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An assessment of cleaning and sampling methods for food-contact surfaces in premises preparing and selling high-risk foods

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SUMMARY

The performance of agar-contact plates and an alginate-swab method for sampling food surfaces before and after cleaning was compared. Contact plates were more convenient, and were at least as sensitive as the swabbing method. To assess cleaning efficiency repeated sampling was carried out in selected premises, and several cleaning methods were introduced for trial periods. Some surfaces, notably wood and polypropylene, were particularly difficult to clean. For these scrubbing with a nylon brush was the best method. Other surfaces were more easily cleaned, and generally the methods introduced as part of this study were better than the original method used in the premises. Paper proved to be unpopular, and cleaning solutions applied with it did no better than those cleaned with a multiuse cloth kept soaking in a detergent and hypochlorite solution.

INTRODUCTION

Although the importance of effective cleaning of food surfaces is well recognized, little has been done to compare different sampling and cleaning methods in actual food premises.

Various methods can be used for sampling bacteria on hard surfaces. The recovery of bacteria from soluble calcium alginate swabs is greater than from cotton-wool swabs [1]. Swabbing is generally considered to be more sensitive than direct sampling by agar-impression methods [2, 3], but the type of surface being sampled and whether or not the bacteria have clumped or formed microcolonies on it are important factors in comparing these methods. The introduction of plastic contact plates provided a simple and reliable method for sampling relatively clean surfaces [4]. Direct replica plating onto selective media means that specific bacteria can be looked for after a period of recovery on a non-selective medium [5]. In a recent laboratory study these contact plates showed at least comparable results with those obtained by an alginate-swabbing method [6].

A variety of detergents and disinfectants is available for cleaning food surfaces. If more than one agent is chosen they must be compatible and each should be used at the recommended concentration. Laboratory studies [6] and carefully controlled tests in food premises [2] have shown that disinfectants can provide an

extra margin of safety. Even so some surfaces, such as wood, remain difficult to clean adequately. In practice the preparation and use of cleaning agents is rarely controlled. Most cleaning solutions are applied with reusable cloths, which are frequently used in both raw and cooked food areas. These multiuse cloths may be heavily contaminated with bacteria [7, 8], and are difficult to disinfect adequately after each use. Paper, which has performed well in laboratory studies [6], has been recommended as an alternative, but has not been widely accepted in food premises.

This study compares alginate swabs and agar-contact plates for sampling different types of food surfaces. The effectiveness of a variety of surface cleaning methods is examined, and the acceptability of the different techniques is assessed.

MATERIALS AND METHODS

Preliminary laboratory experiments

Tests using agar-contact plates and alginate swabs were carried out on surfaces contaminated with *Escherichia coli* dried in milk are previously described [8]. In some experiments contact plates which had been used to sample contaminated surfaces were incubated at 37 °C for 2, 4, 6 or 8 h, and then replicated directly onto MacConkey agar. In further tests small numbers of *E. coli* (final concentration approximately 100 colony forming units) were added to milk which had been heavily contaminated with other bacteria (approximately 10^7 colony forming units). Replication tests were used to try and detect *E. coli* on these contaminated surfaces. To try and determine whether or not either sampling method could detect bacteria by the other, some surfaces which had been sampled by the swab method were retested by contact plates and vice versa. Some swab fluids were centrifuged before examination. Finally two polypropylene pads were obtained from one of the premises, and these were cleaned by a variety of methods including scrubbing with a nylon brush soaked in the detergent and hypochlorite solution. The results were compared with those obtained by cleaning the pads with wiping cloths or with paper.

Premises

Fifteen premises which prepared and sold sliced cooked meats were studied. The study was divided into four parts (see Cleaning methods) each of which, with the exception of part four where samples were collected for 2 weeks, lasted for 4 weeks. Two food-contact surfaces which had either just been used or were in use were chosen in each of the premises, and these were sampled throughout the study period. Five types of surface were studied (Formica, stainless steel, marble, polypropylene, and wood), with adjacent areas being sampled before and after cleaning.

Sampling methods and microbiological examination

All surfaces were sampled using contact plates. These were kept for approximately 1 h at ambient temperatures, depending on the time taken to reach the laboratory, incubated for 3 h at 37 °C, and then replicated onto MacConkey

agar. Both plates were incubated overnight at 37 °C. On contact plates growth was classified as scanty (25 or fewer colonies), light (up to 75 colonies), moderate (up to 200 colonies) and heavy (confluent or almost confluent growth). Colonies which resembled coliform bacilli on the MacConkey medium, which produced indole from tryptophan at 44 °C, and which grew and produced gas in brilliant green bile broth were identified as *E. coli*.

