J. Hyg., Camb. (1970), **68**, 221
Printed in Great Britain

Comparison of materials used for cleaning equipment in retail food premises, and of two methods for the enumeration of bacteria on cleaned equipment and work surfaces

By R. J. GILBERT

Food Hygiene Laboratory, Central Public Health Laboratory, Colindale Avenue, London, N.W. 9

(*Received* 12 *December* 1969)

SUMMARY

There is no official scheme for testing disinfectants and detergent/disinfectants for use in the retail food trade and few recommended procedures have been given for the cleaning of equipment with these agents. Therefore, field trials were carried out in a large self-service store. Comparisons were made of the various cleaning efficiencies, as determined by bacterial plate counts, of detergent and disinfectant solutions and machine cleaning oils applied with either clean cloths or disposable paper towels to items of equipment. The most satisfactory results were always obtained when anionic detergent (0·75 % w/v) and hypochlorite (200 p.p.m. available chlorine) solutions were applied in a 'two-step' procedure.

Tests were made to compare the calcium alginate swab-rinse and the agar sausage (Agaroid) techniques for the enumeration of bacteria on stainless steel, plastic, formica and wooden surfaces before and after a cleaning process. Although recovery rates were always greater by the swab-rinse technique, the agar sausage technique was considered to be a useful routine control method for surface sampling.

INTRODUCTION

In the report of the Aberdeen typhoid outbreak (Report, 1964) it was suggested that some form of testing scheme for the various bactericidal detergents intended for use in shops and food premises was desirable. Such a scheme might be similar to that already operated for disinfectants and detergent/disinfectants used in the dairy industry. It is possible to support these comments but still appreciate that government advisors and the manufacturers of disinfectants would find it difficult though not impossible to design a suitable test method.

The Hoy Can Test (Hoy & Clegg, 1953; Clegg, 1955) forms part of the procedure by which all disinfectants and detergent/disinfectants (often referred to as detergent/sterilizers) for use in the dairy industry are examined. The disadvantages of the Hoy Can Test, which arise from the rather complicated nature of the test and the cumbersome equipment used, led Lisboa (1959) to develop a method in which the 10 gal. (Hoy & Clegg, 1953) or 5 gal. (Cousins, Hoy & Clegg, 1960) milk cans were replaced by stainless steel tubes. In their present form the Hoy Can and Lisboa Tube Tests do not appear to have been employed for evaluating disin-

fectants and detergent/disinfectants for use in the retail food trade. However, attempts could be made to modify this type of test to make it more applicable, i.e. to make the conditions of the test simulate those encountered in practice in food establishments. Although such a testing scheme is desirable for the approval of disinfectants it is also necessary to have actual 'field-tests' on retail premises to determine the suitability of the material.

Part I of this paper describes a comparative assessment, based on bacteriological tests only, of some types or combinations of detergents, disinfectants and detergent/disinfectants for cleaning items of equipment in retail food premises. Most disinfectants and detergent/disinfectants used in the retail food trade contain compounds which release chlorine or quaternary ammonium compounds. There are numerous products on the market with activity based on these two compounds; representative types only were tested.

After the cleaning and disinfection of equipment and surfaces it is necessary to have a simple method of assessing the efficiency of the procedures. A visual inspection is always useful and Brookes & Fennell (1952) developed a powder-dusting technique which was easy to apply and indicated the presence of grease or film on eating utensils. They claimed that the powder-dusting technique gave better control of dish-washing and a more sensitive differentiation of the performance of detergents than would be possible by bacteriological tests. Nevertheless, the powder-dusting technique does not appear to have been widely used.

The various techniques for the microbiological examination of surfaces have been reviewed by Favero *et al.* (1968). The basic methods can be classified as follows: (i) the swab-rinse technique; (ii) rinse-tests; (iii) agar contact methods; and (iv) direct counts from surface agar plating. Other modifications of these methods have been described in the literature. In this country the swab-rinse technique using cotton wool or calcium alginate swabs and an agar contact method using 'agar sausages' (Agaroid, Oxoid Ltd, London, S.W. 1) are commonly employed. A short comparative study of the enumeration of bacteria on surfaces by these two methods is given in Part II of this paper.

PART I

Comparison of various agents used for cleaning equipment in retail food premises

All tests were made at one large modern self-service store by arrangement with the directors of the company and the manager. The store was clean and well organized and the staff had been given instruction on hygienic methods of food handling. Twenty-four visits were made over the period March–September 1968, usually at weekly intervals.

