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ORIGINAL ARTICLE

Verification of cleaning efficiency and its possible role in programmed hygiene inspections of food businesses undertaken by local authority officers

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Abstract

Aim: The aim of this study was to determine whether or not the assessment of surface cleanliness could make a contribution to visual inspections of food premises.

Methods and Results: Forty-five premises were studied with both rapid (ATP) and traditional microbiological swabbing being used to test surfaces that either come into direct contact with prepared foods or were likely to be touched by hands during food preparation. A significant link was found between aerobic colony counts and ATP measurements. In most cases, the visual appearance of surfaces could not be used to accurately predict either microbial or ATP results.

Conclusion: This study suggests that ATP testing is a useful indicator of surface cleanliness and could be helpful to local authority officers as part of risk assessment inspections.

Significance and Impact of the Study: This study provides further evidence that visual inspection alone may not always be adequate to assess surface cleanliness. In high-risk premises, ATP could, if appropriately targeted, help identify potential problem areas. The results are available at the time of the inspection and can be used as an on-the-spot teaching aid.

Introduction

Cross-contamination is an important contributory factor in many outbreaks of foodborne disease (Sagoo *et al.* 2003). Food businesses across the United Kingdom have a duty in law to provide a clean working environment. A Food Law Code of Practice provides instructions and criteria for local authority officers responsible for inspections of food businesses (Food Standards Agency 2004). The agency has also issued guidance on good food hygiene practice to help smaller businesses. This includes sections on cleaning and avoiding cross-contamination (Food Standards Agency, 2005; Safer Food Better Business). In practice, the risk from cross-contamination is further increased if the temperature of the food is not subsequently controlled or a surface is left uncleaned, permitting bacterial growth. Reusable wiping cloths can spread bacteria across many areas of the food environment during cleaning (Tebbutt 1988). Contamination can occur directly between foods but more often than not it is from hands or via contaminated food-contact surfaces and equipment. Although inspections of food businesses are now risk based, and the choice of cleaning agents and cleaning schedules are part of the inspection process, a judgement on cleanliness is still largely based on visual assessment. Although damaged surfaces such as badly scored cutting boards can make cleaning difficult, if not impossible, and damp surfaces are more likely to be contaminated, some work suggests that surfaces that appear visually clean can still harbour food

debris and bacteria, which may lead to contamination of the product (Moore and Griffith 2002). It is also apparent that cleaning and cross-contamination continue to cause concern in butchers' shops that sell raw and ready-to-eat meat, despite the introduction of HACCP plans (Griffith *et al.* 2003).

Traditionally, surface swabs are tested for the presence or absence of bacteria on food-contact surfaces. Prior to cleaning, the levels of bacteria on a surface will vary considerably depending on the food it last came into contact with as well as on the condition of the surface itself. Surfaces such as cutting boards, which are cleaned after each use, are normally tested after cleaning and prior to reuse, as this best reflects the cross-contamination risk from surface to foods. As regards guidelines, the European Community (Commission Decision 2001/471/EC 2001) provided that cleaned and disinfected surfaces in meat establishments should have less than 10 CFU cm^{-2} for total viable counts. A similar recommendation had been put forward by the US Public Health Service (Favero *et al.* 1984). A target value of $<2{\cdot}5$ CFU cm^{-2} after cleaning has been achieved for a range of surfaces in hospitals (Griffith *et al.* 2000) and has also been applied in several types of food premises (Moore and Griffith 2002). Some environmental surfaces, such as door handles and taps, which are frequently touched as part of food handling practices, are invariably cleaned less often and these can be tested without precleaning, as this best reflects practice during the day.

While microbiological guidelines for cleaned surfaces exist, the results from tests are not immediate and thus offer little help as part of hygiene inspections. The test also fails to detect food debris that may or may not accompany bacteria and which may become a suitable nutrient source enabling small numbers of organisms to grow. Rapid tests, such as ATP detection, have been used to set cleaning targets by serial sampling before and after cleaning and have been used successfully to monitor cleaning efficiency in some larger food manufacturing premises. One supplier (Biotrace 2002) has proposed a cleaning target of 500 relative light unit (RLU) per 10 cm^2 and Moore and Griffith (2002) also used this to measure surface cleanliness in four different food-processing environments. It has not been established whether or not a cleaning standard for ATP testing can be applied as part of routine hygiene inspections carried out by local authority officers. The purpose of this study is to compare microbiological and ATP results obtained from a variety of food-contact surfaces and determine whether or not a microbiological target was achieved and how this relates to the ATP score obtained at the same time of sampling.

