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Observations on procedures for thawing and spit-roasting frozen dressed chickens, and post-cooking care and storage: with particular reference to food-poisoning bacteria

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SUMMARY

A comparison was made of four methods of thawing frozen chickens and an average thaw time for each method was determined.

Fully and partially thawed chickens, inoculated with salmonellas, *Clostridium welchii* and *Staphylococcus aureus* were cooked in a spit-roasting oven at different temperatures for different lengths of time. The chickens were examined freshly cooked and after storage under various conditions.

Spit roasting fully thawed chickens until the outer skin was golden brown was sufficient heat-treatment to kill salmonellas and *Staph. aureus* but *Cl. welchii* could survive. Salmonellas could also survive if the chickens were not fully thawed before cooking.

Incorrect storage after cooking was shown to encourage the growth of pathogens.

The incidence of intestinal pathogens in frozen dressed chickens and environmental hazards in spit-roasting establishments were also studied. Of raw chickens examined 35% contained salmonellas (9 serotypes), 63% contained *Cl. welchii* and 63% *Staph. aureus*.

INTRODUCTION

Over the past years there has been a change in production methods for certain livestock, notably poultry, intended for domestic consumption.

The systems of intensive rearing have brought about an increased consumption of poultry. Surveillance studies were directed towards home-produced as well as imported foods in an effort to find the source of salmonella serotypes causing gastroenteritis in the human population.

Salmonellas have been found in a high percentage of dressed carcasses both frozen and chilled examined on a large scale in Britain (Hobbs, 1971; Crabb & Walker, 1971), Ireland (Timoney, Kelly, Hannan & Reeves, 1970), United States of America (Wilder & MacCready, 1966; Surkiewicz, Johnston, Moran & Krumm, 1969; Morris, McMurray, Galton & Wells, 1969; Morris & Wells, 1970), Israel (Seligmann & Lapinsky, 1970) and Italy (Pascucci *et al.* 1970).

Attention was drawn to the hazards of contaminated poultry by a series of outbreaks due to *Salmonella virchow* from chickens stored after cooking (Semple,

Turner & Lowry, 1968). It was suggested that inadequate thawing and unhygienic conditions contributed to a massive build-up of salmonella contamination in the shop and in the chicken portions sold. In tracing the source of this outbreak a chicken-packing station and associated rearing farms were investigated (Pennington, Brooksbank, Poole & Seymour, 1968). *S. virchow* was found in samples including litter, cloacal swabs, plucked and unplucked chickens and feedstuffs from 9 of 14 farms as well as from eviscerated chickens, giblets, water from a chill tank and sewer swabs at the processing plant. Many salmonella serotypes are carried by poultry without evidence of illness so spread of the organism cannot be prevented by removal of sick birds before processing. However, inspection of edible offal from chickens on the processing line may reveal evidence of infection, for example spots on the liver (H. E. Marthedal, personal communication).

The infection rate of the live birds and the serotypes found will vary from farm to farm, depending on a number of factors including infection on the breeding farm (J. Lee, personal communication; Jackson, Lindsay & Shiel, 1971) and contamination of feedstuffs. It is likely that spread from carcass to carcass will take place during processing. The correct use of chlorinated water will reduce the spoilage flora and may reduce the incidence of salmonellas but the organisms will still remain inside the carcass and deep in the skin – sucked inside the feather follicles (Dixon & Pooley, 1961; Barnes, 1965). The inclusion of packets of edible offal inside the carcass may add to the spread of serotypes.

This report describes an investigation initiated by a request from the British Poultry Meat Association Ltd. It was desired to find out methods of thawing and cooking (spit-roasting) frozen dressed chickens so that consumers would be protected against the hazard of food poisoning.

Frozen dressed and wrapped poultry with weights ranging from 2 lb. 4 oz. to 2 lb. 14 oz. with enclosed giblets were supplied by four English packing stations. The chickens were stored frozen at $-10°$ C. (14° F.) until required.

The investigation included experiments on thawing, cooking and storage. The incidence of intestinal pathogens in frozen dressed chickens and environmental hazards in spit-roasting establishments were also studied.

THAWING

Methods

Experiments were carried out based on the recommended methods of thawing frozen chickens, as printed on wrappers or included on leaflets by the various poultry-packing companies.

Temperature recordings were made throughout the thawing periods by inserting chrome alumel thermocouples deep into the cavity of each bird, into the breast meat and into the meat between the fleshy portion of the leg and the side of the breast to a depth of 2–2·5 cm. The thermocouples were connected to a Comark electronic thermometer (Comark Electronics Ltd., Littlehampton, Sussex) calibrated in ° C. with a recording range of -100 to $+300°$ C. with an accuracy of $\pm 0{\cdot}5°$ C. Ten thermocouples could be attached to the thermometer at any one

time. Ambient temperatures were recorded throughout each experiment. The thawing period was taken from the time the chickens were placed in the required situation, with the least possible delay after removal from the deep freeze, to the time when all the thermocouples registered 0° C.

Holding at room temperature at 15–21° *C.* (59–69·8° *F.*)

Ten chickens between 2 lb. 4 oz. and 2 lb. 2 oz. in weight were thawed at room temperature 15–21° C. individually on stainless-steel or enamel trays; five chickens were thawed within and five without their polythene bags. Temperature recordings were made at hourly intervals up to 8 hr. In a second experiment chickens were left to thaw at room temperature for 24 hr., which is longer than the recommended period.

Storage in a domestic refrigerator at 4° *C.* (39·2° *F.*) *overnight*

Ten chickens, 2 lb. 8 oz. to 2 lb. 14 oz. in weight, were thawed individually on trays placed on a shelf in a refrigerated room, at approximately 4° C.; five chickens were thawed within and five without their polythene bags. Temperature recordings were made at hourly intervals except during the overnight period.

Immersion in cold running water at 16–21° *C.* (60·8–69·8° *F*)

Five chickens, 2 lb. 4 oz. in weight and in polythene bags, were placed on a shallow enamel tray in the sink under a stream of cold water directed on to the centre of the breast bone so that the water flowed fairly evenly over the whole bird. Temperature recordings were made at half-hourly intervals of both air and water and also at the usual points in the chicken.

Holding at room temperature with removal of giblets as soon as possible

Ten chickens, 2 lb. 4 oz. to 2 lb. 12 oz. in weight, five within and five without the bag, were left to thaw at room temperature and recordings were made every 30 min. The giblets were removed when the cavity was sufficiently thawed but before the whole carcass was thawed out. Care was taken with the thermocouples in the cavity, and if disturbed they were replaced immediately near the original position.

