An evaluation of the efficiency of cleaning methods in a bacon factory

By J. F. DEMPSTER

*Animal Sciences Division, Agricultural Institute,
Dunsinea, Castleknock, Co. Dublin*

SUMMARY

The germicidal efficiencies of hot water (140–150° F.) under pressure (method 1), hot water + 2 % (w/v) detergent solution (method 2) and hot water + detergent + 200 p.p.m. solution of available chlorine (method 3) were compared at six sites in a bacon factory. Results indicated that sites 1 and 2 (tiled walls) were satisfactorily cleaned by each method. It was therefore considered more economical to clean such surfaces routinely by method 1. However, this method was much less efficient (31 % survival of micro-organisms) on site 3 (wooden surface) than methods 2 (7 % survival) and 3 (1 % survival). Likewise the remaining sites (dehairing machine, black scraper and table) were least efficiently cleaned by method 1. The most satisfactory results were obtained when these surfaces were treated by method 3.

Pig carcasses were shown to be contaminated by an improperly cleaned black scraper. Repeated cleaning and sterilizing (method 3) of this equipment reduced the contamination on carcasses from about 70 % to less than 10 %.

INTRODUCTION

The standard of hygiene in food processing is most important. As pointed out by Goldenberg (1968), 'there is often a real correlation between the cleanliness of a factory and the quality of its goods'. Properly planned and executed, a cleaning programme forms part of the factory's quality control measures and enhances the product's reputation by helping to reduce spoilage and cross-contamination by pathogenic micro-organisms. As recently as 1967 opinions were expressed that not enough is known about cleaning and sterilizing materials, and even when the facts are known they are not put into practice (Goldenberg & Relf, 1967). That hygienic control in food processing and distribution is vitally important is made clear from the report of the Aberdeen typhoid outbreak (Report, 1964).

There are available today many types of cleaning and sterilizing materials suitable for use in the food industry (Thomas, 1969). However, efficient cleaning is an expensive operation. It should be the responsibility of the control laboratory to ensure that it is done as efficiently and economically as possible (Dyett, 1963).

The slaughter, butchery and dressing of a bacon pig (Wiltshire process) involves the following stages. The animal is stunned, shackled, and exsanguinated in an

area remote from the remainder of the killing line. The carcass is then immersed in a tank of hot water (c. 140° F.) in which it is scalded. In this tank the surface hairs are softened for subsequent removal in the dehairing machine. After dehairing, the carcass passes into the singeing furnace (c. 1400° F.) for about 15 sec. The burnt skin is removed by a black scraper. This equipment consists of a tunnel in which rotating blades scrape off the charred tissue. After scraping, the carcass is eviscerated, split down the backbone into sides which are chilled overnight before being cured. This whole process results in much debris (blood, skin, hair, etc.) collecting on floors, walls and equipment. The work described in this paper was undertaken to devise a reliable method of cleaning such an area. The germicidal efficiency of a number of cleaning methods was compared at various sites along the killing line. Because of its construction, the black scraper soon builds up hardened residues of skin and hair on the blades unless it is regularly cleaned after use. The scraper was repeatedly cleaned by one of the test methods and the effect of this on the surface bacterial content of carcasses was investigated.

MATERIALS AND METHODS

The following cleaning procedures were selected for comparison: (1) hot water (140–150° F.) high-pressure spray; (2) method 1 followed by brushing with a 2 % (w/v) solution of hydrated sodium silicate at 150–160° F. and rinsing with cold water; (3) method 2 followed by spraying with a working solution of 'Chloros' containing 200 p.p.m. of available chlorine. The stock solution of Chloros contained 12 % active constituent. A working solution was made by adding about 7·5 ml. of stock solution to 1 gal. of cold water. The Chloros was applied with a knapsack sprayer and allowed to act for 20 min. before being rinsed off.

Six areas were chosen for treatment as follows: tiled wall of sticking pen (wall A), tiled wall of bleeding passage (wall B), wooden barrier rail of scalding tank, metal platform of dehairing machine, blades of black scraper and the surface of an evisceration table. These areas were selected because of the build-up of contamination known to occur at these sites. The allocation of cleaning method to area was randomized to prevent bias in favour of any one method. Each area was treated by each method on five separate occasions to give a total of 90 results (6 areas × 3 methods × 5 replications). Each area was swabbed as follows; the tiled walls, dehairer platform and the table were swabbed on two adjacent 100 cm.² areas with a metal template; the rail of the scald tank was swabbed on duplicate areas with a 25 cm.² template; and four adjacent blades of the scraping machine were swabbed with the same 25 cm.² template.