Materials and methods

Premises and sampling sites

Premises were allocated by environmental health officers as part of the planned inspection programme for their authority. Six authorities in the northeast region of England (Darlington BC, Hambleton DC, Hartlepool BC, Middlesbrough BC, Redcar and Cleveland BC and Sedgefield BC) took part. All sampling were carried out by one of the authors (GMT) and sites were either those that come into direct contact with foods, e.g. cutting boards and storage containers or those that might become contaminated during routine handling operations. For cutting boards, only those that had been cleaned and were ready for use were tested. Any colour coding, the condition of the board and the way it was stored were recorded. The method of cleaning boards after use was also determined. The type and condition of plastic food containers were recorded, as was the method of storage before use. Only containers that were ready to use were sampled. Other surfaces tested included taps on wash-hand basins, refrigerator door handles or recesses, microwave oven controls and bin lids. These were all surfaces regularly touched by hands that were not cleaned until the end of the working day or sometimes after longer time intervals. The appearance of the surfaces was recorded. For wash-hand basins, the presence of soap, the method used to dry the hands, and in some premises any evidence that the basins were used on a regular basis were all noted. The hands of one or more staff handling foods were also tested for ATP both before and after washing. The availability of hot water, the type of soap and the means of hand drying were noted.

Inspection procedures

Inspections were unannounced and followed the format set out in the Food Law Code of Practice (Food Standards Agency 2004). At the time of the visit, the officer informed the proprietor or representative that it was a routine inspection and that swabs would be taken for microbiological examination. Agreement to take swabs for ATP analysis was obtained. The proprietor or representative was shown the results of the ATP tests and the possible reasons for any bad results were discussed and remedial action suggested.

Collection and reading ATP samples

Clean-Trace® swab devices (Biotrace International, Bridgend, UK) were used. The swabs were stored between 2 °C and 8 °C and were allowed to warm up to room tem-

perature immediately prior to use. When possible an area approx. 10 × 10 cm was sampled with the swab being rotated while being drawn across the surface in one direction and then in the opposite direction. For surfaces that were not flat, approx. half the surface was sampled (for taps both hot and cold taps were included). The swab handle was then pushed firmly into the swab tube, and the device shaken for at least 5 s before inserting in the sample chamber of a Uni-Lite® NG luminometer (Biotrace Fred Baker Ltd). After pressing the measure button on the luminometer, the reading in RLU was recorded.

Some samples were collected from hands by sampling the thumb and third finger plus palm before hand washing and the index finger and fourth finger plus palm immediately after hand washing.

Collection and testing microbiological samples

The technique for surface swabbing was as described by Roberts and Greenwood (2003) except that templates were not routinely used. Individually packed sterile swabs (dry swabs with blue plastic shaft; Medical Wire and Equipment, Wiltshire, UK) were used. If the surface was dry, the first swab was dipped in resuscitation and neutralizer solution [peptone, sodium chloride, lecithin (3 g l^{-1}), Tween 80 (30 g l^{-1}) and sodium thiosulfate (3 g l^{-1})] before sampling the test area. When possible an area approx. 10 × 10 cm was tested, otherwise approx. half the total area was sampled. A second dry swab was then drawn across the same area and both swabs broken off in the 10 ml neutralizer solution. Swabs were placed in a cool box, returned to the laboratory within 1 h and refrigerated upon arrival. In the laboratory, the bottle of diluent containing the swab and approx. five small glass beads (3 mm diameter) was shaken until the cotton wool had been broken down into fibres. This usually took between 30 and 60 s. An aerobic colony count was performed using the standard method issued by the Health Protection Agency (2005a)). Briefly, after mixing the sample, a spiral plater instrument was used to distribute 50 μl of the sample onto plate count agar (Oxoid). Each plate was left on the bench for approx. 15 min to allow absorption of the inoculum, inverted and then incubated at 30 °C for 48 h. Colonies were counted either manually or by an automated colony counter as specified in the standard method. For *Escherichia coli*, a 0·5 ml volume of the swab fluid was spread onto BCIG chromogenic agar (Oxoid) as described in the standard method (Health Protection Agency 2005b). After absorption of the inoculum, each plate was incubated at 30 °C for 4 h to allow resuscitation of the bacteria and then for a further 18 h at 44 °C. Blue colonies indicating beta-glucuronidase activity were counted as *E. coli*.