Some surfaces were also sampled with alginate swabs using two swabs/area [9]. An area adjacent to that tested by the contact plate was sampled. Serial dilutions of the swab solutions were cultured onto Columbia agar, and a 1 ml amount of the swab fluid was spread on MacConkey agar. The plates were incubated overnight at 37 °C. The total number of bacteria recovered from a surface was calculated and *E. coli* was identified as previously described.

Reusable wiping cloths were placed in plastic bags. Twenty millilitres of Minimal Recovery Diluent containing 0·4% sodium thiosulphate were added, and the contents were mixed thoroughly. In the laboratory as much fluid as possible was expressed from the cloth, and using a spiral-plating machine, 50 μl was spread onto CLED agar. A further 1 ml of the cloth fluid was pipetted onto MacConkey agar. Total viable counts were determined after overnight incubation at 37 °C, and *E. coli* was looked for as previously described. Where cloths were kept soaking in a detergent and hypochlorite solution, 1 ml of the fluid was added to 9 ml of nutrient broth containing 3% Tween 80. Using a Pasteur pipette 10 drops of the disinfectant/diluent were placed separately onto the surface of each of two well-dried CLED agar plates. The plates were incubated for 72 h, one at room temperature and the other at 37 °C. The growth of five of more colonies on one plate was considered unsatisfactory.

Cleaning methods

Four cleaning methods were compared in the premises.

Method A. The staff were asked to continue with their usual method of cleaning food surfaces and equipment.

Method B. A solution containing 0·2% neutral detergent (Lemon Plusfoam, Lever Industrial Ltd) and hypochlorite (200 p.p.m. available chlorine; Chlortabs, Lever Industrial Ltd.) was used. The cleaning agents were provided as part of the study, and instructions for preparing appropriate quantities at the right concentration were provided at each of the premises. The solution was prepared at least four times during the working day. For cleaning, a small amount of the solution was dispensed from a wash-bottle onto the area to be cleaned. The surface was then wiped with paper (3-ply, Kimberly-Clark) ensuring that all the surface was covered, and as far as possible, a uniform downwards pressure was applied to the paper during cleaning. The surface was allowed to dry before sampling.

Method C. An identical detergent and hypochlorite solution was dispensed onto a surface, which was then wiped with a reusable cloth. After use the cloth was rinsed and returned to a container filled with cleaning solution. This solution was changed at least four times during the day. Cloths were soaked overnight in double-strength solution.

Method D. A two-stage cleaning process was used. Two wash-bottles one containing a detergent solution (Plusfoam, 0·2%) and the other a hypochlorite

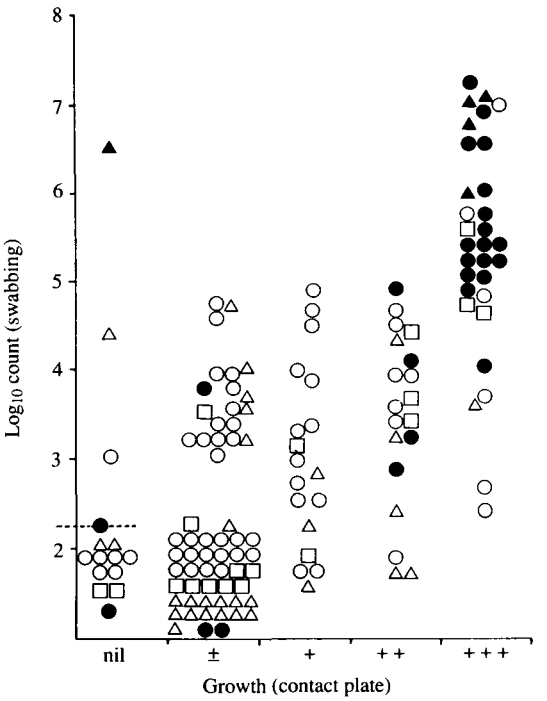

Fig. 1. Comparison of agar-contact plates and an alginate-swab method for detecting bacteria on Formica (○), stainless steel (△), marble (□), polypropylene (●) and wood (▲) surfaces after routine cleaning. The dotted line indicates the lower cut-off point for the swabbing method.

solution (Chlortabs, 200 p.p.m. available chlorine) were used. The cleaning solutions were applied with separate pieces of paper.

