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Hygienic control of mass catering establishments, microbiological monitoring of food and equipment

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Abstract

During the period 2001–2002 a total of 236 inspections were performed on 27 catering establishments in the province of Ferrara (Emilia-Romagna region, Italy), after a HACCP system was introduced and educational programs for food staff was undertaken for approximately 10 years. A total of 370 food samples and 140 surface swabs were taken and examined for microbiological quality. The surveillance system has brought to light various shortcomings regarding the equipment (36 corrective actions) and incorrect procedures (47 corrective actions). The tool and work surfaces showed an unacceptable contamination in 10% of samples. The data also highlight a certain percentage of unacceptable samples of foods, especially with regard to *Escherichia coli*, ranging from 5.4% for the "first and second courses" to 10.8% for the "raw meats and meat preparations". Nevertheless, the hygienic quality of services and foods has improved in comparison with previous surveys, showing that the staff educational programs and the application of HACCP principles have increased the level of awareness regarding food hygiene in those working in catering services.

Keywords: Catering services; Microbiological food quality; HACCP

1. Introduction

Foodborne diseases (FBD), in particular gastro-intestinal infections, represent a very large group of pathologies with a strong negative impact on the health of the population because of their widespread nature. Little consideration is given to such due to the fact that their symptoms are often moderate and self-limiting. This has led to a general underestimation of their importance, and consequently to incorrect practices during the preparation and preservation of food, resulting in the frequent occurrence of outbreaks involving groups of varying numbers of consumers (CDR, 2002; Leoni, Pizzoli, Rangoni, & Rossi, 1996; Notermans & Hoogenboom-Verdegaal, 1992; Olsen, MacKinon, Goulding, Bean, & Slutsker, 2000; Scuderi, Fantasia, Filetici, & Anastasio, 1996). In Italy, the Emilia-Romagna region set up an efficient surveillance network for FBD. Data from the Regional Health Office show that between 1988 and 2000 1564 episodes of FBD were reported, 1139 (72.8%) of these were caused by *Salmonella* (Emilia Romagna region, Health Assessorship, 2002). One of the most significant risk factors identified is cross contamination, particularly between the food and the preparation surfaces (Bisbini, Leoni, & Nanetti, 2000; Legnani, Leoni, & Brunozzi, 1997). In recent years, in accordance with the European Directive 93/43/CEE du Conseil (1993) and the Italian law D. Lvo 155/97 (1997), the Public Health Services have done much to promote widespread educational and information programs. In this context, the Health District of Ferrara (Emilia-Romagna region, Italy) has undertaken an educational program for food personnel training in order to promote knowledge of good manufacturing practices and implementation of the HACCP system. The aim of this study is to evaluate the hygienic quality of some catering establishments in the province of Ferrara and the microbiological safety of the foods provided by these services, after the educational program for food workers has been performed for approximately 10 years.

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2. Materials and methods

2.1. Catering establishments

The Health District of Ferrara covers a territory with about 355 000 inhabitants. Within this district there are 309 mass catering establishments. Of these, 125 are food service establishments working in hospitals, schools and commercial companies, with a production potential ranging from 250 to over 1000 meals a day. The other 184 are specialized commercial establishments operating within the urban framework (restaurants, pizzerias, fast food establishments, bars, etc.). The investigation described here only took into account the first type of establishment, since it caters for subjects that are more vulnerable to FBD (hospitals, children and the elderly). The study was performed on 27 service establishments, randomly selected from the 125 in the territory of Ferrara, eight establishments with a production potential of more than 250 meals a day (range between 325 and 1450 meals) and 19 with a production potential below 250 a day (100–200 meals).

2.2. Inspections and sample collection

During the period 2001–2002 a total of 236 inspections was undertaken on the 27 catering establishments. Each inspection consisted of two parts: the first phase involved the collection of information about the hygienic state of the buildings and the equipment used, and an evaluation of the production process according to the HACCP system. The aspects taken into account were (1) structural characteristics (walls, covering, floor, etc.) (2) equipment (3) procedures of food production and storage (4) development of HACCP plans. The information was recorded on specially prepared forms in order to standardize data for each of the different operators. The second phase involved the collection of samples of raw and cooked foods (a total of 370). In addition 140 samples were taken from various surfaces in contact with the food, after normal cleaning procedures had been completed. Most attention was focused on cooked preparations ready for consumption (about 60% of the food samples examined) because the risk of gastrointestinal infections is normally associated with the consumption of this type of food, if prepared using insufficient levels of heat followed by poor storage.

