Teagasc
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Irish Domestic Food Safety Knowledge, Practice and Microbiology with Particular Emphasis on *Staphylococcus aureus*

The National Food Centre

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RESEARCH REPORT NO 69

IRISH DOMESTIC FOOD SAFETY KNOWLEDGE, PRACTICE AND MICROBIOLOGY WITH PARTICULAR EMPHASIS ON *STAPHYLOCOCCUS AUREUS*

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SUMMARY

This study examined consumer food safety knowledge on the island of Ireland. Domestic refrigerators were tested for the presence of a range of pathogenic bacteria. The effect of refrigerated storage on the antibiotic resistance and thermal resistance of *S. aureus* were also investigated. Irish consumers displayed a considerable lack of knowledge about correct refrigeration temperatures and proper hygiene procedures to prevent cross-contamination in the kitchen. Domestic refrigerators were contaminated with a range of bacterial pathogens including *S. aureus* (41%), *Salmonella* spp. (7%), *Escherichia. coli* (6%), *Listeria monocytogenes* (6%) and *Yersinia enterocolitica* (2%).

The average temperature of some domestic refrigerators would be likely to support the growth and multiplication of *S. aureus*. Additional research demonstrated that chilled storage did not significantly enhance the resistance of these pathogens to antibiotics nor to subsequent thermal treatments such as cooking.

INTRODUCTION

Every year there are thousands of confirmed cases of food poisoning in Ireland and many more go unreported. This represents an unacceptable cost in terms of human suffering and an economic loss to the Irish economy in terms of medical treatment and lost working days. Without doubt, many food poisoning cases originate in the domestic environment when correct food handling, storage and preparation practices are not observed. Thus agencies such as *Safefood, the Food Safety Promotion Board* are charged with the task of educating the public on correct practices for handling and preparing food in the home.

The objectives of this research were:

1. to conduct a knowledge survey to establish consumer awareness of how food should be hygienically handled and stored

2. to conduct a research survey to test for the presence of bacterial pathogens in Irish domestic refrigerators
3. to conduct research investigating the effect of refrigerated storage on the growth and resistance of *S. aureus*.

FOOD SAFETY KNOWLEDGE SURVEY

Approximately 1020 homes were visited throughout the island of Ireland. The locations were selected by the Marketing Research Bureau of Ireland (MRBI) to ensure the sample was demographically representative of Irish society. In each home, the person mainly responsible for food purchase, storage and preparation was interviewed and a knowledge survey completed. The data obtained were analysed using the Statistical Packages for the Social Sciences (SPSS). The main findings were:

- the time lapse from retail purchase of food to domestic refrigeration was less than 30 minutes (58%), 30 to 90 minutes (35%), 90 minute to 3 hours (6%) or more than 3 hours (1%).
- only one fifth of respondents (22.4%) were aware of the correct refrigeration temperature (1 to 5°C).
- approximately one quarter (23.2%) of surveyed refrigerators contained a thermometer.
- respondents in lower income households (C2DE)* were significantly ($P > 0.001$) less likely to know the correct refrigeration temperature.

* Social class A includes upper middle class occupations such as senior professionals, chartered accountants, architects who are partners in the business, dentists and senior executives. Social class B includes middle class occupations ranging from recently-qualified professionals and army lieutenants to head masters in small schools. Class C1 are other white collar workers, including junior civil servants and secretaries. Class C2 are skilled workers, such as electricians. Class D are unskilled workers. Class E includes casual workers and pensioners dependent on state pensions and with no other income and those on social security. Class F are farmers.