Duplicate areas (each 30 cm.^{2}) from the upper and lower surfaces of the blade of a cooked-meat slicing machine were swabbed using two calcium alginate swabs/area (Higgins, 1950): the technique used has been described previously (Gilbert & Maurer, 1968). The same technique was used for swabbing one side of a large carving knife blade (80 cm.^{2}) and a bench mounted can-opener (1 cm.^{2}

blade and about 4 cm.^{2} area above the blade). Four swabs were used for the carving knife and two for the can-opener. Inactivating agents were added to the quarter-strength Ringer's solution used as diluent, 0·5 % w/v sodium thiosulphate when the cleaning agents contained 200 parts per million (p.p.m.) of available chlorine, and 0·5 % v/v Tween 80 (a sorbitan mono-oleate) when the cleaning agent contained a quaternary ammonium compound. Sodium thiosulphate was

Table 1. *The types and concentrations of detergent, disinfectant, detergent/disinfectants and machine cleaning oils used, and times taken to complete the cleaning procedure*

Code*	Cleaning agent used: Type	Cleaning agent used: Concentration	Applied with	Time for cleaning (min.)
A	Detergent (anionic)	0·75 % w/v	Clean cloth	9–10‡
B	Disinfectant (hypochlorite)	200 p.p.m.†	Clean cloth	9–10‡
C	Detergent (anionic)/disinfectant (chlorinated trisodium phosphate)	0·75 % w/v 20 p.p.m.†	Clean cloth	9–10‡
D	Detergent (anionic)/disinfectant (chlorinated trisodium phosphate)	0·75 % w/v 20 p.p.m.†	Paper towel	9–10‡
E	Detergent (anionic) followed by disinfectant (hypochlorite)	0·75 % w/v, 200 p.p.m.†	Paper towel	12–13‡
F	Detergent (non-ionic)/disinfectant (quaternary ammonium compound)	0·6 % v/v	Clean cloth	9–10‡
	Machine cleaning oil (*X*)	Undiluted	Paper towel	2 §
	Machine cleaning oil (*Y*)	Undiluted	Paper towel	2 §

* The code letters A–F refer to the lettered columns in Figs. 1 and 2.

† p.p.m. = parts per million of available chlorine.

‡ These times include the filling of buckets with hot water, the stripping, cleaning, rinsing and reassembly of the slicing machine, and the cleaning and rinsing of the carving knife and can-opener.

§ These times refer only to the cleaning of the upper and lower surfaces of the cutting blade of the slicing machine.

not added to the diluent when the cleaning solution used contained only 20 p.p.m. of available chlorine. All plate counts were made on blood agar using a modified Miles & Misra (1938) technique with incubation for 48 hr. at 22 and 37° C.

The cleaning techniques used in the present study were described by Gilbert & Maurer (1968). Experiments were made with 'single-step' procedures using detergent, disinfectant or detergent/disinfectant solutions alone, and with a 'two-step' procedure using detergent solution followed by disinfectant solution. The effects of several detergents and disinfectants used together or separately (Table 1), applied either with disposable paper towels or freshly cleaned and disinfected cloths, were tested on each of four separate occasions.

Some manufacturers of slicing machines recommend the use of certain vegetable

oils for the regular cleaning of their machines; such oils will also act as lubricants. An assessment of two oils (Table 1, *X* and *Y*) was made to determine whether, when applied with disposable paper towels, they were as efficient in a cleansing procedure as detergent, disinfectant or detergent/disinfectant solutions.