Statistical analysis

Correlations and probability values were calculated from results based on natural logarithms in order to help normalize the data. For comparisons, the analyses used the nonparametric equivalent of a *t*-test called the Kruskal–Wallis test. This test compared the median values from the two groups.

Results

Between July 2004 and August 2005, a total of 45 food premises were examined. Of these, 37 were grouped as caterers (restaurants, take-aways and cafes) and eight were retailers/manufacturers (butchers making pies or sandwich manufacturers). Most premises were small with less than five people working in the food preparation area at any one time, but in five premises between five and ten staffs worked in the kitchen and in one, a hospitality provider, up to 50 could be employed at any one time.

Cutting boards were used in 43 premises and all but one, a wooden board, were made of polypropylene. The conventional colour-coding system (red for raw meat, yellow for cooked meat, green for salads, etc.) was found in 33 (76·7%) of the premises. Thirty-eight boards were available for testing. In the remaining premises, boards were either in use, awaiting to be cleaned, or were drying after cleaning. Overall, the aerobic colony count ranged from <2 to 5·0 × 10^5 CFU cm^{-2} and *E. coli* was detected on six (15·8%) of them with a range of 0·2–12 CFU cm^{-2}. The surface condition of the boards tested was good in 24 cases (this category included those that were only lightly scored) and 14 boards were either heavily scored or showed other marked surface damage. Of boards in poor condition, the median test results were 100 CFU and 111 RLU (both per cm^2) whereas for those boards in good condition, the values were 12 and 59, respectively (Table 1). Sixteen boards were markedly stained with median counts of 1450 CFU cm^{-2} and 143 RLU cm^{-2}, whereas clean or boards with only minimal discolouration had median counts of 11 CFU and 82 RLU (Table 1). Neither aerobic colony counts nor ATP results were significantly related to the visual appearance of the boards sampled [for boards in good *vs* poor condition; aerobic counts ($P = 0·36$) and ATP ($P = 0·45$)] and for clean *vs* dirty boards; aerobic counts ($P = 0·12$) and ATP ($P = 0·27$).

Twenty-two boards of those sampled were used for cooked meat (yellow), 12 were for salads (green) and 4 were for raw meat (red) (Table 1). Microbial and ATP counts from both cooked meat and salad boards were similar (median counts for cooked meat boards 67 CFU and 132 RLU and for salad boards 69 CFU and

Table 1 Comparison of ATP and microbiological results from ready-to-use cutting boards based on the surface condition, appearance, colour and storage of boards in the premises

	ATP (RLU cm^{-2})		Colony count (CFU cm^{-2})		*Escherichia coli*	
Board (number tested)	Range	Median	Range	Median	Present (%)	Range (CFU cm^{-2})
Surface condition						
Good/lightly scored (24)	0·77–4666	59	<2–50 000	12	3 (12·5)	1–3
Heavily scored/damaged (14)	0·58–2268	111	<2–500 000	100	3 (21·4)	0·2–12
Appearance*						
Visually clean (21)	0·58–4666	82	<2–50 000	11	4 (19)	0·2–3
Stained (16)	2·75–1682	143	<2–500 000	1450	1 (6·3)	1
Colour†						
Yellow (22)	2·05–4666	132	<2–500 000	67	2 (9·1)	1–3
Green (12)	0·77–659	108	<2–500 000	69	2 (16·7)	0·2–2
Red (4)	59–2268	731	30–210 000	5200	2 (50)	2·4–12
Storage‡						
Separated in rack (21)	0·77–2268	43	<2–14 000	28	2 (9·5)	2–12
Stacked (11)	0·58–4666	109	<2–50 000	1900	3 (27·3)	0·2–3

*Information not collected on one board.
†Boards colour coded with yellow used for cooked meat, green for salad items and red for raw meat.
‡Six boards neither stacked nor retained in racks, of these three were kept at the place of use.

108 RLU). Four boards [two cooked meat (9·1%) and two salad (16·7%)] had *E. coli* on them. Although only four raw meat boards were tested, these showed higher counts (median count 5200 CFU and 731 RLU) and two of the four boards had *E. coli* present.

Of the boards tested, 21 were stored in racks with the surfaces separated, 11 were taken from a stack, and 5 were routinely left out on work surfaces in the area of use after cleaning. It was a common practice in the take-away premises selling Chinese foods to keep the board at the workstation. The median counts from the boards stored in racks were 28 CFU and 43 RLU, for those stacked 1900 CFU and 109 RLU (Table 1) and for boards stored on workbenches 210 CFU and 241 RLU (all values per cm^2).

