In MN supply chain	0.2516	0.0150	-0.1689	0.1707	0.0834	0.2828	1.0000		
Export	0,3220	0.2735	0.3882	0.6838	0.6397	0.7298	0.1831	1.0000	
Science	0.1951	0.0116	0.2342	0.6964	0.2580	0.4900	0.1336	0.4900	1.0000

[1] See the text for explanation of the nine categories.
HACCP/FSMS = hazard analysis and critical control point/ food safety management system; MN = multinational; Q = quality; QMS = quality management system.

A much higher correlation was observed between QMS certified companies and the use of quality tools than the companies having HACCP or FSMS certificates (r=0.35 compared to 0.089). Companies with independent control sectors used more quality tools (r=0.465), while there was no correlation between the number of quality tools and whether the company was in the production sector.

4. Conclusions

This survey identified four groups of companies using quality tools and control. The first group represented companies that had only HACCP-based food safety systems since is it a legal requirement and these companies used only flow charts as quality tools. They had limited or no internal controls. The second group were the ones that in addition to HACCP were aware of the need to control the effectiveness of their good hygiene practice (GHP) and used various types of check sheets. They also had some initiatives in controlling the effectiveness of their GHP. The use of check sheets was on a daily or weekly basis and the results were explored using tools such as histograms and Pareto diagrams. The control mechanism in this group of companies focused on food safety. Depending on the business drivers, exporters were the companies that filled the third group since they started using more quality tools mainly as a result of their customers' requirement for quality or food safety analyses. These companies also had control as an independent sector. Finally, mature management systems with business drivers that enforce use of quality tools have all seven tools in place, have control as an independent sector and have documented laboratory methods.

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