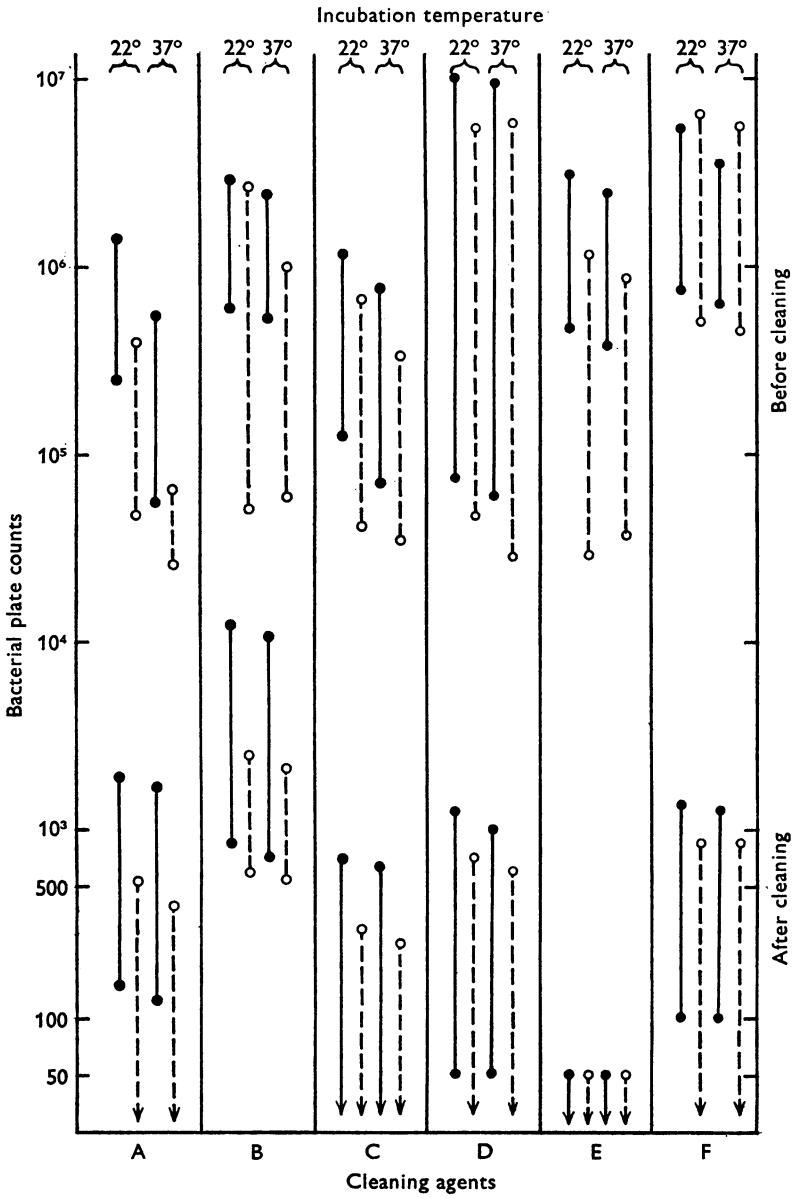

Fig. 1. Range of bacterial plate counts at 22 and 37° C. from swabbed areas of upper and lower surfaces of a slicing machine blade, before and after cleaning. ●——● = Upper surface of blade; ○- - -○ lower surface. A–F, different cleaning agents used. For explanation see Table 1.

