BACTERIOLOGICAL INVESTIGATION OF THE WASHING AND STERILIZATION OF FOOD CONTAINERS

A REPORT TO THE MEDICAL RESEARCH COUNCIL

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INTRODUCTION

In recent years, owing to wartime conditions, there has been a great expansion in large scale catering by local authorities, notably in British Restaurants and in the school meals services. Outbreaks of food poisoning, undoubtedly associated with these services, have from time to time been the cause of considerable disability, although, so far as is known, cases have seldom been really serious. A typical case is marked by rapid onset of symptoms, vomiting or diarrhoea or both, starting within 2 or 3 hr. of the offending meal, but usually recovery is rapid. The course of most outbreaks does not suggest true bacterial poisoning, and organisms of the Salmonella group have rarely, if ever, been isolated. The picture is that of chemical food poisoning or of poisoning by bacterial toxins rather than by actual proliferation of bacteria in the victims.

Knox & Macdonald (1943) found that samples of gravy which had caused food poisoning showed very high bacterial counts, and sporing anaerobes were isolated in nearly pure culture on several occasions. Investigation showed that the gravy was prepared the day before and kept under conditions which allowed bacterial growth. Even if the gravy was sterilized by heat before consumption, it appeared to be capable of causing food poisoning. The outbreaks could, therefore, be attributed, though exact proof was lacking, to the presence of non-specific bacterial toxins. As soon as the general hygiene of the kitchen was improved and the practice of preparing gravy the day before was stopped the outbreaks of food poisoning ceased.

With these and similar outbreaks in mind, local authorities have become increasingly interested in the standards of hygiene desirable in kitchens in which meals on a large scale are prepared. Particular attention has been directed to the cleanliness of the containers in which meals are sent from central kitchens for distribution. Some authorities have felt it necessary to introduce a method of sterilizing these containers. In this country no attempt has so far been made to lay down any bacteriological standards for utensils used in canteens, restaurants or kitchens. In the U.S.A., however, the subject has received considerable attention (Report, 1943 and Report, 1944) and the recommended standard is not more than 100 living organisms of all kinds per utensil.

It must be admitted that there is little direct evidence to show that the mere presence of large numbers of organisms constitutes a serious danger to health. On the other hand their presence is presumably an indication of faulty hygiene and should serve as a warning of the possible presence of pathogens. It is obviously desirable that the numbers of organisms, whatever their source, should be kept as low as possible.

It was against this background that the present investigation was started in Leicester, at the request of the Ministry of Education. The Ministry had supplied a simple gas-heated jet steam sterilizer of a kind which is in use by a number of local authorities, while the local Education Authority had installed in the central kitchen a steam boiler capable of filling a large steam cabinet. This gave us the chance to compare the efficiency of two methods of steam sterilization. It was felt, however, that undue reliance on sterilization of containers might easily lead to neglect of the need for careful washing. The scope of the inquiry was therefore enlarged, and the work was planned to answer the following questions:

(1) What is the average range of bacterial counts to be expected from containers before and after washing?

(2) Can a jet sterilizer be relied upon to sterilize the standard types of containers and their lids?

(3) How does the jet sterilizer compare with the steam chamber?

(4) What order of bacterial cleanliness can be obtained by simple attention to hygiene in washing?

CONDITIONS OF THE INVESTIGATION

The work was undertaken at the central meals kitchen, which supplied about 3000 meals a day on 5 days of the week to some 65 schools. The meals were sent by van in large containers, mostly insulated to keep them hot, and the containers were collected

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and brought back to the central kitchen in the early afternoon. Utensils, such as plates, cups, spoons, etc., were washed at the separate schools and were not dealt with in this inquiry. Our investigations were confined to the large containers, which were all washed at the central kitchen. Some were washed at the schools first, but many were returned unwashed as they contained remains of food which were given to pigs. Table 1 shows the numbers, sizes, capacity, surface areas and other features of the different types of containers in use on an average day.