In each experiment samples of chicken were taken at the beginning and end of the period of time required for thawing. The samples included portions of the breast and back skin, portions of mixed giblets and drip and cavity fluids. Tests included general and coliform counts and enrichment cultures for pathogenic organisms. Skin from the wing and leg area and part of the cavity wall were also examined by enrichment cultures for salmonellas only.

Selenite F and tetrathionate (Rolfe, 1946) fluids incubated at 37° C. for up to 72 hr. were used for enrichment for salmonellas. Subcultures were made on deoxycholate sucrose and bismuth sulphite agars. Suspicious colonies were picked, identified and serotyped. Two bottles of veal cooked-meat medium, one heated at 60° C. for 15 min. and the other left unheated after inoculation and incubated overnight, were used for the isolation of *Clostridium welchii*; both bottles were

Table 1. *Mean thawing times/lb. weight chicken*

Method of thawing	Mean thawing time (hr./lb. weight of chicken)	
	In bag	Out of bag
Room temperature	2·9	2·0
Domestic refrigerator	8·1	7·9
Cold running water	1·2	Not tested
Room temperature with removal of giblets as soon as possible	2·2	1·7

subcultured on neomycin blood agar (Sutton & Hobbs, 1968) incubated anaerobically. Colonies thought to be *Cl. welchii* were picked, identified by the Nagler reaction and serotyped.

Cooked-meat medium containing 10% NaCl incubated at 37° C. overnight and subcultured on phenolphthalein phosphate plus polymyxin agar was used for the selection of *Staphylococcus aureus*. Colonies thought to be *Staph. aureus* were tested for coagulase production, phage-typed and in some instances examined for enterotoxin production.

Results

The results are given in Table 1. They showed that removal of the polythene bag shortened the thaw time. At room temperature the average thaw time for chickens with bags compared with chickens without bags was almost 1 hr./lb. shorter. With a lower temperature of storage, in the refrigerator, there was little difference in the thaw time of chickens with and without the bags. When chickens were thawed in the refrigerator without a bag the skin showed signs of dehydration, and marks of freezer burn became more obvious. The most rapid thaw time was achieved by holding the bagged carcasses in cold running water. The average time for 5 chickens was 1·2 hr./lb. Removal of the giblets while chickens were thawing in bags at room temperature reduced the thaw time 0·7 hr./lb. but only 0·3 hr./lb. when the bag was first removed.

The means of the total aerobic colony counts (surface drop count on blood agar) on breast and back skin before and after thawing by the four methods are given in Table 2. The mean counts on other samples taken from the chicken after thawing were approximately the same except after prolonged thawing at room temperature, when the counts were higher.

In general, higher counts were obtained from the back skin than from skin taken from the breast region. The chickens were thawed breast upwards, so that fluid drained towards the back of the bird on to the metal tray and at the end of the thawing period the chicken carcass was resting in a pool of fluid which would encourage bacterial growth. Apart from method 1(*b*) there was no significant increase in the number of organisms found on the skin during the thawing periods. When chickens were allowed to thaw at room temperature for longer than the recommended period of time the number of bacteria per g. of back skin increased.

Table 2. *Mean bacterial counts before and after thawing by the four variations in thawing method*

Method of thawing	Condition of chicken	Sample of skin examined	Mean bacterial count/g. Before thawing	Mean bacterial count/g. After thawing
1(*a*). Room temperature	In bag	Breast	$2{\cdot}00 \times 10^4$	$1{\cdot}40 \times 10^4$
		Back	$5{\cdot}80 \times 10^4$	$3{\cdot}50 \times 10^4$
	Out of bag	Breast	$2{\cdot}50 \times 10^4$	$2{\cdot}00 \times 10^4$
		Back	$1{\cdot}30 \times 10^5$	$9{\cdot}30 \times 10^4$
1(*b*). Prolonged thawing at room temperature	In bag	Breast	$6{\cdot}50 \times 10^3$	$1{\cdot}75 \times 10^4$
		Back	$3{\cdot}25 \times 10^4$	$3{\cdot}95 \times 10^6$
	Out of bag	Breast	$4{\cdot}00 \times 10^3$	$2{\cdot}50 \times 10^3$
		Back	$1{\cdot}25 \times 10^3$	$6{\cdot}63 \times 10^5$
2. Domestic refrigerator	In bag	Breast	$2{\cdot}95 \times 10^4$	$1{\cdot}88 \times 10^4$
		Back	$2{\cdot}99 \times 10^4$	$2{\cdot}72 \times 10^4$
	Out of bag	Breast	$2{\cdot}93 \times 10^3$	$2{\cdot}42 \times 10^3$
		Back	$1{\cdot}59 \times 10^4$	$2{\cdot}90 \times 10^4$
3. Cold running water	In bag	Breast	$3{\cdot}00 \times 10^4$	$3{\cdot}70 \times 10^4$
		Back	$2{\cdot}50 \times 10^4$	$3{\cdot}14 \times 10^4$
4. Room temperature with removal of giblets as soon as possible	In bag	Breast	$5{\cdot}25 \times 10^3$	$4{\cdot}78 \times 10^3$
		Back	$1{\cdot}33 \times 10^4$	$2{\cdot}38 \times 10^4$
	Out of bag	Breast	$1{\cdot}00 \times 10^3$	$2{\cdot}50 \times 10^3$
		Back	$1{\cdot}40 \times 10^4$	$1{\cdot}15 \times 10^4$

The breast skin became dry and patchy after prolonged exposure to atmospheric temperatures without the polythene bag.

The pattern of *Escherichia coli* counts followed that of the general colony counts.

COOKING AND STORAGE AFTER COOKING

Methods

Experiments were carried out in which chickens were inoculated with suspensions of *Salmonella*, *Cl. welchii* and *Staph. aureus*, before being cooked in a spit-roasting oven for varying periods of time at thermostatically controlled temperatures. Some chickens were allowed to thaw fully before they were inoculated and cooked, others were inoculated and cooked while still partially frozen.

Four areas of each thawed or partially thawed chicken were inoculated before cooking (*a*) deep in the breast muscle, (*b*) deep in the leg muscle, (*c*) between the leg and the body of the bird and (*d*) inside the cavity. The suspensions were inoculated in 0·5 ml. volumes into the muscle areas, and 0·5 ml. was sprayed into the cavities, using disposable plastic syringes. The suspensions for inoculation were prepared from overnight broth cultures of *Salmonella* and *Staph. aureus*, centrifuged, washed in neutral phosphate buffer and the cells resuspended in a small quantity of buffer. These dense suspensions were diluted to give an initial concentration of 10^8 organisms per ml., the number of organisms being estimated by means of opacity tubes, and then serial tenfold dilutions were made to give the required number of organisms for each experiment. The dense suspensions were usually prepared on the day of use, but occasionally they were stored overnight

at 4° C. until required. *Cl. welchii* spores readily in the intestinal tract but not in laboratory media. Spore suspensions were prepared from samples of faeces supplied by a local hospital from a patient with diarrhoea during a suspected outbreak of *Cl. welchii* food poisoning. The method was described by Sutton (1969). The spore suspension used in most experiments contained approximately 3×10^8 spores per ml., harvested from a strain of non-haemolytic *Cl. welchii* type ix; this suspension was diluted as required. Suspensions were stored at 4° C.