- younger respondents (< 25 years old) were significantly ($P < 0.005$) more knowledgeable than older respondents (>25years old).
- approximately half of consumers reportedly stored raw meat correctly (on the bottom shelf / drawer) in their refrigerators.
- respondents indicated that they used a variety of agents for cleaning their refrigerator including washing-up liquid (39.4%), sanitizer or detergent (31.7%), baking soda (16.3%), vinegar (10.4%), salt (0.1%) and water (2.1%). They used these cleaning agents hot (10.8%), warm (71.3%) or cold (7%) and applied them with a dish-cloth (54.7%), a clean cloth (21.1%), a paper towel (12%), a "J-cloth" (9.4%) or a sponge (2.8%).
- to prevent cross-contamination via knives, respondents reportedly washed the knife with detergent and hot water (72.8%), wiped the knife with a cloth (13.3%), rinsed the knife using cold water (7.5%), used the knife as it was (*i.e.* without cleaning - 2.8%), used separate knives for raw meat and cooked foods (2.2%) or washed the knife with detergent, hot water and bleach (1.3%).
- to prevent cross-contamination via cutting boards, respondents reportedly washed the board with detergent and hot water (72%), wiped the board with a cloth (13.1%), rinsed the board with cold water (6.1%), re-used the board without cleaning (3.5%), used a separate cutting board (3%) or washed the board with detergent, hot water and bleach (3%).
- of the 56.5% respondents who had a pet, 302 (52.4%) allowed the pet into the kitchen.
- when asked to identify those occasions when hand washing was important, respondents indicated 'before meals' (69.9%), 'after handling raw meat' (64.6%) and 'after using the toilet' (49.6%). Only 7% reported after touching a pet as an occasion when hand washing was important.
- respondents described a variety of hand washing practices. The method of hand washing considered correct included using (ordinary) soap and warm / hot water (63.7%), antibacterial soap and warm / hot water (21.7%) and washing-up liquid and hot water (4.1%). The methods

considered incorrect were rinsing with warm / hot water (without soap) (6.6%), rinsing with cold water (3.0%) and wiping with a tea towel, dish-cloth or "J-cloth" (0.9%).

- respondents reported defrosting frozen meat at room temperature (56.2%), in the refrigerator (23.6%), or in a microwave oven (13.1%).
- respondents stored meat leftovers in the fridge (57.6%), in the oven (6.0%), at room temperature on a table or counter (5.2%), in the freezer (2.9%) and in an un-refrigerated cupboard (1%).
- In terms of reheating meat, respondents reported heating leftovers until they were hot (42%), warm (10.1%) or serving cold (20.1%) and this question was not applicable to 27.8% of respondents.
- when asked how they cooked roast beef, steak and beef burgers they reported that meats were cooked until "well done" (roast beef - 83.7%, steak - 75.6%, beef burgers - 82.7%), "medium" (roast beef - 9.7%, steak - 15.8%, beef burgers - 2.5%) or "rare" (roast beef - 3.2%, steak - 5.3% and beef burgers - 0.1%).
- respondents used a variety of tests to check that red meat was sufficiently cooked including visual inspection (39.7%), "until the juices ran clear" (28%), "brown inside" (12.5%), cooking for a specified period (7.5%) and "until the meat falls from the bone" (5%).
- in relation to poultry, respondents checked such meat was sufficiently cooked by visual inspection (32.5%) "until the juices ran clear" (30.6%), until brown (outside) (13.6%), cooking for a specified period (8.4%), "until meat falls from the bone" (8.5%) and "by taste" (2.8%).
- when asked to estimate the percentage of food poisoning associated with home food preparation, 38.9% of respondents suggested up to 20% of cases, 18.7% of respondents suggested between 21% and 40% of cases, 23.4% of respondents suggested between 41% and 60% of cases, 13.9% of respondents suggested between 61% to 80% of cases, and 1.7% of respondents suggested between 81% and 100% of cases. The remainder, (3.3%) did not express an opinion. Those consumers who believed that

less than 20% of food poisoning occurred in the home were significantly ($P < 0.05$) less likely to wash their hands correctly.

- when questioned about direct experience of food poisoning within the last 12 months, approximately four fifths (80.5%) of respondents claimed the question was not applicable as neither they nor a family member had suffered from food poisoning during that time.
- of those who had experience of food poisoning within the last 12 months, respondents suspected restaurants (31.8%), the home (26.7%), take-aways (20%), mobile take-aways (12.8%), barbeques (2.0%) and crèches (0.5%). 6.2% of those who had experience of food poisoning within the last 12 months did not express an opinion as to the potential source of the illness.
- respondents reported learning correct food safety practices from their parents or grandparents (52.1%), school (28.4%), general experience (25.6%), television (21%), newspapers or magazines (16.6%) work (8%), third level education (6.5%), brochures (5.7%), friends (4.9%), cooking classes (4.3%), food safety agencies (2.9%), radio (1.8%), medical doctors (1.1%) and the internet (0.5%).

