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Sources of contamination of cooked, ready-to-eat cured and uncured meats

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SUMMARY

Forty-five samples of unsliced, cooked, ready-to-eat meats on sale in retail premises and supermarkets were examined. Thirty-six (80 %) had *Escherichia coli* I and 21 (47 %) had coagulase positive staphylococci in numbers ranging from 1 to > 1000/100 cm.^{2}. Twenty-one samples contained *Clostridium* spp. in numbers from 1 to > 100/100 cm.^{2}. Of the 45 samples tested, 11 (factory-produced) and 7 (home-produced) were examined after cooking but before being offered for sale. Cooked hams were contaminated after handling in a factory, as were samples of canned corned beef after sale and exposure for 24 hr. Some sources of contamination were: (*a*) raw beef, (*b*) factory and shop surfaces and equipment, and (*c*) workers' hands. Curing brines used in retail shops and supermarkets to produce corned beef were a potent source of contamination. The effect of holding cooked meats at ambient temperature on their spoilage (22° C) and food-poisoning (37° C) microflora was demonstrated.

INTRODUCTION

Human food-poisoning is commonly associated with bacteria originating from animal sources; in most cases, infection is contracted indirectly by eating contaminated meat and meat products (Report, 1970). Such contamination may occur within the slaughterhouse (Walton, 1970) or in processing and handling before sale (Foster, 1972; Casman, McCoy & Brandly, 1963; Timoney, Kelly, Hannan & Reeves, 1970; Gilbert, 1969; Gilbert & Watson, 1971). The high incidence of bacterial food-poisoning in man (Morisetti, 1971) indicates that it is necessary to prevent contamination of meat and meat products in the food industry. In the case of cured products, the raw materials (beef and pork) and the curing brines used are potential sources of food-poisoning bacteria. For example, in the curing of beef, the cuts, usually silverside and brisket, are pumped with a brine and immersed in another brine for a number of days. The process may, or may not, be conducted under refrigeration. The cured beef, called corned beef, is usually displayed for sale immediately on removal from the curing tank. In the event of the brines and the corned beef containing potential food-poisoning organisms, there is

a real possibility of these being transferred to cooked cold meats where the latter are sold in close proximity to the former. This investigation was undertaken to determine whether such contamination could take place. Other sources of contamination of cooked, ready-to-eat meats were also investigated.

MATERIALS AND METHODS

Survey of registered food premises

In November 1971 a survey of registered food premises in County Dublin was carried out to examine the procedures used for the preparation and sale of pickled meat (beef and pork).

One hundred and twenty-three premises were registered under the Food Hygiene Regulations (1950) and these consisted of eighteen supermarkets with registered meat counters, and one hundred and five meat shops (pork and beef).

As a result of the survey it emerged that, in forty-two premises, there might be possible cross-contamination by potential food poisoning organisms from cured meat to cooked ready-to-eat products sold in the same premises.

Contamination seemed likely to occur through the handling and sale of both cured meat and cooked meat by the same workers using the same counters and weighing scales etc. The danger of cross contamination was not considered immediate in the remaining premises surveyed because cooked cold meats were sold by different workers using different scales and at different counters.

BACTERIOLOGICAL EXAMINATION

Retail shops

Cured meats

Forty-five samples of cooked meats on sale in 15 retail premises were examined. Of these, 18 were tested after cooking and before sale. Surfaces were swabbed by rubbing an area of 100 cm.^{2} with two cotton gauze pledgets (moistened with diluent) using a sterilized stainless steel template. The swabs were broken into a Universal bottle containing 20 ml. $\frac{1}{4}$ strength Ringer's solution $+0{\cdot}1\,\%$ of added peptone. The bottles were shaken on a laboratory flask shaker for 5 min.

Escherichia coli I was enumerated by filtering 5 ml. of swab-rinse solution through an Oxoid membrane filter (Grade 0·45, 5 cm. diam.). The membrane was incubated on a pad soaked in resuscitation broth (Oxoid MM 20) for two hours at 37° C. and then transferred to a second pad soaked in MacConkey membrane broth (Oxoid MM 6*a*) in an aluminium airtight tin and incubated for 18 hr. at 44° C. in a watertight copper cylinder (Astell laboratory Services, Catford, London, S.E. 6) in a water bath at 44° C. $\pm$ 0·2° C.

Confirmation of *Escherichia coli* I was carried out using the Eijkman test (Mackie & McCartney, 1960). Typical lactose-fermenting colonies on the MacConkey broth impregnated membranes were picked off and purified on VRB agar (Oxoid CM 107). Tubes of brilliant green broth were inoculated and incubated in a water bath (44° $\pm$ 0·2° C.) for 18 hr.