RESULTS

Preliminary experiments showed that replication of contact plates onto MacConkey agar reliably transferred *E. coli* when carried out between 3 and 6 h after the initial contamination of the contact plates. Shorter times resulted in poor transfer, and a longer time interval was sometimes associated with smearing of some colonies. Replication also detected small numbers of *E. coli* on contact plates heavily contaminated with other bacteria. Further tests showed that the alginate swab method failed to detect organisms after a surface had been sampled with contact plates, but that contact plates were able to detect *E. coli* on a surface which had previously been sampled by swabbing.

The degree of correlation between agar-contact plates and alginate swabs varied, but was greatest where higher or lower population densities were being studied (Fig. 1). As expected confluent growth was often found on contact plates applied to surfaces before cleaning, and exact comparison between the two sampling methods was not possible. Replication detected *E. coli* more often on food surfaces than did swabbing (16/143, 11·2% positive for contact plates and

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8/143, 5·6% positive for the swabbing method). Contact plates were used in all subsequent tests. For the purposes of this paper a reduction by two or more categories in the amount of growth on the plates (see Methods) was chosen to indicate satisfactory cleaning, and where the counts remained the same or were increased this was taken to indicate that cleaning was unsatisfactory.

Table 1 shows the results obtained after cleaning various types of surfaces. Wood and polypropylene surfaces were particularly difficult to clean, and none of the methods was satisfactory. Forty of 47 wood surfaces remained heavily contaminated after cleaning, and 39 of 72 polypropylene pads still had large numbers of bacteria on them. Laboratory tests showed that polypropylene or wood surfaces could be cleaned by brushing, and that the difficulty in cleaning was related to the amount of surface damage. Formica, stainless steel and marble surfaces were more easily cleaned. Generally the methods introduced as part of this study achieved better results than did the technique in use at the start of the survey (see Table 1). This also applied to *E. coli* with 16 of the 175 surfaces cleaned by the original method being positive compared to only 5 of the 280 surfaces cleaned by the survey methods. Cloths kept soaking in a detergent and hypochlorite solution performed as well as an identical solution applied with paper. Except for wood and polypropylene surfaces, a two-stage process performed slightly better than a combined detergent and hypochlorite solution, but the number of surfaces examined by this method was small.

Table 2 compares the microbiological results obtained from wiping cloths in nine premises. Generally cloths stored in a detergent and hypochlorite solution had lower counts and fewer of them were positive for *E. coli* than cloths not soaked after use. However 18 of the 51 in-use disinfectant tests were unsatisfactory, and 7 of the solutions contained large numbers of bacteria. With one exception surfaces wiped with a cloth kept in a detergent and hypochlorite solution were more likely to be successfully cleaned than those wiped with cloths which were not disinfected after use. However in one of the premises (G in Table 2) the results from surfaces cleaned with cloths soaked in a detergent and hypochlorite solution were not improved. In this kitchen both surfaces sampled were used for preparing raw foods, and one of them was polypropylene. The routine cleaning method was a two-stage process, and involved scrubbing the surfaces with detergent and then with a concentrated hypochlorite solution.

DISCUSSION

Sampling food surfaces is a complex problem, and the results depend on many factors, including the type of surface, the cleaning solution and how frequently it is used, the sources of contamination, and the temperature. The accuracy and reproducibility of all sampling methods are reduced when the numbers of bacteria on the surface are low. Some differences between methods are probably due to an uneven distribution of bacteria on the surface. Recent work in food-manufacturing premises suggests that bacteria often occur as microcolonies in biofilms rather than singly on food surfaces [10]. Swabbing may break up these colonies, whereas agar-impression methods fails to distinguish between single and clumped organisms. Detergents used during cleaning could also disperse clumps of bacteria,

Table 1. *Comparison of four methods for cleaning different types of food surfaces*

Cleaning method	Surface: Total using method†	Surface: Type	Assessment of surface after cleaning*: % Satisfactory	Assessment of surface after cleaning*: % Unsatisfactory
Usual technique before survey	175	Formica	38	45
		Stainless steel	22	58
		Marble	17	58
		Polypropylene	27	67
		Wood	4	79
Detergent and hypochlorite solution applied with paper	138	Formica	50	30
		Stainless steel	42	37
		Marble	67	17
		Polypropylene	11	61
		Wood	17	44
Detergent and hypochlorite applied with cloth kept soaking in the solution	107	Formica	52	7
		Stainless steel	50	21
		Marble	50	25
		Polypropylene	25	50
		Wood	0	100
Detergent then hypochlorite applied with paper as a two-stage process	35	Formica	44	28
		Stainless steel	40	0
		Marble	100	0
		Polypropylene	0	67
		Wood	not tested	

* Satisfactory if growth reduced by two or more categories and unsatisfactory if growth remained the same or was increased after cleaning.
† Results from 13 surfaces not included because either no samples or only one of the pair was received.