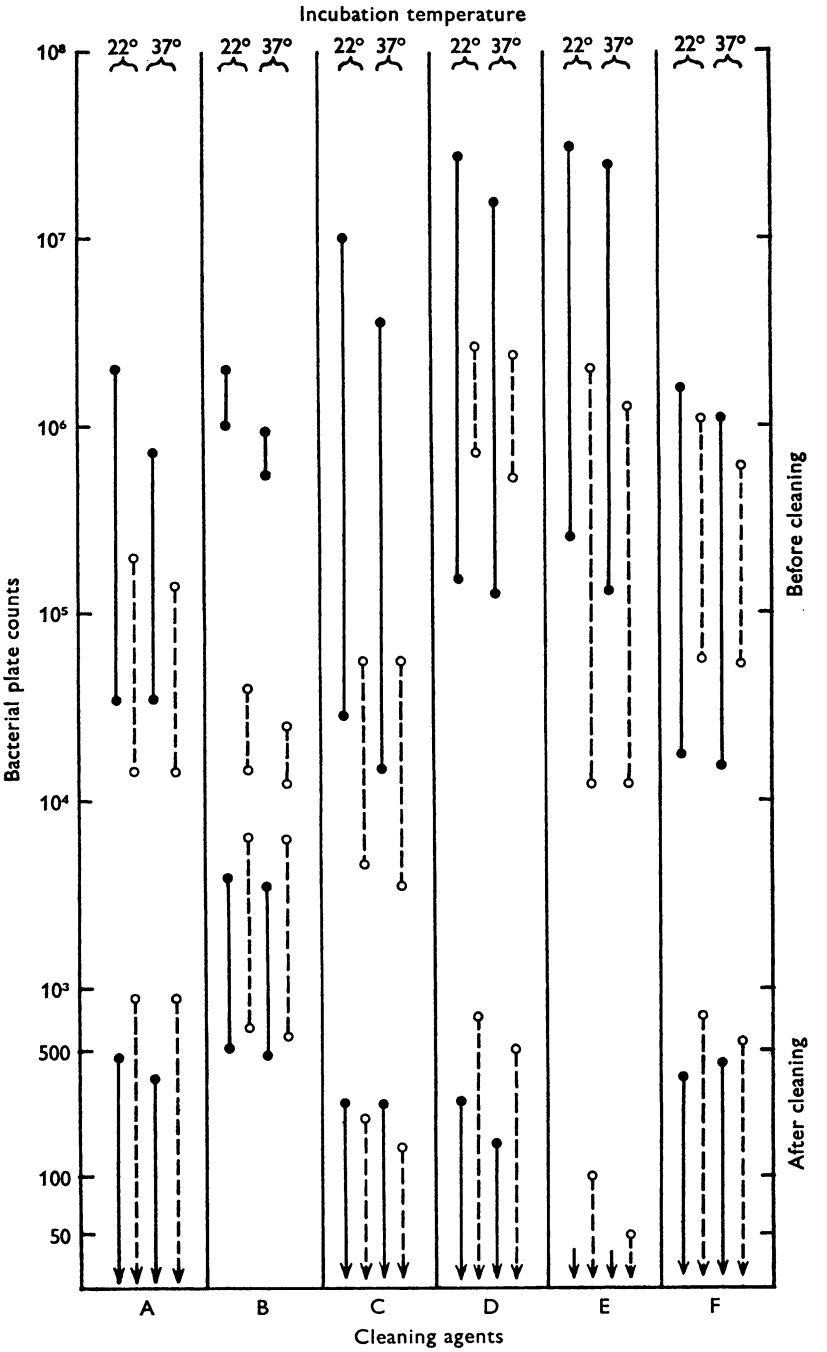

Fig. 2. Range of bacterial plate counts at 22 and 37° C. from swabbed areas of a carving knife blade and a can-opener, before and after cleaning. ●——● = Carving knife blade; ○- - -○ = can-opener. A–F, different cleaning agents used. For explanation see Table 1.

RESULTS

It is more difficult to standardize field-tests on cleaning and disinfecting agents than *in vitro* tests carried out in a laboratory. Reasonable care was taken to standardize the conditions in the self-service store and tests were replicated whenever possible. The items tested had all been cleaned at about 5 p.m. on the previous day by the staff normally responsible, and they had been in use for at least 3 hr. on the day when tests were made. The number of cooked and canned meats cut on the slicing machine before test areas were sampled was in the range of 17–25 (mean 20)/visit: the most popular products sliced on the machine were ham, pork

Table 2. *Experiments with machine cleaning oils*

(Bacterial plate counts at 22 and 37° C. from swabbed areas of slicing machine blades before and after cleaning.)

		Plate counts/swabbed area					
				After cleaning with oil			
		Before cleaning		*X*		*Y*	
Object swabbed	Expt.	22° C.	37° C.	22° C.	37° C.	22° C.	37° C.
Upper surface of blade	1	162,000	87,500	6625	4750	N.D.	N.D.
	2	250,000	56,250	17,500	11,250	N.D.	N.D.
	3	125,000	70,000	N.D.	N.D.	3750	2250
	4	225,000	210,000	N.D.	N.D.	40,000	25,000
Lower surface of blade	1	525,000	362,000	41,250	23,750	N.D.	N.D.
	2	120,000	36,250	26,250	20,000	N.D.	N.D.
	3	60,000	35,000	N.D.	N.D.	4750	3250
	4	400,000	65,000	N.D.	N.D.	5500	2500

Machine cleaning oils *X* and *Y* applied with disposable paper towels.
N.D. = not done.

luncheon meat, corned beef, jellied veal, ox tongue, savoury sausage, liver sausage, continental sausage and salami. The can-opener had been used for opening many cans of meat and the carving knife for cutting or slicing various types of savoury, liver or continental sausage and salami.

Fig. 1 shows the range of plate counts from swabbed areas of the slicing machine after normal use and after treatment with solutions of the cleaning and disinfecting agents applied with clean cloths or paper towels. Each count represents the mean from duplicate swabbed areas. Counts were usually higher after incubation at 22° C. than at 37° C. After incubation, plates were examined to ascertain the types of bacteria present. Before cleaning, micrococci, coliform and aerobic sporing bacilli were usually found and, on several occasions, α-haemolytic and non-haemolytic streptococci, *Klebsiella* spp. and *Proteus* spp. were also isolated. No effort was made to isolate salmonellas as it is unusual to find these organisms in cooked or canned meats, but on two occasions coagulase-positive staphylococci were found.