A mixed inoculum was prepared from equal volumes of the appropriate concentration of individual suspensions of each organism.

In the first series of experiments the chickens were thawed in the refrigerator at 4° C. (39·2° F.) for 24 hr. and then left at room temperature for about 1 hr. before use. In the second series the chickens were allowed to thaw at room temperature for removal of the giblets, placed in polythene bags and returned to −10° C. (14° F.) storage overnight; the temperature on removal was approximately −2 to −3° C. (28·4–26·6° F.).

The oven for spit-roasting was a Barbecue King model SF (Barbecue King Sales Ltd., Trafford Road, Reading) with a capacity for 12 chickens, 4 on each of 3 spits. It was more convenient to use 9 chickens (3 per spit) for the experiments.

The temperature and time recommended for cooking 2–2¼ lb. chickens on the Barbecue King Spit roasting apparatus was 149° C. (300° F.) for approximately 1 hr. The oven was heated to the required temperature before the birds were loaded onto the spits. Temperature recordings were made in different parts of the chickens at regular intervals throughout the cooking periods.

In each experiment ten chickens were inoculated with the appropriate organism or mixture of organisms. One chicken was examined without cooking, the remainder were loaded onto the spits (3 per spit) for cooking. A complete spit with 3 chickens was removed after periods of 20, 40 and 60–75 min. in the oven. Temperature recordings were made in one chicken, in sites opposite the inoculated areas and in the cavity, each time a spit was removed. The centre chicken on the third spit was used throughout for temperature recordings. The thermocouples could not remain in the chickens during cooking because of the rotating spits; between readings they were kept immersed in a bowl of 2% Hycolin solution and rinsed thoroughly before use.

Bacteriological examination, i.e. counts and enrichment cultures for each of the inoculated organisms, was carried out on the groups of three chickens on each spit removed at different times during cooking; one was examined immediately, one was left at room temperature and examined the next day and the third was stored under various conditions for different periods of time.

In the first three experiments, fully thawed chickens (2¼ lb. in weight) inoculated with $7{\cdot}5 \times 10^6$ *S. virchow* (Experiment 1), $1{\cdot}75 \times 10^5$ *S. senftenberg* 775 W (Exp. 2) and 1×10^3 *S. typhimurium* phage type 2c(14) (Expt. 3) at each site, were cooked at 149° C. (300° F.) for periods up to 70–75 min. In each experiment three chickens were removed after 20 and 40 min. and the remaining three chickens after 70 min. (Expt. 1 and 2) and 75 min. (Expt. 3) cooking. The time at which the last spit was removed depended on whether the chickens appeared to be fully cooked.

Table 3. *Growth of salmonellas from fully thawed chickens inoculated with ca.* 7,500,000 *Salmonella* virchow *and cooked at* 300° F. (*Expt.* 1)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*d*)
Uncooked	None	250,000	130,000	200,000
20	None	150,000	1,400	300,000
	O/N at RT	5,600	> 1,000,000	> 1,000,000
	O/N at 39·2° F. followed by 5 hr. at 109·4° F.	5,100	> 1,000,000	> 1,000,000
40	None	–	–	–
	O/N at RT	–	–	–
	O/N at 39·2° F. followed by 5 hr. at 109·4° F.	–	–	–
70–75	None	–	–	–
	O/N at RT	35,000	–	–
	O/N at 39·2° F. followed by 5 hr. at 109·4° F.	–	–	–

The following notes apply to this and succeeding tables up to 14(*c*).

Sites of inoculation: (*a*) deep in breast muscle; (*b*) deep in leg muscle; (*c*) between leg and body of the bird; (*d*) inside the body cavity.

O/N = overnight. RT = room temperature. UC = colonies uncountable owing to overgrowth of other organisms. Culture positive by enrichment method.

– = organisms not grown. + = organisms grown by enrichment only.

< 100 or < 500 = organisms grown by enrichment only. Numbers too small to be detected by counting methods with these lower limits.

In Experiments 4 and 5 fully thawed chickens inoculated with 625 and 750 *S. typhimurium* at each site were cooked at 107·2° C. (225° F.) and 121° C. (250° F.) respectively for periods up to 75 min. In Experiment 6 the chickens were inoculated with 880 *S. typhimurium* and the cooking temperature was increased to 204° C. (400° F.) for up to 60 min.

The experiments were repeated with fully thawed chickens given mixed inocula containing approximately equal numbers of *S. typhimurium*, *Cl. welchii* and *Staph. aureus* (10^3–10^4 of each organism), using cooking temperatures of 107·2° C. (225° F.), 149° C. (300° F.) and 204° C. (400° F.) (Expts. 7, 8 and 9).

In the last group of experiments (10–12) partially thawed chickens given a mixed inoculum were cooked at 204° C. (400° F.), 149° C. (300° F.) and 121° C. (250° F.) for up to 60 min.

Results

The results of the 12 cooking and storage experiments are summarized in Tables 3–14.

Survival of salmonellas

In Expts. 1–3 (Tables 3–5) with one exception salmonellas were not detected by enrichment methods after cooking for 70–75 min. at 149° C. (300° F.); the chickens were examined directly after cooking and after storage.

In Expt. 1 salmonellas were isolated from the breast region of the chicken stored

Table 4. *Growth of salmonellas from fully thawed chickens inoculated at different sites with ca.* 175,000 Salmonella senftenberg 775 *W and cooked at* 300° *F. (Expt.* 2)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (a)	(b)	(d)
Uncooked	None	1,000	7,100	15,000
20	None	5,000	200	1,000
	O/N at RT	1,000	1,500,000	400,000
	O/N at 39·2° F. followed by 4 hr. at 109·4° F.	15,000	100,000	400,000

After 40 and 70–75 min. cooking there was no growth of *Salmonella* from any site either direct or after storage at RT or at 109·4° F.

For notes see Table 3.

Table 5. *Growth of salmonellas from fully thawed chickens inoculated at different sites with ca.* 1,000 Salmonella typhimurium *phage type* 2*c*(14) *and cooked at* 300° *F. (Expt.* 3)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (a)	(b)	(c)	(d)
Uncooked	None	< 100	–	< 100	< 100
20	None	–	< 100	< 100	< 100
	O/N at RT	< 100	30,000	4,000	5,000,000
40	None	< 100	–	< 100	< 100
	O/N at RT	–	–	–	–
70–75	None	–	–	–	–
	O/N at RT	–	–	–	–

For notes see Table 3.