Table 2. *Total viable counts and the isolation of* Escherichia coli *from wiping cloths used for cleaning surfaces in nine premises*

	Routine cleaning method before survey			Cloths soaked in detergent and hypochlorite solution		
Premises	Total count score*	*E. coli* present	Number of times cleaning unsatisfactory (total examined 12)	Total count score	*E. coli* present	Number of times cleaning unsatisfactory (total examined 12)
A	17	0	6	0	0	0
B	23	1	7	11	1	1
C	22	1	9	15	2	8
D	22	2	9	2	0	6
E	31	1	4	11	1	0
F	40	5	12	8	1	0
G	26	3	0	17	0	9
H	20	3	6	0	0	2
J	25	0	6	10	2	2
Mean score/ premises	25·1	1·8	6·6	8·2	0·8	3·1

* Total counts were scored as 10^4 or less = 0, up to 10^5 = 1, up to 10^6 = 3, up to 10^7 = 5, up to 10^8 = 7, and more than 10^8 = 9.

and these, if not removed, would affect the counts. The efficiency with which swabs pick up bacteria and subsequently release them into the counting fluid could limit the sensitivity of the swabbing method. Both methods have limitations, and neither contact plates nor swabbing provides immediate results for controlling plant hygiene.

The type of surface markedly influenced the cleaning results. Wooden boards were frequently heavily contaminated with bacteria both before and after cleaning, and are best avoided. Polypropylene pads gave more variable results, and successful cleaning was associated with the amount of surface damage. Most pads sampled had some damage, and this study has highlighted the dangers of using these. Toughened glass cutting surfaces, which are smooth and easier to clean, might be considered, but these are expensive and the danger from chipping and subsequent contamination of the food product would need to be considered carefully.

Although well suited to use in food premises, hypochlorites are readily inactivated by food residues and soaking cloths in a dilute solution is usually not recommended. To overcome this problem cloths must be thoroughly rinsed after each use, and the solutions must be changed frequently since inactivation of the disinfectant is inevitable. Some of the cloth-soaking solutions tested here contained large numbers of bacteria, and more frequent changes of these solutions than those recommended may be necessary. Starch-iodide papers could be used as a simple and quick check for free chlorine. Chlorine compounds are also irritants, and even at the low concentrations used here, repeated handling of cloths could lead to skin problems in some people. At the very least hands should be rinsed and dried after using cloths. Disposable gloves might be used in some premises. Despite their greater cost disinfectant tablets are safer to use than concentrated solutions and also accurate solutions can be more easily prepared. Cleaning with nylon brushes, only the bristles of which need to be immersed in the cleaning solution, is worth considering. These are more efficient at cleaning some types of surface and are better in less accessible areas. Spray application of disinfectant can help to achieve an even distribution on the surface, but this method is likely to be relatively expensive and is not suitable for hypochlorites.

Although cleaning was carried out under observation and at times when it may not normally have been done, there was no evidence that attitudes towards cleaning methods markedly changed during the survey. Staff working in the premises claimed to give a high priority to cleaning, but none had introduced a satisfactory cleaning programme. Cleaning plans were absent, and the choice, preparation and use of cleaning agents were not controlled. Given the well-recognized dangers of wiping cloths, it is also surprising that paper is not more widely used. When introduced for a trial period paper was disliked by staff who found it less absorbent than cloths and likely to disintegrate during use. The results, which were no better than those with multiuse cloths, may reflect an unwillingness by staff to adapt their methods to suit paper. Management also identified the additional cost of paper and the problem of disposing of the waste as further disadvantages.

This study has highlighted the need to reassess cleaning techniques. In the near future Environment Health Officers are likely to place greater emphasis on

hygiene practices during their inspections of high-risk premises. Agar-contact plates, which are useful indicators of surface contamination, could be used to supplement these inspections. Their major drawback is the time interval before results are available, and more rapid methods of monitoring surface hygiene, such as ATP detection by bioluminescence [11], are worth investigating alongside more traditional methods.

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