The viable counts were greatly reduced by all the cleaning procedures. The most satisfactory results, i.e. lowest counts, were obtained when detergent (0·75 % w/v) and disinfectant (hypochlorite, 200 p.p.m. available chlorine) solutions were used in a two-step procedure. The least satisfactory results, i.e. highest counts, were obtained when a solution of disinfectant (hypochlorite, 200 p.p.m. available chlorine) alone was used.

Fig. 2 shows the range of plate counts from swabbed areas of the carving knife and can-opener after normal use and after treatment with solutions of the cleaning and disinfecting agents applied with clean cloths or paper towels. The most satisfactory results were again obtained when detergent (0·75 % w/v) and disinfectant (hypochlorite, 200 p.p.m. available chlorine) solutions were used in a two-step procedure.

Table 2 shows the plate counts from swabbed areas of the slicing machine after normal use and after cleaning with the two machine oils (*X* and *Y*) applied with paper towels. The results show that plate counts after cleaning with *X* or *Y* were often unsatisfactory.

Part II

Comparison of the swab-rinse and agar sausage techniques for assessing the cleanliness of equipment and surfaces in food premises

All tests were made at another large modern self-service store by arrangement with the directors of the company and the manager. The store was clean and well organized and the staff had been given instruction on hygienic methods of food handling. Five visits were made over the period September 1968–May 1969 at *ca.* 2 monthly intervals; a Senior Public Health Inspector was present on each occasion.

Three areas of a slicing machine (upper and lower surfaces of the stainless steel blade and the blade cover), a large stainless steel carving knife, a plastic display dish, a formica working surface and a wooden chopping table were selected for the tests. They were all in the area used for the preparation of cooked meats except the wooden chopping table, which, although near this preparation area, was used exclusively for the cutting and boning of raw meat. The equipment and surfaces were cleaned with a combined anionic detergent/disinfectant (20 p.p.m. available chlorine) solution and tests were made both before and after cleaning.

Four areas (each about 8 cm.^{2}) were tested using the agar sausage technique with plate count and MacConkey Agaroid sausages. The use of slices of agar medium cut from an agar sausage to grow bacteria from surfaces was first described by Ten Cate (1963, 1965). The areas within two metal templates (each about 8 cm.^{2}, i.e. similar in area to the surface of a slice from an agar sausage) were also tested, using the calcium alginate swab-rinse technique with surface plating on blood agar (Higgins, 1950) as described previously (Gilbert & Maurer, 1968). The swab-rinse technique was carried out by the author and the agar sausage technique by the Public Health Inspector. Randomly selected areas in close proximity to each other were sampled at the same time. The blood agar plates and the plate count and MacConkey Agaroid slices were incubated for 24 hr. at 37° C.

Table 3. *Comparison of the swab-rinse and agar sausage (Agaroid) techniques*

(Bacterial counts at 37° C. from test areas of shop equipment before and after cleaning.)

		Counts/test area				
		Before cleaning*	After cleaning			
				Agar sausage technique		
Object	Visit	Swab-rinse technique† B.A.	Swab-rinse technique† B.A. (P)	P.C.A.‡ (Q)	MacC.A.‡	Column (P) / Column (Q)
Slicing	1	105,000	800	85	80	9·4
machine	2	475,000	860	> 100	> 100	< 8·6
blade.	3	225,000	112	19	21	5·9
Upper	4	875	< 25	2	2	< 12·5
surface	5	1,037,000	50	6	5	8·3
Slicing	1	132,000	235	16	18	14·7
machine	2	900,000	150	13	18	11·5
blade.	3	200,000	187	17	19	11·0
Lower	4	4,250	< 25	4	3	< 6·2
surface	5	275,000	75	12	12	6·2
Slicing	1	3,250	240	16	17	15·0
machine.	2	8,750	75	24	33	3·1
Blade	3	20,000	25	4	4	6·2
cover	4	500	25	4	3	6·2
	5	22,500	< 25	2	2	< 12·5
Carving	1	15,000	200	39	28	5·1
knife	2	102,500	200	24	23	8·3
	3	5,000,000	25	4	2	6·2
	4	362,500	< 25	4	3	< 6·2
	5	4,000	25	3	2	8·3
Plastic	1	2,500	50	8	5	6·2
dish	2	62,500	30	4	4	7·5
	3	312,500	25	3	3	8·3
	4	36,250	< 25	2	2	< 12.5
	5	17,000	25	3	4	8·3
Formica	1	1,250	50	7	5	7·1
working	2	250	75	6	8	12·5
surface	3	37,500	25	8	9	3·1
	4	1,750	< 25	2	2	< 12·5
	5	2,500	25	2	2	12·5
Wooden	1	287,500	3,750	> 100	> 100	< 37·5
chopping	2	362,500	35,000	> 100	> 100	< 350·0
table	3	3,250,000	45,000	> 100	> 100	< 450·0
	4	7,500	875	20	24	43·7
	5	125,000	10,750	> 100	> 100	< 107·5