The food samples were selected randomly, put into sterile plastic bags and quickly transported to the laboratory in an insulated and refrigerated box. An aliquot of 10 g of each food sample was homogenized in a Stomacher with 90 ml of peptone water 1%. The homogenized sample was then used as the basis for the total plate counts, and enumeration of coliforms, *Escherichia coli* and *Staphylococcus aureus*. For the recovery of *Salmonella, Listeria* and *Yersinia*, aliquots of 25 g of each sample were homogenized in 225 ml of the respective enrichment broth for each organism. The surface samples were collected using the swab-rinse technique. A sterile swab, moistened with saline solution, was rubbed for 20 s over the working surfaces or the tool surfaces to be sampled. A sterile paper template was used to outline a known area, inside which the swabbing was done. The swab was then placed in a tube containing a known quantity of physiological solution, shaked and squeezed in the diluent, and the rinse fluid plated in appropriate culture media.

2.3. Bacteriological techniques

Table 1 shows the microbiological parameters investigated and the relative identification techniques (Istituto Superiore di Sanità, 1996; Mossel, Corry, Struijk, & Baird, 1995). The same techniques were used to recover the microorganisms from the swab diluent. Colony forming units (cfu) per volume unit were converted into cfu per surface unit, taking into account the relation between the sampling surface and the volume of saline solution used to dilute material from the swab.

Data processing was performed after the absolute microbiological values had been transformed into $\log_{10}(x+1)$.

3. Results

3.1. Inspection of the catering centers

A detailed analysis of all the forms used for the survey brought to light certain factors that could affect the hygienic safety of the meals prepared at mass catering establishments, in that they may lead to bacterial contamination of the surfaces and subsequently of the food.

With regard to the structural characteristics, the catering centers were all conforming to the safety standards, thanks to the measures adopted to correct the problems identified by previous monitoring (Berveglieri, Magri, Bertasi, Rossetti, & Kumer, 1994; Boschetti et al., 1996).

With regard to the equipment, the most common problems identified were: inadequate extraction fans (7 centers), the lack of liquid soap and/or paper towels (6), cutlery with wooden handles (6) and wooden cutting boards (5), presence of hand-operated wastebins (5), no thermometers in the refrigerators (4), unsuitable containers for the transport of meals (3), no blast chiller (2).

During the process of preparation and storage of foods the most common mistakes were the incorrect arrangement of refrigerator shelves and cool stores (5 centers) and the lack of complete separation between raw and cooked foods (3). Furthermore the surfaces appeared to be incorrectly cleaned at least once in 15

Table 1
Microbiological parameters investigated and relative identification techniques

Microbiological parameters	Medium	Incubation conditions	Identification procedures
Total plate count	Plate count agar (oxoid)	32 °C for 48 h	Enumeration of cell forming units
Total coliforms	Mac Conkey agar (oxoid)	36 °C for 48 h	Enumeration of cell forming units (lactose fermenting)
E. coli	Violet red bile agar + MUG (oxoid)	44 °C for 24 h	API 20E biochemical tests (Biomerieux)
Staphylococcus aureus	Baird parker selective agar (oxoid)	36 °C for 48 h	API 20 *Staph.* biochemical tests (Biomerieux)
Salmonella	Pre-enrichment in buffered peptone water (oxoid) Selective enrichment in selenite cystine broth (oxoid) Isolation in Hektoen enteric agar (oxoid)	Pre-enrichment: 36 °C for 24 h Selective enrichment: 42 °C for 24 h Isolation: 36 °C for 24–48 h	API 20E biochemical tests (Biomerieux) serological identification
Listeria sp.	Selective enrichment in *Listeria* enrichment broth (oxoid) Isolation in Palkam agar (oxoid)	Selective enrichment: 32 °C for 24–48 h Isolation: 36 °C for 24–48 h	Haemolytic and catalase activity API *Listeria* biochemical tests (Biomerieux)
Yersinia enterocolitica	Selective enrichment in peptone sorbitol bile salts broth Isolation in *Yersinia* selective agar (oxoid)	Selective enrichment: 4 °C for 3 weeks isolation: 32 °C for 24 h	Lipase (tween 80), esculin hydrolysis, xylose fermentation, pyrazinamide enzyme API 20E biochemical tests (Biomerieux) serological identification

(work surfaces) and 12 (tools surfaces) establishments. When problems regarding the equipment or incorrect procedures were identified, corrective actions were performed immediately.