The production of indole was tested by inoculating tubes of peptone water with

the cultures and incubating the tubes at 30° C. for 5 days. Indole was detected by adding Ehrlich's reagent.

Clostridium spp. were enumerated by filtering another 5 ml. portion of the swab rinse solution through the filter apparatus. The membrane was then placed on a plate of iron-sulphite agar (Oxoid CM 79) and overlaid with the same medium. The plates were incubated for 3 days anaerobically at 37° C. Coagulase positive staphylococci (CPS) were enumerated on the egg yolk – glycine – pyruvate – tellurite agar (EGPTA) of Baird-Parker (1962) by spreading 0·1 ml. serial dilutions on freshly prepared plates by the method of Davis & Bell (1959) and incubating the plates for 24–48 hr. at 37° C.

Fresh beef

Fresh beef (16 fore-ends and 16 hindquarters) was examined in the same way as the cured meats. Methods for the enumeration of *E. coli* I, *Clostridium* spp. and CPS were as described above.

Brines

Brines (31) from retail premises were collected in 120 ml. sterile plastic screw-capped jars and transported to the laboratory within 1 hr. A total count (25° C. for 5 days) was carried out by plating serial dilutions of the brine in 4% (w/v) saline on plate count agar (PCA, Oxoid) + 4% (w/v) of added NaCl. *E. coli* I and *Clostridium* spp. were enumerated by diluting 1 ml. of brine in 9 ml. of 4% (w/v) saline + 0·1% peptone and proceeding with the filtration technique as described earlier. Coagulase positive staphylococci were counted as described above.

Canned corned beef

One tin (3·2 kg.) of canned corned beef in each of six retail shops was opened aseptically and a 100 cm.^{2} area swabbed as described earlier. The butcher was asked to sell only half of each and retain the remaining portion for swabbing 24 hr. later. The procedures as described earlier were carried out to enumerate *E. coli* I, *Clostridium* spp. and CPS.

Equipment and surfaces

Shops' scales (11), slicing machines (10) and counter tops (6) were swabbed as described for the fresh beef samples and examined for *E. coli* I, *Clostridium* spp. and CPS.

Factory

Cooked hams

Ten hams, factory-cooked for 8 hr. at 158° F. (int. temp.) were opened aseptically and a 100 cm.^{2} area on each was swabbed. Each ham was allowed to follow the normal production pattern which consisted of peeling off jelly, trimming fat, cutting the larger hams into two, hand-packaging into new shrinkwrap plastic bags and drawing a vacuum. The packages were opened, then re-swabbed (100 cm.^{2}) to determine the degree of contamination during processing after cooking.

Equipment and surfaces

Equipment (aprons, knives, table tops) and the workers' hands were examined by swabbing, in each case a 100 cm.^{2} area.

Effect of holding cooked meats at constant temperatures

Nine samples of cooked, ready-to-eat meats (92 g. packets) were incubated at 20° C. ± 1° in a refrigerated incubator (Gallenkamp, London, E.C. 2) and at 2-hourly intervals total colony counts at 37° C. and 22° C. were made. Each sample was chopped up and mixed in a sterile jar. Ten grammes were weighed into 40 ml. sterile water, homogenized and 0·1 ml. serial dilutions in Ringer's solution plated on PCA containing 3% (w/v) of added NaCl. The plates were incubated for two days (37° C.) and 3 days (22° C.).

RESULTS

The degree of contamination found on the surface of cooked, ready-to-eat meats on sale in retail shops is shown in Table 1. *E. coli* I in excess of 1000 organisms/100 cm.^{2} was present in five samples of cooked ham and one sample of corned beef. Coagulase positive staphylococci were present in six cooked hams in similar numbers. Obviously this contamination resulted from the handling of these meats by personnel who also worked with other meats, e.g. raw meat and corned beef.

To determine the initial bacteriological condition of these meats, 18 were examined after cooking and before sale, i.e. before handling. The results are presented in Table 2. Three out of 11 factory-produced cooked hams and/or corned beef contained *E. coli* I in excess of 1000/100 cm^2 and two samples had coagulase positive staphylococci in excess of the same figure. Surprisingly only one out of seven samples of home-produced cooked meats and corned beef had numbers in excess of this figure, and the incidence of staphylococci on these samples was $< 1/\text{cm}^2$.

In order to establish the origin of the contamination of factory-produced cooked meats, 10 cooked hams were examined immediately after cooking and again after re-packaging. The results are presented in Table 3. As expected, the hams were free of the three 'indicator' organisms after cooking. However, the removal of the jelly, the trimming of fat, general handling and re-packaging, resulted in re-contamination. Thus, cooked hams can become contaminated even before they reach the retail level. Similarly, six tins (3·2 kg.) of corned beef which were aseptically opened proved to be sterile. However, after 24 hr. exposure they became contaminated.