* Counts before cleaning were all uncountable (> 100) by the agar sausage technique except that from slicing machine blade cover on MacConkey agar at visit 4 (80/test area), and from formica working surface on both media at visit 2 (18/test area).

† Mean of two counts, two swabs/count.

‡ Mean from two Agaroid slices.

B.A. = blood agar; P.C.A. = plate count agar (Agaroid); MacC.A. = MacConkey agar (Agaroid).

RESULTS

Table 3 shows bacterial counts from areas of equipment and surfaces both before and after cleaning. The number of bacteria present on the stainless steel, plastic and formica surfaces was greatly reduced by the cleaning procedure, but the results for the wooden surface were far less satisfactory, as would be expected. Dilutions could be made from the rinse solutions so that viable counts were readily calculated by the swab-rinse technique. One direct count only was obtained from an agar slice and it was difficult to count > 100 colonies/slice. As a result it was usually impossible to calculate the factors by which the swab-rinse and agar sausage counts differed before cleaning, since the number of colonies on the Agaroid slices were too numerous to count. However, such factors could be calculated from the results of many of the tests carried out after cleaning. For the stainless steel surface of the blade and cover of the slicing machine, the stainless steel carving knife, the plastic display dish and the formica working surface the factors by which counts by the swab-rinse technique exceeded those by the agar sausage technique were within the range 3·1–15·0; it was usually impossible to calculate the factors for the wooden chopping table. Furthermore, differences noted were subject to the recovery media which were different for the two techniques, viz. blood agar for the swab-rinse technique and plate count agar for the agar sausage technique.

DISCUSSION

An assessment of the activities of surface active agents for use in the catering industry has been given by Hobbs, Emberley, Pryor & Smith (1960) and a description of the use of disinfectants in the food industry by Goldenberg & Relf (1967).

The choice of detergents and detergent/disinfectants for use in the retail food trade should be governed by the following factors: (*a*) they must be efficient under the conditions of use, e.g. the removal of protein and fatty material associated with meat and other food products; (*b*) they must not affect those who use them; (*c*) they must not damage or corrode equipment or working surfaces; (*d*) they must not affect the colour or flavour of food in contact with equipment and surfaces cleaned by their use; (*e*) they must be easily rinsed away; (*f*) they must be easy and safe to dispense and handle and (*g*) they must be compatible if mixed.

At the present time there seems to be no limit to the number of detergents, disinfectants and detergent/disinfectants commercially available. Instructions on the label for the use of these products are usually both clear and concise but all too often not enough consideration is given by the user to the choice of a suitable product for a particular purpose. For example, many retail premises are known to be using hypochlorite solutions without a detergent to clean equipment and working surfaces. It is imperative that workers in retail food premises should appreciate that in order to achieve cleanliness and freedom from bacteria it is not sufficient to 'disinfect' by the use of disinfectants alone; visible grease and food material must be removed by scraping and scrubbing or thorough washing with hot water containing detergent or soap. Suggested cleaning routines for surfaces, equipment (including slicing machines) and utensils in the retail meat trade have

been published recently (Food Hygiene Code of Practice, no. 8, 1969). Any disinfection procedure, e.g. with hypochlorite, should include or follow a cleaning process, and the use of combined detergent/disinfectants has become popular in retail food premises and catering establishments. The main advantage of such products is that the time taken to complete the cleaning and disinfection process is considerably reduced; the main disadvantage is that some of the disinfectant action will be rapidly lost owing to inactivation by food material. The applications of detergent/disinfectant mixtures together with their advantages and disadvantages have been reviewed by Davis (1968). In the time available it was possible to test only a few of the cleaning and disinfecting agents commercially available, but at least three of the five tested have been or are used by large retail food organizations.