In accordance with HACCP principles, all the 27 food production centers have developed a HACCP plan, identified the critical control points for each operational or process step, fixed the procedures, the frequency and the persons responsible for monitoring. The HACCP support documentation showed some inadequacy concerning "food supply and receipt" (10 centers), "sanitation procedures" (7) and "keeping food warm" (3).

3.2. Food samples

The overall data in Table 2 reveals a high level of hygienic safety in the foods examined. *Salmonella* and other potential pathogens were found only in 2.7% of the samples (10 out of 370 examined). This percentage was higher in raw foods (raw meats and raw vegetables) where 8 samples were seen to be contaminated. Of particular interest was the only isolation of *Salmonella*, a serogroup B from a sample of poultry meat. *Listeria monocytogenes* was the most widely spread pathogenic species, it was isolated from 4 of the 5 groups of food investigated, most commonly in raw vegetables, but also in one sample of raw ham and in one sample of soft cheese. The foods examined in this study can, on the whole, be considered as "gastronomic products" and as such most of them are not covered by Italian legislation regarding microbiological quality standards. For the purposes of the present study standards for specific types of foods have therefore been taken from national or international regulations, or from authoritative researchers. In particular some reference values were established for the "first and second courses" and the "multi-ingredients preparations" taking into account the standards proposed by some regional regulations and different Authors. The microbiological criteria taken for reference are reported as an Appendix A. Although various European countries consider an acceptable level for *L. monocytogenes* as <100 cfu/g at time of consumption, the standard given is the most restrictive limit fixed by the Italian Regulation (OM 7.12.1993). Table 3 shows the percentages of conformity to the microbiological reference standards of the various groups of foods. The data highlight a certain percentage of unsatisfactory samples with regard to *E. coli*, ranging from 5.4% for the "first and second courses" to 10.8% for the "raw meats and meat preparations". The percentages of food samples that do not completely conform to the standards is higher for the total plate count at 32 °C, ranging from 8.3% for the "raw vegetables" to 25.0% for the "raw meats and meat preparations".

3.3. Surfaces

Table 4 shows the bacterial contamination of surfaces in contact with the food. The parameters taken for reference are the total plate count at 32 °C, which is correlated, although not specifically, with hygiene procedures, and the traditional indicators *E. coli* and *S. aureus*. Considering all the types of surfaces, only 71.4% were conforming with the advisory standards for the

Table 2
Bacteriological contamination of the various groups of foods sampled in catering establishments (log unit)

Foods	Bacteriological tests	Geometric mean (cfu/g)	SD (cfu/g)	Minimum (cfu/g)	Maximum (cfu/g)
Raw meats and meat preparations (fresh or frozen meat to be cooked, minced meat, stuffing, etc.) *n*: 37	Total count at 32 °C	5.25	2.12	2.00	9.44
	E. coli	0.55	1.28	0.00	4.51
	S. aureus	0.27	0.97	0.00	4.20
	Salmonella[a]	1 positive sample of poultry meat (serogroup B)			
	L. monocytogenes[a]	1 positive sample of minced pork			
	Y. enterocolitica[a]	2 positive samples of sausage and minced beef			
First and second courses (cooked foods ready for consumption: pasta, cooked meats dressing for meat, ham cooked vegetables) *n*: 220	Total count at 32 °C	2.60	2.25	0.00	8.62
	Total coliforms	0.58	1.25	0.00	5.88
	E. coli	0.17	0.77	0.00	6.20
	S. aureus	0.13	0.80	0.00	6.65
	Salmonella[a]	absence			
	L. monocytogenes[a]	1 positive sample of raw ham			
	Y. enterocolitica[a]	absence			
Multi-ingredients preparations (cooked and un cooked foods ready for consumption: Russian salad, sauces sea-foods, salads, etc.) *n*: 35	Total count at 32 °C	5.01	2.20	0.00	8.62
	E. coli	0.23	0.76	0.00	3.30
	S. aureus	0.00	0.00	0.00	0.00
	Salmonella[a]	absence			
	L. monocytogenes[a]	absence			
	Y. enterocolitica[a]	absence			
Soft cheeses *n*: 35	Total coliforms	1.06	1.61	0.00	5.04
	E. coli	0.52	1.21	0.00	5.04
	S. aureus	absence			
	Salmonella[a]	absence			
	L. monocytogenes[a]	1 positive sample			
	Y. enterocolitica[a]	absence			
Raw vegetables *n*: 43	Total count at 32 °C	5.52	1.06	4.07	7.86
	E. coli	0.24	0.69	0.00	3.04
	Salmonella[a]	absence			
	L. monocytogenes[a]	3 positive samples of salad			
	Y. enterocolitica[a]	1 positive sample of frozen carrots			

[a] Presence–absence test.