In Table 4, some of the sources of contamination of cooked meats are tabulated. First, the raw beef bought in by the retailer (fore-ends and hindquarters) contained the 'indicator' organisms at various concentrations. The corned beef produced from this raw meat was similarly contaminated. Equipment (scales, slicing machines and counter tops) also contributed their quota of infection. In the factory, aprons, tables, knives and the hands of workers were found to be sources of *E. coli* I and staphylococci. *Clostridium* spp. were virtually absent from these surfaces.

Table 1. *Contaminated cooked, ready-to-eat meats on sale in 15 premises. Distribution of colony counts/100 cm.² of different organisms in various ranges*

Sample	No. tested	*Escherichia coli* I					*Clostridium* spp.				*Staphylococcus aureus*			
		0	1–10	11–100	101–1000	> 1000	0	1–10	11–100	> 100	0	1–100	101–1000	> 1000
Cooked hams	27	5	3	7	7	5	13	8	6	0	11	1	9	6
Corned beef ex tin	10	1	3	1	4	1	5	4	0	1	9	0	1	0
Other meats, e.g. brawn, hazlett, luncheon meat, roast pork and beef	8	3	3	1	1	0	6	1	1	0	4	3	1	0
Total	45	9	9	9	12	6	24	13	7	1	24	4	11	6
%	100	20·0	20·0	20·0	26·6	13·3	53·3	29·0	15·5	2·2	53·3	8·8	24·4	13·3

Table 2. *Contamination of meats in retail shops and supermarkets after cooking and before being offered for sale. Distribution of colony counts/100 cm.² of different organisms in various ranges*

Sample	No. tested	*Escherichia coli* I					*Clostridium* spp.			*Staphylococcus aureus*			
		0	1–10	11–100	101–1000	> 1000	0	1–10	11–100	0	1–100	101–1000	> 1000
(*a*) Factory-produced	11	3	1	3	1	3	7	2	2	6	0	3	2
(*b*) Home-produced	7	3	2	1	0	1	6	1	0	5	2	0	0
Total	18	6	3	4	1	4	13	3	2	11	2	3	2

(*a*) Nine were cooked hams and two were corned beef. Some of these meats were wrapped in greaseproof paper, the remainder were cellophane wrapped.

(*b*) Three were cooked hams, one was a sample of cooked pork, and three were corned beef. Some were unwrapped, the remainder were wrapped loosely in greaseproof paper.

able 3. *Contamination of cooked hams during repackaging in factory and of canned corned beef on sale in retail shops. Distribution of colony counts/100 cm.² of different organisms in various ranges*

Sample	No. tested	*Escherichia coli* I*				*Clostridium* spp.			*Staphylococcus aureus*		
		0	< 10	10–100	101–1000	> 1000	0	< 10	10–100	> 100	0	< 100	> 100	> 1000
ictory-produced hams														
(1) After cooking	10	10	0	0	0	0	10	0	0	0	10	0	0	0
(2) After repackaging	10	2	2	6	0	0	9	0	1	0	6	0	3	1
op corned beef														
(1) Ex tin	6	6	0	0	0	0	6	0	0	0	6	0	0	0
(2) After 24 hr.	6	2	1	0	1	2	2	2	1	1	6	0	0	0

* Seven examined and six were positive (Eijkman test).

Table 4. *Sources of contamination of cooked meats in retail shops and a factory. Distribution of colony counts/100 cm.² of different organisms in various ranges*

Sample	No. tested	*Escherichia coli* I†					*Clostridium* spp.				*Staphylococcus aureus*			
		0	< 10	10–100	> 100	> 1000	0	< 10	10–100	> 100	0	< 100	> 100	> 1000
Retail shops														
1. Fresh beef														
(*a*) Fore-ends	16	4	4	2	6	0	5	5	4	2	10	3	3	0
(*b*) Hindquarters	16	2	6	4	4	0	4	9	2	1	12	2	2	0
2. Corned beef*	13	1	2	7	3	0	5	3	5	0	8	1	1	1
3. Equipment														
(*a*) Scales*	11	5	2	4	0	0	4	4	3	0	8	0	2	0
(*b*) Slicers*	10	9	1	0	0	0	7	3	0	0	8	0	0	0
(*c*) Counters	6	4	0	1	1	0	1	1	4	0	4	0	1	1
Factory														
1. Equipment														
(*a*) Aprons*	2	1	0	1	0	0	1	0	1	0	0	0	0	1
(*b*) Tables	2	0	0	2	0	0	2	0	0	0	1	0	1	0
(*c*) Knives	2	1	0	0	0	1	2	0	0	0	2	0	0	0
2. Hands of workers	4	0	0	4	0	0	4	0	0	0	0	0	3	1

* Two samples of corned beef, one set of scales, two slicing machines and one apron were not examined for *Staphylococcus aureus*.
† Eight examined, all were positive (Eijkman test).