The results from Part I of this paper were not altogether surprising. The use of a disinfectant solution alone (Figs 1 and 2) gave rather unsatisfactory results. The use of a detergent solution alone gave somewhat better results, no doubt due to the removal of many of the bacteria present by the physical action of the detergent. The combined anionic detergent/disinfectant (20 p.p.m. available chlorine) solutions applied with clean cloths or disposable paper towels gave results only marginally better than detergent solutions alone. The use of disposable paper is to be preferred as the risk of cross-contamination will be greatly reduced (Gilbert, 1969). The use of a non-ionic detergent combined with a cationic disinfectant gave similar results to those obtained after using an anionic detergent solution. For the three items tested, slicing machine, carving knife and can-opener, the most satisfactory results were always obtained when an anionic detergent solution and a disinfectant solution (hypochlorite, 200 p.p.m. available chlorine) were used in a two-step procedure.

The use of the two vegetable oils for cleaning the slicing machine blade gave unsatisfactory results (Table 2) and this method of cleaning cannot be recommended.

The effectiveness of any cleaning method depends not only on the cleaning agent used but also on its being used regularly and intelligently. Some examples of cross-contamination by dirty equipment have been described previously (Gilbert, 1969) and so it is also important that the need for regular and effective cleaning should be understood.

The detection and enumeration of micro-organisms on equipment, utensils and working surfaces has attracted the attention of many microbiologists in recent years. The information so gained has been useful in comparative studies of microbiological cleanliness, e.g. for assessing cleaning procedures and for distinguishing 'cleaner' from 'dirtier' objects or areas. Numerous papers from the milk and food industries, from hospitals, and more recently from the aerospace industry have been published: general information on the various techniques available has been given by Walter (1955), Fincher (1965), Favero *et al.* (1968) and Schaeffer (1968). Many investigators have carried out comparative tests on two or more of the methods for surface sampling; the reports of Angelotti, Foter, Busch & Lewis (1958) and Mossel, Kampelmacher & van Noorle Jansen (1966) are noteworthy.

Mossel *et al.* (1966) reported that for counts of *Enterobacteriaceae* on wooden surfaces, a swab-rinse technique with calcium alginate swabs gave results greater by a factor of about 10 than those given by an agar sausage technique; the recovery medium for both techniques was crystal violet neutral red bile glucose agar. Riddle (1967) reported a geometric mean figure of 18 (range 3-286) for this factor when a swab-rinse technique with cotton wool swabs and an agar sausage technique were used for comparative counts on carcasses in bacon factories. The explanation for the observed differences between counts given in the present study by the two techniques is three-fold. (*a*) Compared to the agar sausage technique, the swab-rinse technique is more likely to receive bacteria lodged in microscopic fissures, surface irregularities or deposited on surfaces in dried films. (*b*) Compared to the agar sausage technique, the swab-rinse technique is likely to break up clumps or chains of bacteria when the rinse solution is shaken to dissolve the swabs. It is therefore more likely to measure individual bacterial cells/area tested than the agar sausage technique which provides a mirror image picture of the distribution of bacteria whether they are clumped or not. (*c*) Blood agar used as a recovery medium from the swab-rinse dilutions is a better non-selective growth medium than the plate count and MacConkey agars used for the agar sausages.

The agar sausage technique has been recommended for investigations by Public Health Inspectors (Greig, 1966; Eade, 1968) and as a routine control method for use in the food industry (Goldenberg & Relf, 1967; Riddle, 1967). A comprehensive list of references to uses of the technique has been given by Bridson (1969). It is a valuable visual-aid for the instruction of food handlers since it provides a simple pictorial demonstration of the presence of bacteria on a wide variety of surfaces and might encourage the more efficient cleaning of equipment. The simplicity, speed and economy of the technique together with its applicability in numerous situations make it a most useful routine control method for the relative day-to-day sampling of surfaces. The relatively low recovery rates given by this method in comparison with other techniques must be recognized and practical experience in the interpretations of results is necessary.

It is a pleasure to record my thanks to Dr Betty C. Hobbs and Dr J. C. Kelsey for their advice and constructive criticisms. I am also very grateful to Mr R. T. Govett, Senior Public Health Inspector of the London Borough of Harrow for his helpful and practical assistance. Such a project would not have been possible without the full co-operation of the directors, management and staff of the two self-service stores.

REFERENCES

Angelotti, R., Foter, M. J., Busch, K. A. & Lewis, K. H. (1958). A comparative evaluation of methods for determining the bacterial contamination of surfaces. *Food Research* **23**, 175.