The swabs consisted of cotton gauze wound on $5\frac{1}{2} \times \frac{3}{8}$ in. wooden spatulas. The swabs were transferred to 20 ml. quarter-strength Ringer's solution in Universal bottles and dispatched to the laboratory within 1 hr. Sodium thiosulphate (0·5 %, w/v) was added to the Ringer's solution to inactivate any chlorine carried over when the areas were swabbed after cleaning by method 3. Serial decimal dilutions were prepared in Ringer's solution to which 0·1 % of peptone was added (Straka & Stokes, 1957), plated on Plate Count Agar (Oxoid) and the plates in-

cubated for 5 days at 25° C. The results were expressed as a percentage survival. The F ratio and standard error of the mean percentage survival were calculated.

The effect of cleaning and sterilizing the scraping machine by method 3 on the surface bacterial load of pig carcasses was studied. Observation had shown that the undersides of the scraping blades were heavily contaminated particularly at the point where they are bolted to the horizontal shaft. The most effective method of cleaning was firstly to remove gross dirt with the high-pressure water spray. The detergent was then applied to 6 sets of blades at a time (upper and lower surfaces) with a soft-haired brush. The remaining blades were brought into position in sets of six and treated likewise. After rinsing with cold water, Chloros solution was applied and allowed to act for 20 min. before being rinsed off. Ten carcasses, randomly selected, were examined before and after passage through the scraping machine on two occasions before the machine was cleaned by the test method and on nine occasions after the test method had been introduced. The method used to determine surface contamination was the agar-sausage technique (ten Cate, 1965) The speed of throughput on the killing line precluded the use of the swab-rinse method. The agar sausages consisted of (%, w/v) peptone 1·0; lab-lemco 1·0; NaCl 0·5; agar 2·5 in distilled water and were made by filling 200 ml. of melted medium into 80 cm. lengths (40 mm. diam.) of Nalophane casing (Kalle Aktien Geselleschaft, Weisbaden, Germany). They were sterilized at 121° C. for 15 min. Agar impressions were taken at 10 points on the surface of each carcass and the samples incubated at 25° C. for 3 days. The counts were plotted as a log distribution on probability paper by the method of Hansen (1962) and recorded as the logarithm of the mean count per 10 cm.^{2}. The results were expressed as a percentage survival as before.

<div align="center">RESULTS</div>

The bacterial counts of the six areas before and after cleaning are shown in Tables 1–3.

In Table 1 it is seen that all three cleaning methods produced a satisfactory reduction in numbers of micro-organisms on tiled wall A; 1·32 % of the population survived treatment by method 1 and less than 1 % survived treatment by methods 2 and 3. There was no significant difference between the efficiencies of the last two methods, but there was between these and method 1 ($P < 0.01$). Similarly, all the methods were efficient in cleaning tiled wall B, but no significant difference was found between the different methods on this surface.

Table 2 shows that cleaning by method 1 was grossly inefficient for the rail of the scalding tank (31 % survival). Treatment by methods 2 and 3 resulted in 7 % and 1 % survival respectively. The metal platform of the dehairer likewise was least efficiently cleaned by method 1; there was no significant difference between methods 2 and 3 for this surface.

Table 3 shows that there was a highly significant difference between methods 2 or 3 and method 1 for the cleaning of the scraping machine ($P < 0.001$). Of the population 35 % survived treatment by method 1 whereas 9 % and 3 % respectively survived after cleaning by methods 2 and 3. In this instance the

action of the hot water/detergent/sterilizer (method 3) would not be efficient. Cavett (1969) considered that an effective sanitizer was one which when tested at half user concentration reduced the microbial population by 99·9–99·99 % (i.e. 3–4 log. cycles) in 10 min. The present results may have been partly due to the very poor condition of this equipment at the beginning of the experiment. A

Table 1. *Total plate counts at 25° C. from swabbed areas of tiled walls before and after cleaning*

	Site swabbed					
	Tiled wall A			Tiled wall B		
	Count/cm.^{2}			Count/cm.^{2}		
Cleaning method	Before cleaning	After cleaning	Survival (%)	Before cleaning	After cleaning	Survival (%)
1	13,080	170	1·29	7,570	22	0·28
	113,000	888	0·78	16,080	191	1·18
	27,900	729	2·61	96,700	15	0·01
	39,800	219	0·55	48,290	30	0·06
	22,400	308	1·37	399,000	46	0·011
			1·32†			0·308†
2	197,600	284	0·14	5,880	7	0·11
	58,800	42	0·07	22,000	440	2·00
	165,000	10	0·006	10,800	2	0·01
	192,000	1,860	0·96	1,740	1	0·05
	188,800	17	0·009	644,000	5,200	0·80
			0·237†			0·594†
3	25,000	24	0·09	11,790	11	0·09
	85,000	402	0·47	3,800	24	0·63
	900,000	1,020	0·11	33,300	40	0·12
	373,000	350	0·094	11,280	32	0·28
	596,000	6	0·001	83,300	2	0·002
			0·153†			0·224†

$F = 7·58$** $(P < 0·01)$.　　　　　　　　　　　$F = 0·54$ (N.S.)
s.e. of mean % survival $= 0·236$.　　　　　　　s.e. $= 0·262$.