Table 5. *Bacteriological analysis of curing (immersion) brines used in the production of corned beef*

No. of samples tested	No. of samples with total counts/ml.			No. of samples with *E. coli* I counts/ml.			No. of samples with *Clostridium* spp./ml.			No. of samples with staphylococcal counts/ml.*	
	$< 10^6$	10^6–10^7	$> 10^7$	$< 10^2$	10^2–10^3	$> 10^3$	< 10	10–10^2	$> 10^2$	< 10	⩾ 10
31	4	10	17	13	13	5	27	2	2	25	6

* Coagulase positive.

Table 6. *Effect of incubation at shop temperature of 20° C. on colony counts of cooked ready-to-eat cold meats*

	Counts/g. ($\times 10^4$) at							
	22° C. after (hr.)				37° C. after (hr.)			
Meats	0	2	4	6	0	2	4	6
Chicken/ham	3	1	2925	3075	2	1	2	15
Luncheon meat	1	93	4725	1950	2	4	9	4
Chopped ham	21	30	3000	190	1	1	3	7
Chicken/ham	276	300	500	535	1	7	5	4
Luncheon meat	2	3	3	5	62	91	75	200
Chopped ham	11	8	12	39	50	500	750	2828
Corned beef	21	42	47	25	83	127	100	108
Ham/beef	307	196	161	180	600	4000	3000	6875
Brawn	772	888	1120	668	600	1370	1408	1500

The bacteriological analysis of the curing brines used in retail shops and supermarkets for the curing (corning) of raw beef are shown in Table 5. Of 31 samples tested, 17 had total counts $> 10^7$ organisms/ml. The incidence of *E. coli* I, *Clostridium* spp. and coagulase positive staphylococci were also high; five samples had *E. coli* I $> 10^3$/ml.; 2 had *Clostridium* spp. $> 10^2$/ml. and 6 staphylococci > 10/ml.

The effect of exposure of cooked meats to shop temperature (20° C.) on the total counts at 22° C. and 37° C. is illustrated in Table 6. Irrespective of the initial bacterial count which varied at 22° C. from $0{\cdot}75 \times 10^4$ to $771{\cdot}5 \times 10^4$/g. and at 37° C. from $0{\cdot}45 \times 10^4$ to 600×10^4 g., with few exceptions all samples showed an actively increasing population at both temperatures over a 6 hr. period. Table 6 illustrates that where heavy initial contamination exists on cooked meats, and where these are displayed over a working day in, for example, the window of a retail shop or some other unrefrigerated environment, substantial multiplication takes place. The 37° C. count is particularly important.

DISCUSSION

Evidence is presented in this paper which links the curing of raw meat in retail premises with the contamination of cooked, cured, ready-to-eat meats. Personnel, equipment, utensils, raw materials (raw meat and brines) are potential sources of cross contamination. Although only 10 cooked hams were examined in a factory, each of these was found to be contaminated before reaching retail level. The situation is further complicated when these cooked meats are handled by shop assistants who cure and handle raw meat on the premises. It is not surprising that 86% of all cases of food poisoning arise from made-up meat products, the vast majority of which are cooked meats (Simmons, 1972).

It is for reasons such as these that codes of hygiene require total and complete separation of cooked and raw meats.

The following precautions must be taken where cold meats are sold in the same premises as raw and cured (corned) beef:

(1) Complete separation of raw from cooked meats. This must include the provision of different surfaces and equipment for the handling, cutting, slicing,

weighing, display and sale of such meats (see Food Hygiene Codes of Practice, 1969).

(2) Washing (sanitizing) of hands and equipment before handling a cooked product. Preferably, different staff should be employed on the cooked meats section of the premises. Where possible, tongs, forks or other suitable instruments should be made available for handling a cooked product.

(3) Hold cooked meats under refrigeration, i.e. < 4·4° C. with free circulation of air. Since pathogenic bacteria grow between 4·4° and 48·8° C. (Elliott, 1972) cooked meats should not be permitted to be held in this range for long periods (see Table 6).

(4) Facilities for curing must be provided, preferably under refrigeration, in a separate room or an area remote from the shop proper. Immersion brines should be filtered or otherwise clarified before re-use.

(5) All persons engaged in the handling of meat, both in the factory and in the retail trade, must be provided with suitable protective clothing (protection for the meat, not the worker).

(6) Any person suffering from an infection of the stomach or intestine (vomiting, diarrhoea), septic cuts or boils must not handle meat (raw or cooked) until the condition has disappeared (see Food Hygiene Regulations, 1950).

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