Table 3
Percentage of conformity of the various foodstuffs to microbiological reference standards

Foods	Assessment	Total count cat 32 °C	Percentage of conformity				
			Coliforms	*E. coli*	*S. aureus*	*Salmonella*	*L. monocytogenes*
Raw meats and meat preparations *n*: 37	Conforming	40.0	–[a]	86.5	94.6	97.3	97.3
	Acceptable	35.0	–[a]	2.7	2.7	0	0
	Unacceptable	25.0	–[a]	10.8	2.7	2.7	2.7
First and second courses *n*: 220	Conforming	83.9	85.2	93.5	96.7	100	99.5
	Acceptable	11.1	8.2	1.1	0	0	0
	Unacceptable	5.0	6.6	5.4	3.3	0	0.5
Multi-ingredients preparations *n*: 35	Conforming	82.9	–[a]	82.9	100	100	100
	Acceptable	0	–[a]	11.4	0	0	0
	Unacceptable	17.1	–[a]	5.7	0	0	0
Soft cheeses *n*: 35	Conforming	–[a]	90.3	82.9	100	100	97.1
	Acceptable	–[a]	6.5	11.4	0	0	0
	Unacceptable	–[a]	3.2	5.7	0	0	2.9
Raw vegetables *n*: 43	Conforming	58.3	–[a]	90.7	–[a]	100	93.0
	Acceptable	33.4	–[a]	2.3	–[a]	0	0
	Unacceptable	8.3	–[a]	7.0	–[a]	0	7.0

[a] Examination not foreseen by the microbiological standards used for reference, conforming: cfu/g < m; acceptable: m < cfu/g < M; unacceptable: cfu/g > M.

total plate count at 32 °C; more than a quarter were therefore below the standards commonly reported in the literature as indicative of good sanitation procedures (Nortje et al., 1990; Orefice, 1984; Patterson, 1971). Moreover, 10% of these were totally unsuitable for contact with food and 7.1% were found to be contami-

Table 4
Conformity of surfaces in contact with food to advisory standards [a]

Surfaces	Total count at 32 °C			*E. coli*		*S. aureus*		Pathogens presence/absence test[b]
	Satisfactory <50 cfu/cm^2 (%)	Fairly satisfactory 50–10^4 cfu/cm^2 (%)	Unsatisfactory >10^4 cfu/cm^2 (%)	Satisfactory <1 cfu/cm^2 (%)	Unsatisfactory >1 cfu/cm^2 (%)	Satisfactory <1 cfu/cm^2 (%)	Unsatisfactory >1 cfu/cm^2	
Non-cutting equipment (meat grinder and mincer, hamburger shaper, meat beater, etc.) *n*: 51	66.7	25.5	7.8	92.2	7.8	98.0	2.0	absence
Cutting equipment (liqui dizers, knives, slicers, etc) *n*: 30	80.0	13.3	6.7	100	0	100	0	1 sample *L. monocytogenes*
Work surfaces (tables, wooden and Teflon chopping boards, etc.) *n*: 36	55.6	22.2	22.2	83.3	16.7	100	0	absence
Containers (pans, trays, plates, etc.) *n*: 23	95.6	4.3	0	100	0	100	0	absence
All surfaces *n*: 140	71.4	18.6	10.0	92.9	7.1	99.3	0.7	1 sample *L. monocytogenes*

[a] Patterson, 1971; Orefice, 1984; Nortje et al., 1990.
[b] Presence/absence test; presence: unsatisfactory, absence: satisfactory.

nated by *E. coli* at >1 cfu/cm^2. The most critical surfaces were those used for the preparation of the food (tables, boards): 22.2% had a total plate count at 32 °C above 10,000 cfu/cm^2 and 16.7% were contaminated by *E. coli* at a level above the limit of 1 cfu/cm^2. An unacceptable contamination with *E. coli* (7.8% of samples) was also seen in the non-cutting equipment. The cutting blades and the inner surfaces of the containers were more compliant with the advisory standards, aided by the use of hot water dishwashers that help to clean and decontaminate the equipment. The indicator *S. aureus* does not appear to play a particularly important role in the contamination of the surfaces, since it was isolated from the non-cutting tools in only 2% of samples. As far as the potential pathogens are concerned, *L. monocytogenes* was isolated once from the blade of a knife.