The cleaning procedure for 33 boards was checked. Although most staff said that they rinsed boards before cleaning, this was evidently not always carried out. Boards cleaned manually with either a separate detergent and disinfectant or a combined sanitizer (12 boards) gave best results (median 10 CFU cm^{-2} and 28 RLU cm^{-2} after cleaning; Table 2) and cleaning with a detergent only (11 boards) was less successful (median 1100 CFU and 116 RLU). Those cleaned in a dishwasher also fared less well with median counts of 290 CFU and 217 RLU (both counts per cm^2). Although some cleaning methods appeared to perform better than others, none of the methods was found to be significantly better than any other (P values 0·16 for colony counts and 0·085 for ATP results when manual cleaning with both detergent and disinfectant was compared with detergent cleaning alone and 0·085 and 0·18 when compared with cleaning in a dishwasher).

Reusable plastic containers were commonly used to store foods (36/45 premises). Many were recycled, having been used for foods purchased by the business, e.g. butter or margarine. Of 38 containers sampled, 27 were wet, with pools of fluid sometimes collecting in the bottom. For these, the median aerobic colony count was 38 500 CFU cm^{-2} and the corresponding ATP count was 311 RLU cm^{-2} (Table 3). Of the 27 containers stored wet, 10 (37%) had *E. coli* (range 0·20 CFU cm^{-2} to 8·5 ×

Table 2 Comparison of ATP and microbiological results from cutting boards based on the method of cleaning

	ATP (RLU cm^{-2})		Colony count (CFU cm^{-2})		*Escherichia coli*	
Cleaning method (number tested)*	Range	Median	Range	Median	Present (%)	Range (CFU cm^{-2})
Manual with detergent (11)	17–659	116	<2–29 000	1100	3 (27·3)	0·2–2
Manual with detergent and disinfectant (12)	1·4–665	28	<2–500 000	10	1 (8·3)	2
Dishwasher (10)	0·58–4666	217	<2–50 000	290	2 (20)	3–12

*Information on cleaning procedure was not available for five boards.

Table 3 Comparison of ATP and microbiological results from ready-to-use plastic food-storage containers based on condition of the container

	ATP (RLU cm^{-2})		Colony count (CFU cm^{-2})		*Escherichia coli*	
Condition (number tested)	Range	Median	Range	Median	Present (%)	Range (CFU cm^{-2})
Good (27)	0·34–2768	159	<2–930 000	27 000	8 (29·6)	0·2–850
Damaged (8)*	17–2878	140	<2–960 000	75 000	2 (25)	0·8–59
Inside dry (10)	0·34–718	14	<2–27 000	8	1 (10)	44
Inside wet (27)	1·4–2878	311	2–960 000	38 500	10 (37)	0·2–850

*No information recorded for two containers.

10^{-2} CFU cm^{-2}). Ten containers appeared dry and, of these, the median counts were 8 CFU and 14 RLU (both per cm^2) with one being positive for *E. coli* (44 CFU cm^{-2}; Table 3). Statistical comparison showed a significant link between wet containers and both high aerobic counts ($P = 0{\cdot}0004$) and raised ATP values ($P = 0{\cdot}0012$). Damage to the containers (8/38), mostly at the top where the lid fits onto the base did not appear to be related to microbiology or ATP scores (Table 3). In some premises, large numbers of containers had been kept. With one exception, they were stacked one inside another.

At the time of the visit, wash-hand basins were absent in two premises with staff said to be using a pan-wash sink for hand washing. Although instant hot-water heaters were fitted in four premises, most used water from a piped supply and the time taken to produce hand-hot water varied considerably. For clean taps, the median count results were 44 CFU and 494 RLU (both counts per cm^2), whereas the corresponding results for dirty taps were 7277 CFU and 945 RLU (Table 4). The appearance of the taps was significantly associated with the number of bacteria detected on them ($P = 0{\cdot}0013$), but no significant findings were obtained with ATP values ($P = 0{\cdot}17$).