The levels of knowledge of food poisoning agents is summarised in Table 1. Respondents reported having heard of *Salmonella* (92.9%), *E. coli* O157 (77%) and *L. monocytogenes* (45.2%). A range of other pathogens such as *Campylobacter*, *Bacillus cereus*, *S. aureus*, *Clostridium perfringens*, *Clostridium botulinum*, *Y. enterocolitica* and viruses were each reported by less than 11% of respondents. In general, respondents had limited success in associating pathogens with particular foods. The most frequently reported association was between *Salmonella* and eggs (44%). Some of the other correct associations reported were between *E. coli* O157 and beef (38.7%) and *L. monocytogenes* and soft cheese (28.1%). Interestingly, respondents with more correct microbial knowledge were significantly ($P < 0.05$) more likely to correctly store raw meat and to correctly clean knives and cutting boards.

Table 1: Knowledge about different food poisoning agents (micro-organisms) among Irish consumers.

Micro-organism	Had heard of the bacteria (%)	Associated micro-organism with relevant food (as a % of those who had heard of the micro-organism)		
		Poultry	Pork	Eggs
Salmonella	92.9	23.1	4.7	44
Listeria monocytogenes	45.2	Beef 9.1	Soft cheese 28.1	Vegetables 2.9
		Meat	Water	Salads
Shigella	5.6	7.1	8.9	1.8
		Beef	Raw milk	Burgers
E. coli O157	77	38.7	2.1	15.9
		Poultry	Pork	Eggs
Campylobacter	10.2	19.6	1	3.9
		Rice	Cream/milk	Soup
Bacillus cereus	10.1	9.9	5	0
Staphylococcus aureus	2.5	Milk 2.5	Eggs 0.6	People 21.7
Clostridium perfringens	5.2	Meat 9.6	Spices 0	
Clostridium botulinum	16.7	Canned foods 14.4	Meat 12.6	
Yersinia enterocolitica	1.5	Pork 33.3		
		Shellfish		
Viruses	18.3	6.6		

In 806 homes, the refrigerator was swabbed and the total viable count (TVC), total coliform count (TCC) and the presence or absence of *Escherichia coli*, *Salmonella*, *Campylobacter*, *Listeria monocytogenes*, *Yersinia enterocolitica*, *Staphylococcus aureus* and *Escherichia coli* O157 established using standard International Standards Organisation (ISO) microbiological methods.

The TVC ranged from 0 $\log_{10}$ cfu cm^{-2} to 9.56 $\log_{10}$ cfu cm^{-2} (3,630,780,548 cells per square cm). The TCC ranged from 0 $\log_{10}$ cfu cm^{-2} to 6.43 $\log_{10}$ cfu cm^{-2} (2,691,535 cells per square cm). The average TVC and TCC were 7.1 $\log_{10}$ cfu cm^{-2} (12,589,254 cells per square cm) and 4.0 $\log_{10}$ cfu cm^{-2} (10,000 cells per square cm) respectively (see Table 2). A

Table 2: Bacterial contamination in Irish domestic refrigerators

Test	Result	
	$\log_{10}$ cfu/cm^2	% incidence
Total Viable Count (TVC)	7.1	N/A
Total Coliform Count (TCC)	4.0	N/A
E. coli	N/A	6
Salmonella	N/A	7
Campylobacter	N/A	0
L. monocytogenes	N/A	6
Y. enterocolitica	N/A	2
S. aureus	N/A	41
E. coli O157	N/A	0

N/A = not applicable

number of the target pathogens were detected in the sampled refrigerators *i.e. S. aureus* (41%) *Salmonella* spp. (7%), *E. coli* (6%), *L. monocytogenes* (6%) and *Y. enterocolitica* (2%). *Campylobacter* spp. and *E. coli* O157:H7 were not detected.

FOOD SAFETY REFRIGERATION TEMPERATURE STUDY

The temperature profile over a period of 72 hours was established in 100 randomly selected homes. Forty were at the recommended temperature of 0°C to 5°C, 54 were between 5°C and 10°C and 6 had an average temperature higher than 10°C.

Growth of *Staphylococcus aureus* at domestic refrigeration temperatures

Five cocktails (each containing 5 *S. aureus* isolates) were inoculated into Tryptone Soya Broth (TSB) and incubated at the average domestic refrigeration temperature profile. There was neither an increase nor a decrease in bacterial numbers over the course of the 196 hour storage period. However, the temperature abuse domestic refrigerator temperature profile (obtained by averaging the highest 5 temperature profiles in the domestic fridge temperature survey) showed an increase in bacterial numbers of approximately 3 $\log_{10}$ cfu ml^{-1} over the same time period (Figure 1).