The central kitchen consisted of several rooms (kitchens proper, store rooms, washing-up rooms, etc.). The washing up was done in several sinks in different parts of the building. The general method of washing was as follows: large lumps of food were removed by hand, and containers and lids were washed in hot water containing soap and soda. A dish-cloth was used for washing and the same cloth was used for wiping them dry. Each container was washed in one sink only and no rinsing was done either before or after washing.

Table 1. *The containers*

Type of container	Container: Measurements	Container: Area (sq. in.)	Lid: Measurements	Lid: Area (sq. in.)	Capacity (gal.)	No. in daily use
Torpedo	Height 12 in., diameter 6 in.	243	Approx. 6 in. diam. and 1 in. deep	35	1	70
Tub	Height 9 in., diameter 11 in.	387·75	Approx. 11 in. diam. and 1½ in. deep	124	3	100
15 in. flat tins	15 × 9·5 × 3 in.	289·5	16 × 10 × ¼ in.	177	—	200
19 in. flat tins	19 × 14 × 4·5 in.	574·5	22 × 17 in.	374	—	200

The steam jet sterilizer had been set up in one of the rooms, in which was also the steam chamber which could be filled with steam from a boiler in an adjoining outhouse. In the same room were two galvanized iron sinks. Cold water placed in them could be heated by means of pipes in the bottom conveying steam from the boiler. These sinks had not yet been put into routine use; we used them in the later part of the work for comparing different methods of washing.

BACTERIOLOGICAL METHODS

At the start different methods of sampling were compared, e.g. (*a*) simple addition of a known volume of ¼ strength Ringer's solution allowed to run over the whole inner surface of the containers, (*b*) addition of Ringer's solution which was then washed with a pipette all over the container walls, (*c*) dry swabs, and (*d*) wet swabs. Dry swabs were found to give erratic and very low counts, while wet swabs gave results of the same order as the 'rinse' techniques, though the counts were generally somewhat lower. Wet swabbing was chosen because it was by far the best method for the flat surfaces of lids, it made transport of large volumes of Ringer's solution unnecessary, and it was the method of choice whenever comparison was being made of containers before and after different methods of treatment. The swabs were made of cotton wool wound around wooden sticks in the same way as routine throat swabs. They were inserted with plugs into test tubes and sterilized ready for use. The swabs were made considerably larger than throat swabs, but small enough to fit easily into the ½ in. diameter mouths of 1 oz. screw-capped bottles. Into these 10 ml. quantities of ¼ strength Ringer's solution were distributed, and they were sterilized ready for use. In taking a sample a sterile swab, dipped into one of these bottles to moisten it, was rubbed five times over the surface to be sampled and then returned to the screw-capped bottle. The wooden stick was then snapped off and the screw cap replaced. (The sticks had to be well baked in the hot air oven to make them snap off easily.) Duplicate swabs were taken before and after all jet-sterilizer tests, but only single swabs for steam-chamber tests and for washing-up techniques. Duplicate plates were poured on a few occasions only.

The bottles containing the swabs immersed in ¼ strength Ringer were taken from the kitchen to the laboratory and counts were made as soon as possible —within an hour of taking the last samples. The swabs were rapidly rotated in the Ringer solution, 1 ml. pipettes were inserted, the fluid was sucked up and down ten times, and 1 ml. samples were transferred to sterile glass petri dishes. 9 ml. of melted yeastrel milk agar held at 45–50° C. were poured into the dishes, the glass lids were put on and uniform mixing was ensured by five movements in two directions at right angles, followed by five clockwise, and five anti-clockwise rotations of the dishes. After the agar had set, the plates were incubated for 66 hr. at 37° C. The number of colonies was then counted, using a counting box and a hand lens giving a magnification of × 4. In the early experiments

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counts were made at 20 and 42 hr. as well as 66 hr. The increase in the number of countable colonies between the 1st and 2nd days was very large, and considerable between the 2nd and 3rd days. In the early experiments where 1·5–2 % agar was used spreading colonies caused difficulty: this was eliminated by increasing the agar concentration to 2·5 %.