In most premises, liquid soap was provided for hand washing; however, no soap was available in four premises at the time of the visit. Information on hand drying was obtained in 26 premises with paper being provided in 18 and a reusable towel in 2 premises. In six premises, no means of drying hands was available at the hand washing station. In 13 premises, the efficiency of hand washing was determined by measuring the ATP count before and after washing. A reduction of 80% or more (Bennion 2004) was judged to be satisfactory. Comparison of the results with the appearance of wash-hand basins suggested that the staff in premises where basins were used infrequently, e.g. dry or obstructed, were less likely to achieve good hand washing when specifically asked to do so (5/7 failed to wash hands successfully if the basins were not used and 4/6 achieved the 80% reduction if there was evidence that the basin was frequently used). Basins that showed evidence of use also had lower counts when compared with those that appeared not to have been used (Table 4).

Seventeen refrigerator door handles or recesses were sampled, of which 13 were recorded as having a dirty appearance and 4 were judged to be clean. Comparatively higher results were obtained from ATP testing than from microbiology sampling, suggesting that contamination with food materials via hands was common. The median counts for dirty sites were 156 CFU and 3761 RLU with 100 CFU and 2447 RLU being obtained from clean sites (all counts per cm^2; Table 5).

Overall statistical analysis showed a significant correlation between aerobic colony counts and ATP values for samples taken from cutting boards ($P < 0{\cdot}0001$), from plastic food containers ($P < 0{\cdot}0001$) and from taps ($P = 0{\cdot}0099$). No significant link, however, was found between results on door handles ($P = 0{\cdot}88$).

Table 4 Comparison of ATP and microbiological results from taps on wash-hand basins based on the appearance and on evidence of use

	ATP (RLU cm^{-2})*		Colony count (CFU cm^{-2})		*Escherichia coli*	
Condition (number tested)	Range	Median	Range	Median	Present (%)	Count (CFU cm^{-2})
Taps visually clean (19)	62–24 508	494	<2–7111	44	1 (5·3)	2
Taps visually dirty (16)	30–98 628	945	<2–844 444	7277	0	
Evidence of use of basin†						
Yes (10)	75–14 873	482	<2–25 556	100	0	
No (10)	81–5294	654	<2–101 111	1711	1 (10)	2

*Although not exact in every case an area of 3 cm^2 was assumed for each surface.
†Limited study of 20 wash-hand basins.

Table 5 Comparison of ATP and microbiological results from refrigerator door handles based on the visual appearance of the handles*

Condition (number tested)†	ATP (RLU cm^{-2})		Colony count (CFU cm^{-2})		*Escherichia coli* presence
	Range	Median	Range	Median	
Visually clean (4)	1093–6686	2447	<2–356	100	0
Visually dirty (13)	180–33 279	3761	<2–3111	156	0

*Includes recesses fitted to some doors instead of handles and although not precise in every case an area measuring 3 cm^2 was assumed to have been sampled.

†Appearance of five door handles not recorded at the time of visit.

Bin lids were tested if they were not foot operated and had a lid that was likely to be touched by hands when in use. Five lids were examined (median counts per cm^2 for ATP 1477 RLU and for colony counts 156 CFU). Five samples were taken from microwave controls (median scores per cm^2 of 89 CFU and 9563 RLU). The till pads in three butchers' shops were examined with counts per cm^2 of 1231, 1094 and 778 RLU and 111, 400 and 956 CFU). *Escherichia coli* was not isolated from bin lids, microwave controls or till pads.

Discussion

It is accepted that inspections should be based on risk and should encourage managers or their representatives to identify and control potential food safety hazards in their business. Under European food law, there is a requirement to maintain a clean kitchen environment. One area in which it remains difficult to measure risk is the visual assessment of the cleanliness of surfaces and equipment. The presence of bacteria and/or food material may not always be judged accurately by the naked eye. Tebbutt (1991) found no close link between microbiological examination and visual assessments in restaurants and Moore and Griffith (2002) studied surface hygiene in several food processing environments and concluded that visual assessment seriously underestimates the level of surface contamination.

Although no microbiological standard for food- and hand-contact surfaces exists, there is some evidence to suggest that aerobic colony counts on ready to use, that is supposedly clean, surfaces above 10 CFU cm^{-2} are unsatisfactory (Sagoo *et al.* 2003). Both here and in the study of butcher premises (Griffith *et al.* 2003), ready-to-use surfaces often failed to meet this target. At present we do not know whether the upper limit is set too low for routine use or if cleaning standards are genuinely poor and require greater attention during inspections. By only looking at boards that were clean, dry, had good surface condition and were stored in a rack (seven boards) we did find, however, that a median score of 10 CFU cm^{-2} was achieved. We cannot say what level of contamination, if any, constitutes a health risk; however, there is evidence that potential food pathogens can multiply on surfaces and that surfaces contaminated by pathogens can play an important part in foodborne disease (Holtby *et al.* 1997). The presence of *E. coli*, which is part of the intestinal flora of mammals, suggests cross-contamination by faecal organisms from hands, surfaces or raw foods and is of more immediate concern. Its contamination of cutting boards and plastic food containers, both of which frequently come into contact with ready-to-eat foods and which are stored at kitchen temperatures, allowing bacterial multiplication, suggests an increased safety risk from potential food pathogens.