4. Conclusions

The surveillance system on mass catering establishments in the district of Ferrara has brought to light cases of unsatisfactory hygienic conditions that, however, were less frequent than those found in surveys undertaken before on the same catering centers. Problems regarding the equipment were identified 38 times during the years 2000–2001, compared to 52 in 1993–1994; incorrect procedures concerning food preparation and storage were identified 36 times, compared to 47 in 1993–1994. The microbiological quality of foods also improved, especially with regard to contamination from traditional indicators such as *E. coli* and *S. aureus*. In particular, the latter species, which may be transferred to foods during manual handling, was recovered more rarely than in the previous surveys (Berveglieri et al., 1994; Boschetti et al., 1996).

The staff educational program introduced in the catering centers has certainly helped to increase the level of awareness and the sense of responsibility regarding food hygiene. Nevertheless the situation revealed by the direct inspection of surfaces and the results of the environmental swabs is still unsatisfactory and underlines the need to improve further on the knowledge of good manufacturing practices. The HACCP records concerning the sanitation procedures were inadequate in 7 of the 27 establishments. The surfaces examined showed an unacceptable contamination in 10% of samples, in comparison with 17% in 1993 (Berveglieri et al., 1994) and 14% in 1994 (Boschetti et al., 1996). These findings show that the sanitation protocols are still not applied yet in a way that will assure complete safety in many catering centers. Furthermore the microbiological quality of surfaces has been identified as a useful indicator for the control of the critical point represented by procedures of cleaning and disinfecting. With regard to other critical points such as storage and transport of meals, incorrect procedures were identified in a low percentage of cases.

The results of the present study reveal a number of important points. The first is that the microbiological quality of food and equipment has improved after the application of HACCP principles and widespread educational programs for the food staff over a ten years period in the district of Ferrara. An equally important point is the identification of some weak points in the

general management of the food production process. The knowledge of these problems is essential for the improvement of the control system of food production establishments and to adjust the staff training programs, in order to obtain greater safety in mass catering services.

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Appendix A

Microbiological reference standards for the various foodstuffs submitted for microbiological investigation

Foods	Bacteriological tests	Standards				Source
		n	c	m (cfu/g)	M (cfu/g)	
Raw meats and meat preparations						European regulations: Directive
Minced meats	Total count at 32 °C	5	2	5×10^5	5×10^6	94/65/CE du Conseil, 1994
	E. coli	5	2	5×10	5×10^2	
	S. aureus	5	2	10^2	10^3	Italian regulations: DPR n. 309/
	Salmonella	5	0	absence in 10 g		1998; OM 7.12.1993
	L. monocytogenes	3	2	11	110	
Meat preparations	*E. coli*	5	2	5×10^2	5×10^3	
	S. aureus	5	2	5×10^2	5×10^3	
	Salmonella	5	0	absence in 1 g		
	L. monocytogenes	3	2	11	110	
First and second courses (cooked foods ready for consumption)						References:
	Total count at 32 °C	5	2	10^5	10^6	Emilia Romagna region, 1992
	Total coliforms	5	2	10^2	10^3	Lombardia Region, 2001
	E. coli	5	2	0	10	Reneto Region, 1990
	S. aureus	5	2	10	10^2	Rondinini, 1997
	Salmonella	5	0	absence in 25 g		Mossel, 1995
	L. monocytogenes	5	0	absence in 25 g		ICMSF, 1986
Multi-ingredients preparations (cooked and uncooked foods ready for consumption)						References:
	Total count at 32 °C	5	2	10^6	10^7	Emilia Romagna region, 1992
	E. coli	5	2	0	10	Lombardia Region, 2001
	S. aureus	5	2	10^2	10^3	Reneto Region, 1990
	Salmonella	5	0	absence in 25 g		Rondinini, 1997
	L. monocytogenes	5	0	absence in 25 g		Mossel, 1995
Soft cheeses						
	Total coliforms	5	2	10^4	10^5	European Regulation: Directive
	E. coli	5	2	10^2	10^3	92/46/CEE du Conseil, 1992
	S. aureus	5	2	10^2	10^3	Italian Regulation: DPR n. 54/
	Salmonella	5	0	absence in 25 g		1997
	L. monocytogenes	5	0	absence in 25 g		
Raw vegetables						
	Total count at 32 °C	5	2	5×10^5	5×10^6	French Regulations: Arrêté
	E. coli	5	2	10^2	10^3	22.03.1993; Arrêté 28.05.1997
	Salmonella	5	0	absence in 25 g		ICMSF, 1986
	L. monocytogenes	5	0	absence in 25 g		

n: number of sample units; c: number of sample units with counts between m and M; m: conformity limit; M: acceptable limit.

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