International Journal of Hospitality Management 68 (2018) 105–114

Contents lists available at ScienceDirect

International Journal of Hospitality Management

journal homepage: www.elsevier.com/locate/ijhm

Microbiological quality assessment of meals and work surfaces in a school-deferred catering system

Annalisa Petruzzelli[a], Andrea Osimani[b,*], Stefano Tavoletti[b], Francesca Clementi[b], Vittorio Vetrano[a], Stefania Di Lullo[a], Francesca Paolini[a], Martina Foglini[a], Eleonora Micci[a], Nadia Orazietti[a], Tanya Luchetti[c], Franco Tonucci[a]

[a] Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche, Centro di Riferimento Regionale Autocontrollo, via Canonici 140, 61100, Villa Fastiggi, Pesaro, Italy
[b] Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Università Politecnica delle Marche, via Brecce Bianche, 60131, Ancona, Italy
[c] Comune di Pesaro, Piazza del Popolo 1, 61121, Pesaro, Italy

A R T I C L E I N F O

Keywords:
Mass catering
HACCP
Food hygiene
Environmental contamination
Bacillus cereus

A B S T R A C T

Microbiological contamination is one of the main parameters that must be assessed to assure the safety of foods produced by a catering system. The aim of this study conducted between 2011 and 2015 was to assess the microbiological quality of meals (n = 620), work surfaces (n = 621) and the operators' hands (n = 319) in a school-deferred catering system. A general positive trend regarding the microbial contamination of food samples and surfaces was observed. *Salmonella* spp. and *Listeria monocytogenes* were never detected in prepared foods; moreover, the total mesophilic aerobes and the sulfite-reducing clostridia were always below the reference limit. The occurrence of *Bacillus cereus* in raw and cooked vegetables highlighted the need for corrective action and suggested that continuous monitoring of this toxin-forming microorganism was necessary. A critical evaluation of the data obtained from the microbiological analyses allowed us to obtain an overview of improvements and emerging critical issues.

1. Introduction

Mass catering is for groups of people who share a common interest or must eat outside of the home for any reason, including work, study, leisure, and illness. This branch of the hospitality industry can be divided into the following major sectors: the cost sector (i.e., healthcare, education, schools and colleges, business and industry, and public services) and the profit sector (i.e., hotels, restaurants, fast food, cafes and takeaways, public houses, travel organizations, and leisure operations) (Smith and West, 2003).

As reported by Fusi et al. (2016), the contract catering sector in Italy is worth € 6.2 billion, and the education sector comprises 30% of it (ANGEM, 2014). Moreover, 6 billion meals are provided in Europe each year, involving approximately 600,000 operators (FERCO, 2014).

A catering management system is characterized by highly complex actions that lead to the production of food intended for a large number of consumers. Meal production in a catering plant can be done in a centralized kitchen that conveys the food to the canteen via authorized transportation (i.e., a deferred system) or via the cook–serve system, which represents the conventional approach to catering (Smith and West, 2003).

Biological, physical and chemical contaminants can occur during production, worsening food quality and safety. European food safety regulations are specifically geared to prevent health risks to the consumer. Indeed, according to the Regulation (EU) No 852/2004 of the European Parliament and the Council of 29 April 2004 on foodstuff hygiene, food business operators are responsible for implementing measures and conditions necessary to control hazards by using a preventive approach based on the principles of the Hazard Analysis and Critical Control Point (HACCP) system. Article 4 states that food business operators shall, as appropriate, adopt the following specific hygiene measures: (i) compliance with microbiological criteria for foodstuffs; (ii) procedures necessary to meet targets set to achieve the objectives of the Regulation; (iii) compliance with temperature control requirements for foodstuffs; (iv) maintenance of the cold chain; and (v) sampling and analysis. HACCP is broadly recognized as the best method for the assurance of product safety and is internationally acknowledged as a tool for controlling foodborne safety hazards (CAC, 2003; Wallace et al., 2005; Kafetzopoulos et al., 2013).

Based on the European regulatory framework on food safety, the production actors must conform to very strict hygiene practices to ensure the safety of the end product. These practices are mainly based on

* Corresponding author.
E-mail address: a.osimani@univpm.it (A. Osimani).

http://dx.doi.org/10.1016/j.ijhm.2017.10.003
Received 21 February 2017; Received in revised form 19 July 2017; Accepted 2 October 2017

a series of operational instructions written according to those foreseen by the *Codex Alimentarius* and are included in the HACCP plan. Hygiene practices are implemented to ensure the proper storage and handling of raw materials and end products and to guarantee adequate hygiene conditions of the staff and the production environment (Osimani et al., 2011, 2013a,b; Petruzzelli et al., 2014a,b).

The microbiological contamination of foods prepared by catering systems is one of the main parameters that must be assessed to ensure the safety of prepared foods. Indeed, foods can be contaminated by saprophytic microorganisms (total mesophilic aerobes), as well as by spoilage and pathogens (e.g., *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli*, and *Staphylococcus aureus*). Such contamination depends on the quality of the raw materials and on the application of good manufacturing practices (GMPs) by the staff.