Table 6. *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with ca.* 625 *organisms and cooked at* 225° *F. (Expt.* 4)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (a)	(b)	(c)	(d)
Uncooked	None	–	–	–	< 100
20	None	< 100	< 100	–	< 100
	O/N at RT	25,000	< 100	5,500	UC
	O/N at 39·2° F. followed by 4½ hr. at 131° F.	–	–	–	–

After 40 and 75 min. cooking there was no growth of *Salmonella* from any site, either direct or after storage at RT or at 131° F.

For notes see Table 3.

overnight at room temperature after 75 min. cooking. As the temperature in the breast meat after this period of cooking was 93·9° C. (201° F.) it is not likely that the salmonellas would have survived this temperature. The inoculated strain,

Table 7. *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with ca.* 750 *organisms and cooked at* 250° *F. (Expt.* 5)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	< 100	–	< 100
20	None	< 100	–	< 100	–
	O/N at RT	3,000	130,000	250	> 1,000,000
	O/N at 39·2° F. followed by 4 hr. at 116·6° F.	< 100	–	100	< 100

After 40 and 75 min. cooking there was no growth of *Salmonella* from any site either direct or after storage at RT or at 116·6° F.

For notes see Table 3.

Table 8. *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with ca.* 880 *organisms and cooked at* 400° *F. (Expt.* 6)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	< 100	< 100	< 100	< 100
20	None	–	–	–	< 100
	O/N at RT	15,000	< 500	< 500	UC
	4 hr. at 131° F.	–	–	–	–

After 40 and 60 min. cooking there was no growth of *Salmonella* from any site, either direct or after storage at RT or at 131° F.

For notes see Table 3.

S. virchow, is not known to be particularly heat resistant; it is more likely that the chicken was recontaminated accidentally after removal from the spit-roasting oven.

In Expt. 3, but not in Expts. 1 and 2, salmonellas were recovered from the chicken examined directly after 40 min. cooking but not from the chickens stored overnight. In all three experiments salmonellas were detected directly after 20 min. cooking at 149° C. (300° F.) and after storage overnight.

When chickens were cooked at 107·2° C. (225° F.) (Expt. 4) and at 121° C. (250° F.) (Expt. 5) salmonellas were not recovered after 40 and 75 min. cooking whether the birds were examined immediately or after storage overnight (Tables 6, 7). When the cooking temperature was increased to 204° C. (400° F.) (Expt. 6) salmonellas were again only detected after cooking for 20 min. but not after 40 and 60 min. (Table 8). Chickens cooked for only 20 and 40 min. looked obviously undercooked.

When the experiments were repeated with chickens given mixed inocula and cooked at 204° C. (400° F.), 149° C. (300° F.) and 107·2° C. (225° F.) (Expts. 7–9) salmonellas were recovered from carcasses cooked for 20 min. but not from those cooked for 40 min. or 60–75 min. unless the cooking temperature was low, 107·2° C. (225° F.), when they survived 20 min. and 40 min. (Tables 9*a*, 10*a*, 11*a*).

Table 9(*a*). *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with ca.* 3250 *organisms and cooked at* 400° *F. (Expt.* 7)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	+	+
20	None	+	−	+	+
	O/N at RT	UC	UC	UC	UC
	O/N at 131° F.	−	−	−	−

After 40 and 60 min. cooking there was no growth of *Salmonella* from any site, either direct or after storage at RT or at 131° F.

For notes see Table 3.

Table 9(*b*). *Growth of* Clostridium welchii *from fully thawed chickens inoculated at different sites with ca.* 10,000 *organisms and cooked at* 400° *F. (Expt.* 7)

Cooking time (min.)	Storage	*Cl. welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	+	+
20	None	+	−	+	+
	O/N at RT	> 1,000,000	700,000	700,000	5,000,000
	O/N at 131° F.	−	−	< 500	−
40	None	−	−	−	−
	O/N at RT	< 500	−	< 500	15,000
	O/N at 131° F.	130,000	−	2,500,000	100,000
60	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N at 131° F.	−	−	−	< 500

For notes see Table 3.

Table 9(*c*). *Growth of* Staphylococcus aureus *from fully thawed chickens inoculated at different sites with approximately* 1000 *organisms and cooked at* 400° *F. (Expt.* 7)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	−	−	−
20	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N at 131° F.	−	−	−	−

After 40 and 60 min. cooking there was no growth of *Staphylococcus aureus* from any site either direct or after storage at RT or at 131° F.

For notes see Table 3.

Results from the last group of cooking experiments (Expts. 10–12) when partially thawed birds were used are given in Tables 12(*a*), 13(*a*), 14(*a*). The results showed that the salmonellas survived for longer than when fully thawed birds were used, and the survival time increased as the cooking temperature decreased.

Table 10(*a*). *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with approximately* 1650 *organisms and cooked at* 300° *F.* (*Expt.* 8)

Cooking time (min.)	Storage	Salmonellas/g. of chickens from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	−	+
20	None	+	−	−	+
	O/N at RT	UC	UC	UC	UC
	O/N at 143·6° F.	−	−	−	−

After 40 and 60 min. cooking there was no growth of *Salmonella* from any site, either direct or after storage at RT or at 143·6° F.

For notes see Table 3.

Table 10(*b*). *Growth of* Clostridium welchii *from fully thawed chickens inoculated at different sites with approximately* 1,650 *organisms and cooked at* 300° *F.* (*Expt.* 8)

Cooking time (min.)	Storage	*Cl. welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	+	+
20	None	+	−	−	+
	O/N at RT	1,500,000	10,000	3,500,000	2,000,000
	O/N at 143·6° F.	4,000,000	> 10,000,000	35,000	10,000,000
40	None	+	+	−	+
	O/N at RT	< 500	−	< 500	2,000
	O/N at 143·6 °F.	45,000	< 500	400,000	> 10,000,000
60	None	−	−	−	−
	O/N at RT	< 500	< 500	< 500	< 500
	O/N at 143·6° F.	1,100,000	−	> 10,000,000	> 10,000,000

For notes see Table 3.

Table 10(*c*). *Growth of* Staphylococcus aureus *from fully thawed chickens inoculated at different sites with approximately* 1,650 *organisms and cooked at* 300° *F.* (*Expt.* 8)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	−	−	−
20	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N at 143·6° F.	−	−	−	−

After 40 and 60 min. cooking there was no growth of *Staphylococcus aureus* from any site either direct or after storage at RT or at 143·6° F.

For notes see Table 3.