The surface swabbed varied in different types of experiment and with different types of container or lid. Normally, with torpedo containers the area swabbed was $\frac{1}{20}$ of the total surface, with the tubs $\frac{1}{40}$ and with flat tins $\frac{1}{30}$ for the smaller size and $\frac{1}{36}$ for the larger size. With torpedo and tub lids the area swabbed was $\frac{1}{4}$ or $\frac{1}{2}$, with the lids of the flat tins, $\frac{1}{20}$ for the smaller size and $\frac{1}{24}$ for the larger size.

This routine was modified when samples were being taken of containers after sterilization or efficient washing. The area swabbed was then $\frac{1}{5}$ of the total surface for tubs and torpedoes, $\frac{1}{10}$ for the smaller tins, and $\frac{1}{9}$ for the larger tins. With tub and torpedo lids the area swabbed was $\frac{1}{4}$ or $\frac{1}{2}$, with the lids of the smaller tins $\frac{1}{5}$ and with the lids of the larger tins 1/2·5. Since in all cases swabs were suspended in 10 ml. of Ringer's solution and 1 ml. samples were used for plating, the number of organisms per container was obtained by multiplying the number of colonies counted by 10 × the reciprocal of the fraction of surface sampled.

RESULTS

(1) *General standard of bacterial counts before and after washing.* As would be expected, the bacterial counts varied greatly from container to container, but the average counts on a series of containers washed in the ordinary way in the kitchen were actually higher than the average counts on another series of containers sampled before washing (Table 2). Counts before washing were, of course, subject to very great error since it was impossible to take a fair sample of food remains consisting of thick gravy, small pieces of stew, lumps of potato or custard, etc. At any rate, it is clear that washing of containers in the ordinary way apparently made little difference to the number of bacteria they contained.

Table 2. *Counts before and after routine washing*

No. of containers sampled	Mean count before washing	No. of containers sampled	Mean count after ordinary kitchen wash	Type of container
30	28,360	30	89,538	Torpedo
30	263,660	30	277,180	Tub
30	91,020	30	643,722	15 in. flat tins

These figures are not strictly comparable as the 'before swabs' were obtained from different containers at a later date.

Table 3. *Sterilization of containers by steam jet*

No. of containers tested	Sterilization time (min.)	Approximate count per container: Before sterilization	Approximate count per container: After sterilization	Type of container
11	½	118,842	2,600	Torpedoes
9	1	24,412	2,411	
8	2	146,668	600	
17	3	45,870	585	
12	½	211,560	39,683	Tubs
12	1	365,420	5,717	
12	2	300,800	817	
12	3	153,555	633	
9	½	1,065,100	182,320	Flat tin 15 × 9·5 × 3 in.
9	1	989,620	2,620	
9	2	531,225	1,372	
9	3	438,037	366	
11	½	304,970	472,400	Flat tin 19·5 × 14 × 5 in.
12	1	388,850	224,500	
12	2	248,500	2,055	
12	3	277,710	210	

(2) *Efficiency of sterilization by the steam jet.* Different times of exposure to the steam jet were tested with different containers and lids. The results are shown in Table 3. It is clear that, after 3 min.

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exposure, the counts for all types of container were reduced to well below 1000 per container, that 2 min. exposure was barely adequate and that a shorter time was quite inadequate. In these experiments, the area sampled after exposure to the jet was of the same size as the area swabbed before treatment (from $\frac{1}{20}$ to $\frac{1}{40}$ for different types of container). Owing to the technique used, this necessitated a large dilution factor; for example, with the tub containers, 1 colony on a plate gave a count of 400 organisms per container. Another series of experiments was done in which the effect of swabbing larger areas was examined. As would be expected the apparent counts per container were considerably reduced (Table 4). The figures indicate that approximate sterility was attained after 2 min. exposure to the steam jet.