Several scientific studies and literature reviews have documented that foods supplied by a catering service can be the source of many foodborne outbreaks (Osimani et al., 2016a). The European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC) (EFSA and ECDC, 2015a,b) have recently reported that catering establishments (e.g., catering services, restaurants, hotels, pubs, bars) were identified as the most frequently reported setting for major foodborne outbreaks such as salmonellosis, listeriosis and campylobacteriosis.

Regarding school catering services in Europe, between 2001 to 2012, school and university canteens located in Greece and Italy have been reported as potential sources of *Listeria monocytogenes* (Pesavento et al., 2010; Kotzekidou, 2013; Marzano and Balzaretti, 2013). Moreover, school and college restaurants that were mainly located in the United Kingdom, Spain and Denmark have been involved in many campylobacteriosis outbreaks between 2003 and 2011 (Jimenez et al., 2005; Calciati et al., 2012; Abid et al., 2013). Furthermore, Delbrassinne et al. (2015) recently reported a *Bacillus cereus* foodborne outbreak in a kindergarten in Belgium. The available scientific literature emphasizes that cross-contamination between ready-to-eat food and raw materials, improper storage temperatures (e.g., temperature abuse), inadequate cooking and ineffective cleaning procedures were potential risk factors. Marzano and Balzaretti (2013) reported that the monitoring and improvement of the safety of prepared foods provided by a school catering service represent pivotal actions to protect consumers (e.g., children) from foodborne illness.

Moreover, Article 9 of Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs expressly states that in order to prevent the occurrence of a microbiological risk, food business operators shall analyze trends in the test results to take appropriate action when they observe a trend towards unsatisfactory results. Indeed, different authors state that the microbiological monitoring of end products and food contact surfaces has been effectively used to evaluate the HACCP plan and to discover persistent problems related to microbiological contamination in school catering premises (Osimani et al., 2011; Marzano and Balzaretti, 2013; Osimani et al., 2013; Garayoa et al., 2014; Petruzzelli et al., 2014). Furthermore, long-term monitoring after the implementation of corrective action showed food safety improvement by school catering services (da Cunha et al., 2013; Osimani et al., 2016b).

Regulation (EC) No 852/2004 requires that food business operators shall establish procedures, which shall be done regularly, to verify that the HACCP system is working effectively. Microbiological analyses constitute a valid tool of verification in this context. The aim of the current study was to assess the appropriateness of the HACCP system implemented in a school-deferred catering system in central Italy by evaluating the microbiological quality of the meals produced. To this end, a total of 620 meals produced and distributed between 2011 and 2015 were for microbiological analysis. The analyzed meals were produced for lunch by a centralized production unit that prepares approximately 3200 meals a day, which are distributed to satellite nursery, primary and secondary school kitchens. The number and type of satellite kitchens varied according to the number of schools served each year. Moreover, to evaluate the hygiene of the production environment, 621 and 319 swabs collected from work surfaces and operators' hands, respectively, were for microbiological analysis during the same period.

Table 1
Sampling plan of food products collected in the period 2011–2015.

Years	Catering plants					
	Nursery-schools		Primary- and Secondary-schools		Centralized production unit	
	Number of plants	Number of meals	Number of plants	Number of meals	Number of plants	Number of meals
2011	28	83	15	15	1	7
2012	44	159	17	48	1	16
2013	43	123	17	36	1	10
2014	42	46	8	9	1	8
2015	36	41	6	10	1	9
Total food samples		452		118		50

2. Materials and methods

2.1. Sampling plan

The number of plants involved in the study varied in different years. In more detail, one centralized production unit was studied during the study period (2011–2015). In 2011, 28 nursery schools were studied, 44 in 2012, 43 in 2013, 42 in 2014, and 36 in2015. In 2011, 15 primary and secondary schools were studied, 17 in 2012 and 2013, 8 in 2014, and 6 in 2015. The grouping of satellite kitchens was chosen as previously suggested by Marzano and Balzaretti (2013) with some modifications. In more detail, school types were distinguished on the basis of consumer ages ranging from 3 to 5 years for nursery schools and from 6 to 14 at primary and secondary schools. All plants were managed by the same contractor during the study period.

The number of meals collected each satellite kitchen varied according to the number of consumers served, with a minimum of one analyzed meal/plant per year, up to ~3 meals/plant per year. The number of food samples for the centralized production unit varied from 7 to 16 meals/plant per year according to the number of satellite kitchens served. The number of meals collected also varied, and if a meal was found not to conform to a test standard, the food had to be resampled and reanalyzed. The detailed meal sampling plan is summarized in Table 1.

The number of environmental samples of work surfaces such as tools, tableware, and machinery and the operators' hands varied according to plant size. Tools included spoons, cutlery, pans and chopping boards, tableware included stainless steel preparation tables, shelves and washbasins, machinery included slicing machines, salad washers and meat or vegetables grinders.

The detailed sampling plan for the work surfaces and operators' hands for microbiological analysis is shown in Table 2.

2.2. Food preparation and distribution

First courses included pasta, pasta with tomato sauce, pasta with olive oil, boiled rice with vegetables, and soup, meat or fish main courses included meatballs with tomato sauce, roast pork, roast chicken, cooked veal, and roast flounder, refrigerated main courses included cooked ham and cheese, vegetables included green salads, mixed salads and olives, cooked vegetables included boiled peas, boiled or roasted potatoes, potato puree, and boiled cabbage.

The meals were prepared daily by the centralized production unit