Table 11(*a*). *Growth of* Salmonella typhimurium *from fully thawed chickens inoculated at different sites with ca.* 2,500 *organisms and cooked at* 225° *F.* (*Expt.* 9)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	−	+
20	None	+	+	+	+
	O/N at RT	500	38,000	15,000	950,000
	O/N+	85,000	300,000	330,000	> 10,000,000
40	None	−	−	−	+
	O/N at RT	250	< 500	750	20,000
	O/N+	−	−	25,000	5,000
75	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N+	−	−	−	−

O/N+ = 3–6 hr. at 122° F. remainder of overnight period in slowly cooling cabinet.
For other notes see Table 3.

Table 11(*b*). *Growth of* Clostridium welchii *from fully thawed chickens inoculated at different sites with ca.* 17,500 *organisms and cooked at* 225° *F.* (*Expt.* 9)

Cooking time (min.)	Storage	*Clostridium welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	−	+	+
20	None	+	+	+	+
	O/N at RT	330,000	3,500,000	600,000	150,000
	O/N+	> 10,000,000	> 10,000,000	> 10,000,000	> 10,000,000
40	None)	+	−	−	+
	O/N at RT	6,500,000	< 500	300,000	200,000
	O/N+	5,250,000	15,000	> 10,000,000	> 10,000,000
75	None	−	−	−	−
	O/N at RT	−	−	−	1,300*
	O/N+	−	−	−	7,500

O/N+ = 3–6 hr. at 122° F. remainder of overnight period in slowly cooling cabinet.
* β-haemolytic strain not typable.
For other notes see Table 3.

When the partially thawed birds were cooked at 121° C. (250° F.) (Table 14(*a*)) salmonellas could be isolated after 40 min. but not after 60 min. when the cooked chickens were examined immediately; a few organisms were, however, still present after 60 min. cooking as shown by isolation from enrichment cultures and direct counts when the birds were stored overnight at room temperature. When partially thawed chickens were cooked the final temperatures were appreciably lower than those recorded when fully thawed chickens were cooked for the same length of time. In the last experiment (Expt. 12) the temperatures after cooking were below 60° C. (140° F.) so survival of salmonellas was likely. The chickens looked unappetizing after cooking and the outer surfaces looked pale and undercooked.

Table 11(*c*). *Growth of* Staphylococcus aureus *from fully thawed chickens inoculated at different sites with ca.* 2250 *organisms and cooked at* 225° *F.* (*Expt.* 9)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	−	+	+
20	None	−	−	+	+
	O/N at RT	< 500	< 500	< 500	< 500
	O/N +	−	−	6,500	−
40	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N +	−	−	−	−
75	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N +	−	−	−	−

O/N + = 3–6 hr. at 122° F. remainder of overnight period in slowly cooling cabinet.
For other notes see Table 3.

Table 12(*a*). *Growth of* Salmonella typhimurium *from partially thawed chickens inoculated at different sites with ca.* 15,000 *organisms and cooked at* 400° *F.* (*Expt.* 10)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	< 100	< 100	< 100	< 100
20	None	< 100	< 100	−	< 100
	O/N at RT	250	15,000	< 500	100,000
	O/N at 145·4° F	−	−	< 500	1,000
40	None	−	−	−	−
	O/N at RT	−	−	−	250
	O/N at 145·4° F.	−	−	−	−
60	None	−	−	−	−
	O/N at RT	−	−	−	−
	O/N at 145·4° F.	−	−	−	−

For notes see Table 3.

Survival of clostridial spores

The results of examination of cooked chickens inoculated with spores of *Cl. welchii* showed that the organism could not be found at the end of the longest cooking period when the chickens were examined immediately after cooking at all temperaturesused (Tables 9–14, (*b*) only). Nevertheless some spores survived, and after storage at room temperature overnight *Cl. welchii* was isolated in appreciable numbers from chickens cooked for 20 and 40 min. and in smaller numbers from chickens cooked for 60 and 75 min.

Table 12(*b*). *Growth of* Clostridium welchii *from partially thawed chickens inoculated at different sites with ca.* 250 *organisms and cooked at* 400° *F.* (*Expt.* 10)

Cooking time (min.)	Storage	*Cl. welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	–	–	–
20	None	–	–	–	–
	O/N at RT	750	30,000	< 100	33,000
	O/N at 145·4° F.	250,000	250	250,000	1,500,000
40	None	–	–	–	–
	O/N at RT	–	–	150	250
	O/N at 145·4° F.	–	–	–	–
60	None	–	–	–	–
	O/N at RT	–	–	–	–
	O/N at 145·4° F.	–	–	–	–

For notes see Table 3.

Table 12(*c*). *Growth of* Staphylococcus aureus *from partially thawed chickens inoculated at different sites with ca.* 625 *organisms and cooked at* 400° *F.* (*Expt.* 10)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	–	< 100	–
20	None	–	–	–	–
	O/N at RT	–	< 500	–	–
	O/N at 145·4° F.	–	–	–	–
40	None	–	–	–	–
	O/N at RT	–	–	–	< 500
	O/N at 145·4° F.	–	–	–	–
60	None	–	–	–	–
	O/N at RT	–	–	–	–
	O/N at 145·4° F.	–	–	–	–

For notes see Table 3.

Survival of staphylococci

A few isolations of *Staph. aureus* were made from chickens cooked for 20 min. only; the inoculated strain CI/1968/7895 was not recovered after cooking for longer periods (Tables 9–14, (*c*) only). Occasionally other strains of *Staph. aureus*, those occurring naturally in the chickens, could be isolated after 20 min. cooking and in one instance after 40 min. cooking at 149° C. (300° F.) (Table 10*c*). However, it appears that there is little or no danger from the growth of *Staph. aureus* in undercooked birds as the organism seems to die out quickly. Cross-contamination to and more particularly handling of cooked birds are far greater hazards.

Table 13(*a*). *Growth of* Salmonella typhimurium *from partially thawed chickens inoculated at different sites with ca.* 1,750 *organisms and cooked at* 300° *F.* (*Expt.* 11)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	+	+	+
20	None	+	+	+	+
	O/N at RT	50,000	> 100,000	200,000	+ + +
	O/N at 131° F.	–	–	–	< 500
40	None	+	–	–	+
	O/N at RT	100,000	3,000,000	> 10,000	> 10,000,000
	O/N at 131° F.	–	–	–	< 500
60	None	–	–	–	–
	O/N at RT	–	–	–	–
	O/N at 131° F.	–	–	–	–

+ + + = Not countable because of running together of colonies. Count very high.
For other notes see Table 3.