† Mean.

similar result was obtained for the surface of the evisceration table. Sixteen, 5 and 2 % of organisms survived after treatment by methods 1, 2 and 3 respectively, although no significant difference was found between methods 2 and 3 $(P < 0·01)$ (Table 3).

In Fig. 1 are shown the results of cleaning and sterilizing the black scraper by method 3 on the bacterial content of pig carcasses. Before cleaning the scraper by this method, the number of surface organisms on carcasses was about 70 % of the number present on the carcasses after dehairing. Repeated sterilizing of the scraping blades during a 4-week period reduced the contamination to less than 10 %.

Table 2. *Total plate counts at 25° C. from swabbed areas of scalding tank rail and dehairer platform*

	Site swabbed					
	Scald tank rail			Dehairer platform		
	Count/cm.^{2}			Count/cm.^{2}		
Cleaning method	Before cleaning	After cleaning	Survival (%)	Before cleaning	After cleaning	Survival (%)
1	4,020	1,040	25·87	284,400	860	0·30
	1,353	538	39·70	88,400	2,100	2·37
	48,000	2,980	6·20	151,800	4,580	3·01
	21,030	4,020	19·11	249,800	13,456	5·38
	39,600	25,000	63·11	93,573	7,904	8·44
			30·802†			3·90†
2	39,490	31	0·07	536,000	10,400	1·94
	3,450	449	13·02	177,200	3,540	1·99
	350	1	0·28	9,360	72	0·76
	1,490	22	1·48	57,600	144	0·25
	232	44	18·96	198,400	1,847	0·92
			6·76†			1·172†
3	2,310	32	1·389	124,000	392	0·31
	3,800	31	0·82	82,400	144	0·17
	8,550	4	0·04	360,000	24	0·006
	3,020	75	2·48	272,000	19	0·006
	65,800	156	0·237	130,400	1,931	1·48
			0·993†			0·396†

$F = 6·83^*$ $(P < 0·05)$ $F = 4·75^*$ $(P < 0·05)$

s.e. = 6·05   s.e. = 0·844.

† Mean.

DISCUSSION

The choice of cleaning materials for use in a food-processing establishment is governed by the following factors: (*a*) they must be efficient, (*b*) they must not affect those who use them, (*c*) they must not damage equipment; (*d*) they must not affect the colour or flavour of food in contact with equipment cleaned by their use, (*e*) they must be easily rinsed away, (*f*) they must be easy to handle, and (*g*) they must be cost efficient, i.e. the relative costs of producing the desired effect must be considered (Gilbert, 1960; Thomas, 1967, 1969).

Since the chief concern of the plant hygienist is the protection of the product from contamination it is essential to establish which points in the processing line constitute 'direct' and 'remote' product contamination. Those surfaces which routinely contact the product require immediate and efficient cleaning. Walls would normally be 'remote' contact points and therefore unlikely to constitute a direct hazard. The present results, Table 1, indicate that tiled walls can be as efficiently cleaned by a high-pressure hot-water spray as by treatment with detergent or detergent + sterilizer. It is suggested that the reduction in bacterial numbers on these walls by method 1 was effected by mechanical removal of organisms since the water temperature never exceeded 150° F. Since it would be

Table 3. *Total plate counts at 25° C. from swabbed areas of black scraper and evisceration table*

	Site swabbed					
	Black scraper			Evisceration table		
	Count/cm.²			Count/cm.²		
Cleaning method	Before cleaning	After cleaning	Survival (%)	Before cleaning	After cleaning	Survival (%)
1	81,460	37,760	46·35	10,600	2,420	22·83
	3,760	800	21·27	21,100	3,320	16·51
	4,420	1,800	40·72	8,400	1,510	17·97
	19,200	9,040	46·50	14,000	2,860	20·42
	60,400	14,400	22·18	18,200	268	1·47
			35·404†			15·84†
2	242,060	70,960	29·31	6,600,000	576,000	8·72
	71,200	6,160	8·65	9,200	168	1·82
	35,250	1,704	4·83	24,400	490	2·00
	86,800	552	0·63	19,380	2,420	12·48
	30,080,000	80,900	0·26	19,800	184	0·92
			8·736†			5·188†
3	54,400	656	1·20	530	9	1·69
	704,460	16,520	2·34	154,000	28	0·01
	240,215	1,046	0·43	1,240	45	3·62
	25,600	536	2·09	800	18	2·25
	21,900	1,832	8·36	1,420	16	0·40
			2·884†			1·594†