The effect of domestic chilling on the antibiotic resistance of *Staphylococcus aureus*

S. aureus isolates tested (n=25) were all resistant to penicillin. Resistance to other antibiotics including erythromycin (4 isolates), streptomycin (5 isolates), gentamycin (2 isolates), mupirocin (3 isolates), tetramycin (2 isolates) and chloramphenicol (6 isolates) was also observed. After 1 week at the average refrigeration temperatures previously recorded in domestic refrigerators, the pattern of resistance changed slightly. The number of isolates resistant to erythromycin, gentamycin and chloramphenicol decreased by 3, 2

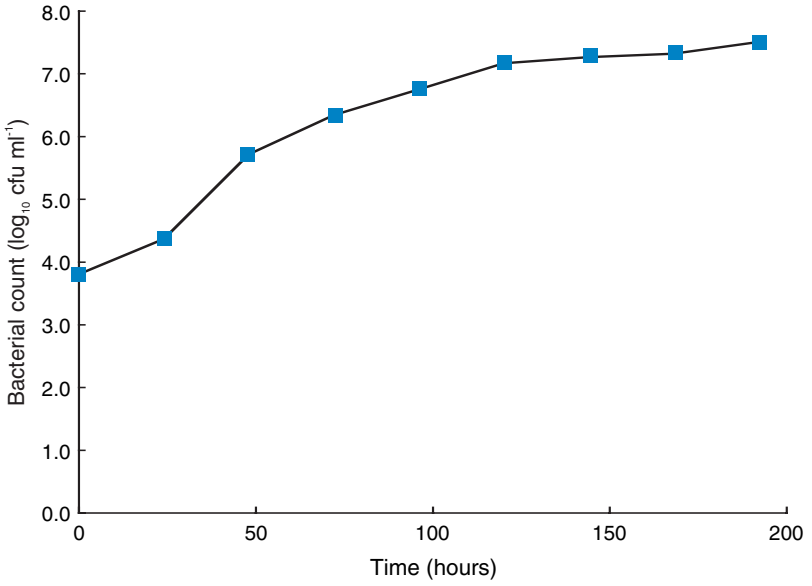

Figure 1: The growth of *S. aureus* at a temperature profile obtained by averaging the five highest domestic refrigerator temperature profiles.

and 5 respectively while the numbers resistant to streptomycin, mupirocin and tetramycin increased by 2, 2 and 1 respectively.

The effect of domestic chilling on the thermal resistance of *Staphylococcus aureus*

A cocktail of *S. aureus* isolates was heat-treated in TSB at 50, 55 and 60 °C with and without pre-chilled storage. Surviving cells were enumerated by plating onto Tryptone Soya agar (TSA) overlaid with Baird Parker agar (BPA). The thermal resistance D-values (time required to destroy 90% of the bacterial population at a given temperature) are shown in Table 3. Chilled storage had no significant effect on thermal resistance.

Table 3: D-values for *S. aureus* isolates with and without chilling

Temperature (°C)	Storage conditions	D-value (min)
50	No chilling	104.2
50	Pre-chilling	112.4
55	No chilling	20.4
55	Pre-chilling	20.0
60	No chilling	5.9
60	Pre-chilling	6.5

CONCLUSIONS

Current domestic refrigeration temperatures may support the growth of pathogenic bacteria like *S. aure*us. Irish consumers need to be educated on correct refrigeration temperatures (1°C to 5°C), supplied with food safe thermometers by refrigerator manufacturers and shown how to monitor the chilled storage conditions in their refrigerators. Furthermore, information should also be provided on recommended refrigerator cleaning practices.

Irish consumers need education on cross-contamination during food storage and preparation. This should include the potential role of hands, knives, forks, chopping boards etc.

A basic knowledge of pathogens like *Salmonella*, *E. coli* O157, etc. and associated foods would facilitate an understanding of safe food practices and provide motivation to store and handle foods in a hygienic manner.

Chilled storage does not enhance the antibiotic resistance nor the thermal resistance of *S. aureus*.

RECOMMENDATION

It is recommended that the food safety risk communication message has an educational focus on [1] chilled storage and [2] cross-contamination and basic microbiological information (pathogens and associated foods) should be used as the motivational factor.

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