Table 13(*b*). *Growth of* Clostridium welchii *from partially thawed chickens inoculated at different sites with ca.* 20,000 *organisms and cooked at* 300° *F.* (*Expt.* 11)

Cooking time (min.)	Storage	*Cl. welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	+	–	+	+
20	None	+	+	–	+
	O/N at RT	2,000,000	1,300,000	100,000	5,500,000
	O/N at 131° F.	–	1,300	500	7,500
40	None	–	–	–	+
	O/N at RT	5,000,000	3,500,000	+ + +	> 10,000,000
	O/N at 131° F.	–	–	–	–
60	None	–	–	–	–
	O/N at RT	–	–	250	–
	O/N at 131° F.	–	–	–	–

+ + + = Not countable because of running together of colonies. Count very high.
For other notes see Table 3.

Effect of storage after cooking

The experiments also showed the importance of storage after cooking. In Expts. 1, 2, 4 and 5 inoculated undercooked chickens were stored overnight at 4° C. (39·2° F.) and then placed in an incubator or warm cabinet at 43° C. (109·4° F.), 47° C. (116·6° F.) and 55° C. (131° F.) for 4–5 hr. This would be comparable to placing chickens left over from a previous day's cooking straight from the refrigerator into a warm cabinet. At 43° C. (109·4° F.) the salmonellas increased in numbers (Table 3, 4), at 47° C. (116·6° F.) the salmonellas survived but could only be detected from enrichment cultures (Table 7) while at 55° C. (131° F.) no salmonellas could be detected at the end of the storage period (Table 6).

Undercooked chickens which had received a mixed inoculum were stored over-

Table 13(*c*). *Growth of* Staphylococcus aureus *from partially thawed chickens inoculated at different sites with ca.* 2250 *organisms and cooked at* 300° *F.* (*Expt.* 11)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	–	+	–
20	None	–	–	–	–
	O/N at RT	+	–	> 500*	UC*
	O/N at 131° F.	–	–	–	–
40	None	–	–	–	+*
	O/N at RT	–	–	–	< 500*
	O/N at 131° F.	–	–	–	–
60	None	–	–	–	–
	O/N at RT	–	–	–	–
	O/N at 131° F.	–	–	–	–

* = *Staph. aureus* naturally occurring in chickens.
For other notes see Table 3.

Table 14(*a*). *Growth of* Salmonella typhimurium *from partially thawed chickens inoculated at different sites with ca.* 875 *organisms and cooked at* 250° *F.* (*Expt.* 12)

Cooking time (min.)	Storage	Salmonellas/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	< 100	< 100	< 100	200
20	None	< 100	< 100	< 100	200
	O/N at RT	30,000	2,500,000	1,000,000	200,000,000
40	None	< 100	–	–	< 100
	O/N at RT	3,300	43,000,000	400,000	250,000,000
60	None	–	–	–	–
	O/N at RT	–	–	200	1,000

For notes see Table 3.

Table 14(*b*). *Growth of* Clostridium welchii *from partially thawed chickens inoculated at different sites with ca.* 1,500 *organisms and cooked at* 250° *F.* (*Expt.* 12)

Cooking time (min.)	Storage	*Cl. welchii*/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	–	–	< 100
20	None	–	–	–	–
	O/N at RT	1,300,000	2,300,000	250,000	2,500,000
40	None	–	–	–	–
	O/N at RT	500,000	15,000,000	35,000	28,000,000
60	None	–	–	–	–
	O/N at RT	–	10,000	200,000	750

For notes see Table 3.

Table 14(*c*). *Growth of* Staphylococcus aureus *from partially thawed chickens inoculated at different sites with ca.* 340 *organisms and cooked at* 250° *F.* (*Expt.* 12)

Cooking time (min.)	Storage	Staphylococci/g. of chicken from sites (*a*)	(*b*)	(*c*)	(*d*)
Uncooked	None	–	–	< 100*	< 100*
20	None	–	–	–	+*
	O/N at RT	1,000*	1,300	30,000	–
40	None	–	–	–	–
	O/N at RT	< 500	–	< 500	< 500
60	None	–	–	–	–
	O/N at RT	–	–	–	–

* *Staph. aureus* naturally occurring in chicken.
For other notes see Table 3.

night (18–21 hr.) in a warm cabinet at 55° C. (131° F.), 62° C. (143·6° F.) and 63° C. (145·4° F.). The chickens were also stored at 50° C. (122° F.), but the warm cabinet was accidentally disconnected and they were only at this temperature for 3–6 hr. and for the remainder of the overnight period they were slowly cooling. Under these conditions there was a large increase in numbers of surviving salmonellas and *Cl. welchii* but only a slight increase in numbers of *Staph. aureus* (Tables 11*a–c*). This illustrates the danger of switching off a warm cabinet still containing cooked chickens and leaving them until the next day.

When chickens were stored after cooking at 55° C. (131° F.) salmonellas were not detected in one experiment (Table 9*a*), but they were detected in small numbers after 20 and 40 min. cooking at 149° C. (300° F.) in the cavity of the chicken in another experiment (Table 13*a*). In both instances there was an increase in the numbers of *Cl. welchii* (Tables 9*b*, 13*b*).

Salmonellas were not found in birds stored at 62° C. (143·6° F.) overnight but were recovered after storage at 63° C. (145·4° F.) in low numbers from the cavity and from the area between the leg and the body of the birds cooked for 20 min. (Tables 10*a*, 12*a*). The discrepancy may have been due to fluctuations in temperature of the warm storage cabinet which was also used to dry apparatus. *Cl. welchii* survived and increased in numbers in chickens stored at both these temperatures. (Tables 10*b*, 12*b*).

There is, therefore, a potential danger from the storage of cooked chickens in a warm cabinet when the temperature is not high enough to prevent growth of *Cl. welchii*; in these experiments 63° C. (145·4° F.) was the highest temperature used for storage overnight. It is suggested that storage cabinets should be either chilled or heated to 65° C. (149° F.).

Table 15. *Growth of intestinal pathogens in cooked chicken breast meat at different temperatures*

Storage temperature		Viable counts (thousands) per gram after				
° C.	° F.	0 hr.	6 hr.	24 hr.	30 hr.	48 hr.
		Salmonella typhimurium 425/g.				
4	39	1·2	1·3	0·5	0·3	1·4
22	72	.	1·8	60,000	400,000	500,000
30	86	.	10	3,500,000	500,000	3,500,000
43	109	.	280	450,000	200,000	30,000
55	131	.	0·25	< 0·5	< 0·5	< 0·5
		Clostridium welchii 2,250/g.				
4	39	0·7	1·1	0·2	0·7	1·4
22	72	.	< 0·5	230	10,000	45,000
30	86	.	35	1,500	18,000	1,500,000
43	109	.	1,500	200,000	200,000	30,000
55	131	.	1,500	< 0·5	< 0·5	< 0·5
		Staphylococcus aureus 325/g.				
4	39	< 0·1	< 0·1	< 0·1	< 0·1	< 0·1
22	72	.	< 0·5	50	550	200
30	86	.	< 0·5	2,500	1,500	2,000
43	109	.	< 0·5	2,500	2,500	1,000
55	131	.	< 0·5	< 0·5	< 0·5	< 0·5
		Total aerobic count				
4	39	6·0	3·8	2·9	5·0	55
22	72	.	10	150,000	2,000,000	4,000,000
30	86	.	30	4,000,000	2,500,000	15,000,000
43	109	.	3,500	3,000,000	4,500,000	2,000,000
55	131	.	2·8	0·25	0·5	15,000

GROWTH OF FOOD POISONING ORGANISMS IN COLD COOKED CHICKEN MEAT

Several experiments were carried out in which cooked chicken portions were inoculated with a mixture of *S. typhimurium* phage type 2c(14), spores of *Cl. welchii* type ix and *Staph. aureus* and left at various temperatures.