Table 4. *Comparison of counts per container obtained by swabbing large and small areas after sterilization*

Type of container	Area	Count per container: After sterilization for 2 min.	Count per container: After sterilization for 3 min.
Torpedoes	1/5	37	17
	1/20	600	585
Tubs	1/5	131	142
	1/40	817	633
Flat 15 in. tins	1/10	226	212
	1/30	1372	366
Flat 19 in. tins	1/9	95	105
	1/36	2055	210

Areas	Mean counts for all containers: After sterilization for 2 min.	Mean counts for all containers: After sterilization for 3 min.
Large	122	119
Small	1211	448

Table 5. *Sterilization of lids by means of the steam jet*

Type of lid	No. tested	Mean count per lid: Before	Mean count per lid: After	Time of exposure (min.)
Torpedo	10	19,745	215	2
Flat tin	8	142,150	337	2
Tub	12	75,240	4602	2
Tub	12	16,977	652	5

Exposure of lids to the steam jet was also investigated. They were held about 1 in. above the steam outflow pipe. The results (Table 5) show that 2 min. exposure was adequate for all except the insulated tub lids, which required 5 min.

(3) For comparison with the steam jet we investigated the effectiveness of the steam chamber. Containers or lids to be tested were put into this, and the steam was run in from the boiler (set to blow off at a pressure of 25 lb./sq. in.). The temperature in the steam chamber reached 218° F. (103·3° C.) in about 5 min.; during this time the pressure in the boiler usually fell to about 7 lb., at which level it could be kept by suitable stoking. Preliminary tests showed that about 5 min. were required for efficient sterilization after temperature equilibrium had been reached. Table 6 shows the results of exposing different types of containers and lids to steam at 218° F. for 5 min.

(4) *Bacteriological standards attainable by careful washing.* Since it was obvious that wholesale sterilization would make demands on equipment and labour which could certainly not be met at the present time, we decided to see how far the bacteriological picture could be improved by simple attention to the technique of washing. It required no bacteriological knowledge to see that there were four main faults in the existing method of washing:

(1) The washing water was not changed often enough.

(2) The water was sometimes not hot enough and there was not enough of it.

(3) The dish-cloths were often far from clean.

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(4) There were no facilities (owing to shortage of sinks) for rinsing before or after washing.

It was felt, however, that it would be interesting to obtain bacteriological confirmation of these points, and to find out precisely at what stage the heavy bacterial contamination was occurring. We were able to show that the bacterial counts on any one container depended very largely on the previous history of the container and on the state of the washing-up water. In one experiment (Table 7) a tub and a torpedo container were taken at random; washing was done as shown in the table. Each container was 'washed' three times in the same sink and sterilized for 2 min. in the steam jet between the washes. It is clear that a sterilized container becomes contaminated to an extent which depends on the state of the washing-up water. This means that if containers are to be sterilized they must be

Table 6. *Sterilization by steam chamber*

No. of lids tested	Sterilization time (min.)	Mean count per lid: Before sterilization	Mean count per lid: After sterilization	Type of container
11	5	57,196	18	Torpedo
17	5	27,102	61	Tub
6	5	147,100	8	15 in. tin
3	5	69,920	0	19 in. tin

No. of containers tested	Sterilization time (min.)	Mean count per container: Before sterilization	Mean count per container: After sterilization	Type of container
11	5	14,090	0	Torpedo
11	5	819,822	5	Tub
7	5	97,328	0	15 in. tin
3	5	203,136	60	19 in. tin