As we did not test cutting boards immediately after cleaning, we cannot say, for certain, whether or not the actual cleaning methods were adequate, as contamination may have occurred during storage and some boards may have been badly scored and difficult to clean by any of the methods. Our study was based on actual practice such that the boards we tested would have been used without further treatment. When available, we tested boards used for ready-to-eat foods; however, four raw food boards were examined when other types were not available, and these showed considerably higher residual counts. It seems likely that the level of contamination prior to cleaning has a bearing on the end results, and there may be a risk of cross-contamination from raw to other boards if they are not separated properly during storage.

Our results suggested that incorporating an antibacterial agent appeared to improve cleaning efficiency of boards, but using a dishwasher did not. Apart from post-cleaning contamination, other reasons such as the operation (e.g. temperature cycle and cleaning fluid) and maintenance of the dishwasher and the protection of bacteria from heat by food material left on the surface may play a part. Further work is needed to look at this key stage in the cleaning process particularly, as most equipment that can be put into a dishwasher is cleaned in this way.

Standards for ATP levels are generally set after trials to determine what levels can be achieved by routine cleaning. In this way, a reclean can be carried out immediately

if the set level is exceeded. A figure of 500 RLU per 10 cm^2 or less has been suggested as an achievable level. In this study, setting such a low level would result in a high failure rate. For example, 75% of visually clean and ready-to-use cutting boards would have failed (median score 8273 RLU). Indeed, the majority of visually clean surfaces studied here would have failed, and we need to ask whether this is a realistic standard outside of larger food processors and whether or not its application would promote greater safety for the customer.

Although a close relationship between ATP and microbiological results might not be expected as bacterial ATP usually contributes only a small fraction of the total ATP measured, this study does suggest that food debris and bacteria go hand in hand on a number of different surfaces. The exception was refrigerator door handles where proportionately higher ATP values were found. Although this may be a genuine difference, the small sample size might be an important factor in these results. On the whole, we found that microbiology provided a clearer distinction than ATP (e.g. see median results in Table 1). This is offset, however, by the speed of ATP testing and benefits of identifying potential problems at the time of the inspection.

In this study, we have tried to assess what value surface testing adds to routine inspections and whether or not the additional cost might be offset by the benefit gained. Although we cannot know whether better cleaning is linked to a reduction in safety risk, the results for cutting boards, a surface that comes into frequent contact with ready-to-eat foods, suggest that sampling might be worthwhile. We accept that in practice, sampling obviously dirty surfaces, particularly those with food debris on them, is not worthwhile. Some staining on cutting boards, however, is common and not always an indication that sampling is not worthwhile.

Surprisingly staff did not always wash their hands well, even when asked specifically to do so. We noticed that staff rarely washed their hands during the course of their work, and those who did so were more likely to rinse the hands rather then wash them. Facilities for hand washing varied considerably and the absence of soap, hot water and means of drying hands are clearly a big disincentive to effective hand washing. In this study, the number of hand samples taken was small, and further work both to observe hand washing practice and to check ATP counts before and after washing would be worthwhile, particularly as hands are so important in cross-contamination. It should be stressed that ATP measurements must be ade immediately after washing and that random testing is not helpful, as natural shedding of both skin cells and ATP will vary from person to person.

Overall, this small study has highlighted that cleaning in small food businesses is often inadequate. We found that rapid ATP testing was a valuable and immediate teaching aid, and poor microbiological results, albeit 48 h after the inspection, were helpful to environmental health officers in follow-up visits. Clearly, it is not possible to apply an ATP target of 500 RLU, as has been successful in large manufacturing businesses, and further work is needed to determine whether or not a cleaning standard could be applied as part of local authority inspections. It is concluded that additional sampling is useful, particularly as not all surfaces that appear visibly clean are clean when tested for either ATP or micro-organisms.

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