The results showed that bacteria known to cause food poisoning grow well in chicken meat (Table 15).

Growth was best at warm atmospheric temperatures when there may be a dangerous increase in the number of bacteria. The experiments were commenced with cold cooked chickens but there would be a greater increase in numbers if the cooked chickens were warm from the oven or warming cabinet.

The results emphasize the need for correct storage after cooking. When the chickens were stored in the refrigerator at approximately 4° C. (39·2° F.) the organisms did not die but the count remained stationary, although there was a tendency for numbers to increase after 48 hr. When stored at 22°, 30° and 43° C. (71·6°, 86·0° and 109·4° F.) numbers increased up to high levels thought to be significant in food poisoning. When stored at 55° C. (131° F.) there was an initial

Table 16. *Incidence of salmonellas in frozen chickens from four English packing stations* (1970–71)

Producer	Birds examined	Birds positive	Positive (%)	Serotypes isolated
A	53	33*	62	*S. senftenberg* (30) *S.* 4,12:d:– (4)
B	56	7	13	*S. senftenberg* (4) *S. montevideo* (1) *S. agona* (2)
C Code A	53 (37)	30† (14)	57 (38)	*S. livingstone* (9) *S. typhimurium*, phage type 1 (8) *S. enteritidis*, phage type 8 (1)
C Code P	53 (16)	30† (16)	57 (100)	*S. bredeney* (15) *S. livingstone* (3) *S. anatum* (1)
D	39	1	3	*S. bredeney*
Total	201	71	35	9 serotypes

* One chicken contained two serotypes.
† Seven chickens contained two serotypes.

increase in numbers of *Cl. welchii*, probably while the cold chicken was warming up; thereafter the organism died out. Salmonellas survived 6 hr. at 55° C. (131° F.) but the numbers dropped almost tenfold, and the organisms could not be recovered later. It is important to note that although storage at 55° C. (131° F.) is ultimately lethal to many organisms, multiplication may occur before chickens reach this temperature. It is therefore unsafe to put cold cooked chickens into a warming cabinet even if the temperature setting is high. Chickens left over from a previous cooked batch should be cooled rapidly, refrigerated and sold cold. The temperature of cabinets for storage of hot freshly cooked chickens should not be lower than 65° C. (149° F.).

INTESTINAL PATHOGENS IN FROZEN DRESSED CHICKENS

All the chickens used in the investigation were examined for the presence of the food poisoning organisms *Salmonella*, *Cl. welchii* and *Staph. aureus*.

Salmonellas were isolated from 71 of 201 (35%) of raw carcasses from four English packing stations. The lowest rates of contamination were 3% of 39 birds and 13% of 56 birds. The highest rates of contamination were 62% and 100% of 53 and 16 birds respectively. There were nine different salmonella serotypes all of which are known to cause human salmonellosis. The results are shown in Table 16.

Cl. welchii were isolated from 115 of 183 (63%) of chicken samples and the highest rate of contamination was 92% of 37 carcasses. The results with serotypes are given in Table 17.

Spores of this organism can survive heat-treatment, boiling or even light roasting. They are encouraged to germinate by cooking and the bacilli subsequently multiply

Table 17. *Incidence of* Clostridium welchii *in frozen chickens from four English packing stations* (1970–71)

Producer	Birds examined	Birds positive	Positive (%)	Serotypes isolated
A	42	25*	60	Type 18 (23) Not typable (5)
B	56	36†	64	Type 3 (29) Type 6 (1) Not typable (7)
C Code A	53 37	48‡ 34	91 92	Type 3 (4) Type 4 (1) Not typable (32)
C Code P	53 16	48‡ 14	91 88	Type 5 (6) Type 4 (1) Type 11 (1) Not typable (8)
D	32	6	19	Not typable (6)
Total	183	115	63	7 serotypes 56 untypable strains

* One chicken contained 3 serotypes and one chicken 2 serotypes.
† One chicken contained 2 serotypes.
‡ Five chickens contained 2 serotypes.

Table 18. *Incidence of* Staphylococcus aureus *in frozen chickens from four English packing stations* (1970–71)

Producer	Birds examined	Birds positive	Positive (%)	Predominant phage types
A	40	35	88	75 (10)
B	47	29	62	Not typable (20)
C Code A	53 37	19 10	36 27	No predominant phage type
C Code P	53 16	19 9	36 56	53/75 (4) 75 (4)
D	32	25	78	53 (11)
Total	172	108	63	

rapidly in slowly cooling masses of meat and poultry, so that rapid cooling and cold storage after cooking is very important if the chicken is not to be eaten freshly cooked and hot.

Staph. aureus was isolated from 108 of 172 samples of raw chicken. The highest rates of contamination were 78% and 88% of 32 and 40 carcasses respectively. The results, showing isolation rates and predominant phage types, are given in Table 18. Seventy strains of *Staph. aureus* were tested for enterotoxin production, one strain produced enterotoxin B and two strains produced enterotoxin C.

The danger of cross-contamination from raw to cooked poultry and the necessity for care in storage after cooking is relevant to contamination of poultry with all three food poisoning organisms.

Table 19. *Organisms isolated from 38 samples of cooked chicken from supermarkets, fish bars and delicatessens*

	Distribution of counts and pathogens				
	$< 5 \times 10^2$/g.	5×10^2–10^3/g.	10^3–10^4/g	$> 10^4$/g.	Total
TVC at 37° C./g.	11	6	12	9	38
Salmonella	0	0	0	0	0
Cl. welchii	3	0	6	1	10
Staph. aureus	3	2	5	0	10
Coliform bacilli (faecal)	0	0	5 (1)	6	8 (1)

TVC = total viable count.