Table 7. *Washing, sterilizing and then rewashing containers*

Container	Time (p.m.)	Count per container after: Washing	Count per container after: Sterilizing	Dish water count per c.c.	
Tub (large insulated)	2.05	3,000 (first wash)	—	2,740	Same water without changing
	2.10	—	0	—	
		Between first and second wash five containers had been washed without changing dish water			
	2.18	6,200 (second wash)	—	8,090	
	2.25	—	0	19,120	
		Between second and third wash dish water was changed			
	2.32	11,800 (third wash)	—	1,460	Fresh water
Torpedo type (deep, narrow, insulated)	2.45	5,100	—	400	Same dish water throughout
	2.47	—	100	—	
		Between first and second wash five containers had been washed in the same dish water			
	2.51	5,200	—	10,920	
	2.55	—	300	—	
		Between second and third wash another five containers had been washed			
	3.00	18,900	—	35,440	
	3.05	—	300	—	

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sterilized each time they are used. Table 8 shows the results of washing, sterilizing and rewashing fifteen containers.

We tried to see whether preliminary rinsing would improve the bacterial counts. For this we had a powerful jet of water from a hose pipe to clear out large and small lumps of food, not all of which could be removed by hand. Cold water was used, but, as would be expected, was ineffective with containers which had been used for greasy foods. Even so, we found that containers gave considerably lower counts after simple rinsing with cold water without previous or subsequent washing than after washing in the routine way with soap and hot water. The method, however, was not pursued, as it was probable that both cold and hot water jets would be necessary, and to do this would have required considerable plumbing.

water, but the dish-cloths were not sterilized before use.

This suggested a series of experiments which showed quite clearly that almost any bacterial picture could be produced at will by simply changing the order in which clean or dirty dish-cloths were used. (By a 'dirty' dish-cloth is meant one taken from the kitchen in the state in which it would have been used in the existing system of washing.) Table 9 shows a comparison of the average counts obtained with different types of container when using a 'dirty' dish-cloth with the results using a 'clean' cloth ('sterilized' by exposure to steam in the steam chamber or by boiling in soda and water). In several experiments therefore, we adopted the following methods.

Method 1. Containers were washed in a sink containing soap and water at 48–50° C., wiped with

Table 8. *Washing, sterilizing and then rewashing containers*

Series	No. of containers	Mean counts on containers: After first wash	After sterilization	After rewash
1	9	426,500 per container	43 per container	144,500 per container
2	6	6,560 per container	216 per container	17,250 per container

Series 1. Conditions of first and second wash are not strictly alike as different dish water was used. In series 1 a larger area was swabbed after sterilization than in series 2.

Table 9. *Comparison of clean and dirty cloths in sink no.* 1

Type of container	No. tested	Mean count after washing with dirty cloth in sink no. 1 (per container)	No. tested	Mean count after washing with clean cloth in sink no. 1 (per container)
Torpedo	9	131,275	8	6,375
Tub	9	250,400	8	17,650
15 in. tin	6	50,400	8	41,250
		Mean of above		
	24	144,025	24	21,758

It was early realized that the state of the dish-cloths used was responsible for the greater part of the bacterial contamination. At the start of the investigation we expected, from past experience with outbreaks of food-poisoning traced to infected gravy, that the torpedo type of container which was mainly used for stews and gravy would give the worst bacterial counts. Table 3 shows that this was not true; the torpedo containers on the average gave the lowest bacterial counts. Torpedoes were washed in an outhouse with no running hot water, but the two women who washed them, making the best of a bad job, boiled their dish-cloths in the copper used for boiling the soapy water before it was ladled into the wash-tub. The other types of container were washed in the main building which had usually, though not always, a fair supply of running hot

a 'sterilized' cloth, rinsed in a second sink containing water alone at about 55° C. and wiped with another sterilized cloth. The cloths used (one for each sink) were not changed in running through a set of six or nine containers. Table 10 shows the average results obtained. Finally, the following method was adopted.

Method 2. The containers were washed in a first sink with soap and water at 48–50° C., wiped with sterilized dish-cloth, and finally rinsed in a second sink in water at 70–80° C. The average results with sixteen containers of each type are shown in Table 11.

DISCUSSION

These experiments showed that provided care was taken to use clean dish-cloths (sterilized just before use) highly satisfactory counts could be obtained.