Bridson, E. Y. (1969). Isolation of surface micro-organisms with the agar slice technique (agar sausage). In *Isolation Methods for Microbiologists*. Eds. D. A. Shapton and G. W. Gould. London: Academic Press.

Brookes, F. C. & Fennell, H. (1952). A powder-dusting test for the control of dish-washing and the comparison of detergents. *Monthly Bulletin of the Ministry of Health and Public Health Laboratory Service* **11**, 264.

CLEGG, L. F. L. (1955). Laboratory and field evaluation of chemical sterilizers for dairy farms. *Journal of Applied Bacteriology* **18**, 358.

COUSINS, C. M., HOY, W. A. & CLEGG, L. F. L. (1960). The evaluation of surface active disinfectants for use in milk production. *Journal of Applied Bacteriology* **23**, 359.

DAVIS, J. G. (1968). Chemical sterilization. In *Progress in Industrial Microbiology* **8**, Ed. D. J. D. Hockenhull. London: J. & A. Churchill Ltd.

EADE, S. A. (1968). An investigation into the efficiency of cleansing processes used in kitchens. *Public Health Inspector* **76**, 407.

FAVERO, M. S., MCDADE, J. J., ROBERTSEN, J. A., HOFFMAN, R. K. & EDWARDS, R. W. (1968). Microbiological sampling of surfaces. *Journal of Applied Bacteriology* **31**, 336.

FINCHER, E. L. (1965). Surface sampling for bacteria. Reprint no. 59, Biophysics Section, National Communicable Disease Center, Atlanta, Georgia, U.S.A.

FOOD HYGIENE CODE OF PRACTICE, no. 8 (1969). *Hygiene in the Meat Trades*. London: H.M.S.O.

GILBERT, R. J. (1969). Cross-contamination by cooked-meat slicing machines and cleaning cloths. *Journal of Hygiene* **67**, 249.

GILBERT, R. J. & MAURER, I. M. (1968). The hygiene of slicing machines, carving knives and can-openers. *Journal of Hygiene* **66**, 439.

GOLDENBERG, N. & RELF, C. J. (1967). Use of disinfectants in the food industry. *Journal of Applied Bacteriology* **30**, 141.

GREIG, J. R. (1966). An improved method of surface bacteriological sampling in food premises. *Public Health Inspector* **75**, 170.

HIGGINS, M. (1950). A comparison of the recovery rates of organisms from cotton-wool and calcium alginate swabs. *Monthly Bulletin of the Ministry of Health and Public Health Laboratory Service* **9**, 50.

HOBBS, B. C., EMBERLEY, N., PRYOR, H. M. & SMITH, M. E. (1960). The assessment of the activities of surface active agents for use in the catering industry. *Journal of Applied Bacteriology* **23**, 350.

HOY, W. A. & CLEGG, L. F. L. (1953). Testing farm detergent-sterilizers using soiled ten gallon cans. *Proceedings of the Society for Applied Bacteriology* **16**, i.

LISBOA, N. P. (1959). A tube test for evaluating agents possessing both detergent and sterilizing properties. *Proceedings of the* 15th *International Dairy Congress, London* **3**, 1816.

MILES, A. A. & MISRA, S. S. (1938). The estimation of the bactericidal power of the blood. *Journal of Hygiene* **38**, 732.

MOSSEL, D. A., KAMPELMACHER, E. H. & VAN NOORLE JANSEN, L. M. (1966). Verification of adequate sanitation of wooden surfaces used in meat and poultry processing. *Zentralblatt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene*, I. Abt. orig. **201**, 91.

REPORT (1964). *The Aberdeen Typhoid Outbreak*, 1964. Edinburgh: H.M.S.O.

RIDDLE, W. (1967). The agar sausage technique and its use as a routine bacteriological control measure in food factories. *Technical Circular no.* 372, *British Food Manufacturing Industries Research Association*, Leatherhead, Surrey.

SCHAEFFER, R. L. (1968). Practical aspects of surface sampling. *Hospitals* **42**, 94.

TEN CATE, L. (1963). Eine einfache und schnelle bakteriologische Betriebskontrolle in Fleisch verarbeitenden Betrieben mittels Agar-Würsten in Rilsan-Kunstdarm. *Fleischwirtschaft* **15**, 483.

TEN CATE, L. (1965). A note on a simple method of bacteriological sampling by means of agar sausages. *Journal of Applied Bacteriology* **28**, 221.

WALTER, W. G. (1955). Symposium on methods for determining bacterial contamination on surfaces. *Bacteriological Reviews* **19**, 284.