$F = 14·29^{***}$ $(P < 0·001)$ $F = 8·33^{**}$ $(P < 0·01)$
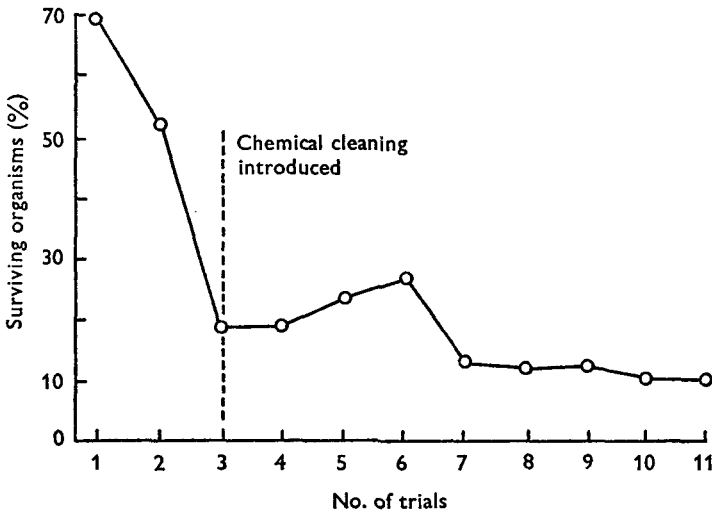S.E. $= 4·585$.   S.E. $= 2·566$.

† Mean

Fig. 1. The effect of sterilizing the blades of the scraping machine on the surface bacterial load of pig carcasses.

cheaper to use hot water only on such surfaces both from a materials cost and time point of view, such a procedure could be adopted in routine cleaning. Weekly bacteriological tests, e.g. the agar-sausage technique (ten Cate, 1965) would indicate the efficiency of the hot-water method. Only when the results proved unsatisfactory would such surfaces be treated with detergent or detergent and sterilizer. In this way much valuable time would be saved and the rationalization of a cleaning schedule effected.

Wooden surfaces with which food comes in contact are most undesirable because they are difficult to clean (Cooper & Dyett, 1967). This has been confirmed in the present investigation. Only after a three-stage treatment (method 3) was a satisfactory reduction in contamination realized. Wood expands when wet and any cracks allow the entry of contamination. Blood soaks in and solid particles of meat, fat, hair and other debris form reservoirs of infection. Working surfaces and containers should preferably be made of stainless steel (Hobbs, 1967).

The dehairing machine is a difficult piece of equipment to clean. Much hair becomes trapped on the drums and at the attachments of the dehairing flails to the drums. Although the hot-water treatment (method 1) removed most of the contamination, effective sterilization was only realized after the surfaces were treated with detergent or detergent and sterilizer (methods 2 or 3). Since the dehairer is a direct contact point it would be necessary to ensure sterilization of this equipment. Galton, Smith, McElrath & Hardy (1954) have shown that extra cleaning of such equipment reduced positive cultures of *Salmonella* on pig carcasses from 69 % to 10 %. Similarly the black scraper requires to be effectively sterilized after use. In fact, this equipment is one of the most serious sources of contamination in a killing line. The carcasses enter it after passing through the singeing furnace in which the temperature is about 1400° F. and are therefore virtually free of surface-contamination at this point. Much transfer of infection can take place from the blades of a poorly cleaned scraper. Since every precaution must be taken to prevent contamination of carcasses during the butchering and dressing operation (Patterson, 1968), extra special care should be taken in the cleaning of the black scraper.

The results for the cleaning of the table confirms observations of other workers (Spencer, 1965; Chalmers, 1961) that efficient cleaning (detergent action) removes most of the contaminating microflora from a surface and therefore paves the way for subsequent disinfection. However, the surface must be clean before it is treated with a sterilizing agent.

Mention has already been made of the necessity for thoroughly cleaning the scraping machine. The results presented in Fig. 1 emphasize the importance of this. Although certain areas of a pig carcass remain unsinged after passing through the singeing furnace (Gardner & Patton, 1969), substantial numbers of organisms on the skin after scraping is indicative of recontamination. As the present results suggest, an improperly cleaned black scraper will cause this recontamination. The results confirm earlier observations that where the bacterial load on equipment is higher than on food, the latter will be contaminated (Shotts, Martin & Galton, 1962; Ølgaard, 1964; Gilbert & Maurer, 1968; Gilbert, 1969). The present results also show that within a short time recontamination of carcasses was substantially

reduced when the scraping machine was effectively cleaned and sterilized. Hansen (1962) similarly demonstrated that the average number of bacteria on dressed carcasses was reduced by about 90 % when equipment was satisfactorily cleaned and sterilized.

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