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The results in fact were almost as good as those given by sterilization in the steam jet or steam chamber. When the large surface area of the containers is taken into consideration, counts of 200–300 organisms per container are certainly as good as the figure of 100 recommended by the U.S. Public Health code for utensils of much smaller area. It can, of course, be maintained that nothing less than complete sterility of containers is safe, and that, therefore, some efficient method guaranteeing sterilization should be introduced. There are several arguments against this: (1) Even if sterility is achieved, the containers are bound to become contaminated as soon as they are put into use again. (2) Apparatus capable of dealing quickly and conveniently with the large number of containers required would be expensive. (3) Such expense would be justifiable only if it could be shown beyond doubt that complete sterility was essential. There is little evidence in support of this, though it is obviously desirable to reduce the bacterial contamination to a minimum. The steam jet or steam chamber would have the attraction of convenience for small units with a few containers, and a series of these sterilizers could be installed in larger units. On the other hand, our later experiments show that highly satisfactory results can be obtained by attention to the simple hygiene of washing. The exact technique used is bound to vary in different local conditions but attention should be paid to the following points:

(1) A plentiful supply of hot soapy water with soda. Some of the newer detergents might be better but soap and soda gave satisfactory results.

(2) Frequent changes of water.

(3) Two sinks—one for washing, the second for rinsing.

(4) Rinsing in water as hot as can be managed (preferably 80° C., with some method of putting in and taking out containers).

(5) The use of clean dish-cloths, which should be sterilized by boiling. Provided these are changed frequently, the same dish cloth can be used for washing and for wiping out in the first sink.

(6) Final wiping out of the containers with a clean dish-cloth (after rinsing in the second sink) is unnecessary if the water in this sink can be kept hot enough, and the articles are inverted so as to allow them to dry rapidly.

Table 10. *Effect of using two sinks in washing* (*Method* 1)

Mean counts per container.

Type of container	No. tested	Before washing	After washing in sink no. 1	After wiping	After rinsing in sink no. 2	After wiping
Torpedo	9	49,000	2,000	1,000	1,800	1,800
Tub	9	403,200	51,600	4,000	2,000	4,400
15 in. tin	9	92,100	7,500	3,000	1,500	6,600

Table 11. *Effect of using two sinks in washing* (*Method* 2)

Mean counts per container.

Type of container	No. tested	Before washing	After washing in sink no. 1	After wiping	After rinsing in sink no. 2	After wiping
Torpedo	16	71,200	3,400	1,000	150	—
Tub	16	319,600	9,200	11,600	300	—
15 in. tin	16	223,200	9,600	4,800	160	—

SUMMARY

1. We have investigated bacteriologically the conditions in a central meals kitchen from which about 3000 meals were issued daily to some 65 departments.

2. Plate counts showed that the containers in which the meals were sent out contained large numbers of organisms, from several thousand to several hundred thousand per container.

3. Counts of this order were obtained both before and after the routine method of washing.

4. These counts were reduced to the order of a few hundred or less per container by steam sterilization.

5. Exposure for 2–3 min. to steam from a simple jet sterilizer was effective for all except large insulated lids which required at least 5 min.

6. Treatment for 5 min. in a chamber filled with steam from a boiler was effective with all types of containers and lids tested.

7. If containers are to be sterilized at all they must be sterilized each time they are to be used.

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8. A great improvement in the bacteriological counts can be achieved by attention to the hygiene of washing, e.g. by the use of plenty of hot water with soap and soda or perhaps preferably with detergents, with a second sink of very hot water for rinsing, and by using fresh sterilized dish-cloths each time the washing water is changed.

9. Counts almost as good as those given by steam sterilization were obtained by washing with soap and water at 48–50° C., wiping with a sterilized dish-cloth and then rinsing in a second sink of water at 75–80° C.

10. The arguments for and against steam sterilization are discussed.

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