ENVIRONMENTAL STUDIES AND EXAMINATION OF SPIT-ROASTED CHICKENS FROM RETAIL PREMISES

A survey of spit-roasting establishments showed faults in the handling procedures of raw and cooked poultry. One employee was usually responsible for both preparation of raw birds for the spit and delivery of cooked birds, whole or in portions, to the shop. The same boards or other surfaces, knives and other utensils and the same hands were used to carry raw birds to, and cooked birds from the spit.

In one of the five stores investigated, *S. typhimurium* was isolated from scrapings taken from a chopping board used both for the preparation of raw poultry carcasses for the spit and for cutting the cooked birds into portions for sale. It was observed that the cooked portions were exposed for sale unrefrigerated.

Results of examination of many samples of cooked chicken showed that heat-sensitive organisms such as *Staph. aureus* and coliform bacilli were present; it is likely that they came from hands, utensils and surfaces contaminated by the raw materials. Some heat-resistant organisms may have survived cooking or they may have reached the carcasses after cooking. Salmonellas were not found on the cooked chicken samples. The results are summarized in Table 19.

Handling and storage after cooking was regarded as a most important factor in the safety and keeping quality of cooked poultry.

CONCLUSIONS

Thawing

The recommended thaw times for 2–3 lb. chickens by the four methods tested are as follows:

(1) *Room temperature* 15–21° *C.* (59–70° *F.*). Left in polythene bag approx. 3 hr./lb. Polythene bag removed approx. 2 hr./lb.

(2) *Domestic refrigerator* 4° *C.* (39·2° *F.*). Left in polythene bag approx. 8 hr./lb. Polythene bag removed approx. 8 hr./lb. (the latter is not recommended as the skin becomes dry and patchy and spoils the appearance of the chicken).

(3) *Under cold running water* 16–21° *C.* (60·8–69·8° *F.*). Left in polythene bag approx. 1¼ hr./lb.

(4) *Room temperature removing the giblets as soon as possible.* Left in polythene bag approx. 2¼ hr./lb. Polythene bag removed approx. 1¾ hr./lb.

The thaw times were converted to hr./lb. weight of chicken to take into account the small differences in weights of the birds used. Experiments were carried out with chickens of one weight group only (2–3 lb.). Klose, Lineweaver & Palmer (1969) thawing turkeys of different weight classes at ambient air temperatures showed that the time of thawing was not proportional to the weight of the bird. At 12·8° C. (55° F.) turkeys weighing 4–6 lb. thawed in 10 hr. while 20–22 lb. birds required only 23 hr. to thaw.

Cooking

From the results of the cooking experiments, recommended cooking times and temperatures for cooking on the spit can be given as follows (preheated oven):

° F.	° C.	min./lb.
300	149	25–30
400	204	20–25

The results of this study show that spit-roasting fully thawed chickens until the outer skin is golden brown (i.e. they look 'done') gives adequate heat-treatment to kill salmonellas and staphylococci, but heat-resistant strains of *Cl. welchii* may survive recommended procedures. Hussemann & Wallace (1951) using conventional cooking methods found that chickens containing large numbers of *S. typhimurium* when broiled for 41 min. or roasted at 163° C. (325° F.) for 35 min./lb. still contained viable salmonellas at the end of the cooking period. But Mabee & Mountney (1970) could not recover *S. senftenberg* 775 W from chicken portions which were deep-fried at atmospheric or 15 lb. pressure for 11 min.

If chickens are not fully thawed, then the internal temperatures reached when the outside looked cooked may not be high enough to kill salmonellas; the lower the cooking temperature the greater the chance of survival.

A high proportion of raw frozen chickens may contain salmonellas but probably low numbers only. If the organisms survive cooking there would be little hazard of food poisoning if the poultry meat is eaten hot and freshly cooked, but when the salmonellas are allowed to grow in warm cooked flesh (e.g. overnight in a warm kitchen) they may increase to numbers able to cause clinical disease.

The results suggest that care in thawing and cooking might lessen the danger from food poisoning but the greatest emphasis should be placed on correct procedure *after* cooking.

Storage

If warm cabinets are used to store freshly cooked chickens they must be hot enough to prevent the survival and multiplication of salmonellas and *Cl. welchii*. The cooked chickens should not be allowed to cool before being placed in the hot cabinet. Cooked poultry required to be eaten cold should be cooled rapidly and refrigerated (or kept as cold as possible) for a limited period of time; it should be sliced when cold not hot.

Cross-contamination

Cooked chicken meat is a good growth medium for salmonellas, *Cl. welchii* and *Staph. aureus*. Any or all of these organisms are present in a large proportion of raw birds and they must be prevented from reaching cooked birds. Precautions to

(1) Keep separate from other foods

(2) Thawing (chickens 2–3 lb.)

	Left in polythene bag	Polythene bag removed
Room temperature 15–21° C. (59–70° F.)	*ca.* 3 hr./lb.	*ca.* 2 hr./lb.
Refrigerator 4° C. (39° F.)	*ca.* 8 hr./lb.	*ca.* 8 hr./lb.
Cold running water	*ca.* 1¼ hr./lb.	—
Room temperature removing giblets as soon as possible	*ca.* 2¼ hr./lb.	*ca.* 1¾ hr./lb.

(3) Remove giblets and wash hands

DO NOT WASH AND DO NOT WIPE

(4) Cook stuffing separately (for conventional roasting methods).

(5) Cooking on spit (chicken 2–3 lb.):
Preheat oven 149° C. (300° F.) 25–30 min./lb.
204° C. (400° F.) 20–25 min./lb.

(6) Wash hands and clean surfaces and equipment before taking cooked poultry out of oven. Avoid use of all-purpose cloths, use disposable paper 'kitchen towels'.

(7) EAT FRESHLY COOKED OR COOL QUICKLY AND STORE COLD.

(8) Avoid handling cooked product.

Fig. 1. Recommended label instructions for frozen chickens

prevent cross-contamination should include the following: (*a*) separate areas, surfaces, utensils and even personnel for handling raw and cooked chickens; (*b*) all surfaces and implements should be thoroughly cleaned as soon as the chickens are placed in the oven; and (*c*) hands must be washed between handling raw and cooked chickens.

Whole cooked chickens should be dissected using meat secateurs or similar implements. Carving should be carried out immediately before service to the table. *Staph. aureus* is found on the skin of many people as well as in cuts, boils and other septic lesions and is frequently transferred to cooked food by hands.

While a high proportion of raw chickens are contaminated with salmonellas the danger of salmonella food poisoning cannot be ruled out. While advice on efficient methods of thawing and cooking is a useful precautionary measure, more emphasis must be given to the danger of cross-contamination from raw to cooked birds by hands, surfaces, equipment and utensils and low temperature storage of cooked birds. Recommended label instructions are given in Fig. 1.

It is felt that efforts should be directed towards the provision of salmonella-free flocks, so that dressed poultry may be free from salmonellas before retail sale.

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