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Issuing Temperature Guidance to Consumers on the Cooking and Storage of Food

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For use by Food Safety Advisors

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Foreword

I am pleased to present this report on issuing temperature guidance to consumers on the cooking and storage of food. This report is the result of the collaboration of public health, food safety and consumer organisations in Ireland, North and South.

Temperature control is critical to ensuring food safety for all consumers. Currently there is much advice and guidance to consumers on the storage and cooking of foods. In order to harmonise the advice, this report presents general guidance for agencies and professionals providing food safety advice to consumers.

I would like to thank ***safefood***, the Food Safety Promotion Board, the Food Standards Agency Northern Ireland, the Food Safety Authority of Ireland, the National Hygiene Partnership and the General Consumer Council for Northern Ireland for their substantial contributions in preparing this report. I would also like to thank Derry City Council for their support throughout.

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1. Introduction

1.1 Background

The purpose of this document is to provide guidance information for agencies, such as health boards, district councils, consumer bodies and others, who produce consumer advice on cooking and storage of food. There is currently much advice and guidance to consumers on the storage and cooking of foods in order to prevent food poisoning. On reviewing this advice it becomes apparent that there are inconsistencies, particularly in relation to the temperature recommendations used for cooking. These inconsistencies may lead to confusion and should be avoided in order that clear messages aimed at modifying consumer behaviour in the home can be communicated. To address this issue, ***safe*food**, the Food Safety Promotion Board, convened a cross-agency working group to consider the most appropriate general guidance that would be acceptable to agencies and professionals providing food safety advice. This report presents the advice agreed by the working group.

1.2 Terms of reference

To produce guidance for agencies, in Northern Ireland and the Republic of Ireland, who are providing advice to consumers on temperature control in relation to cooking and storage of food.

1.3 Scope

The document focuses on qualitative consumer recommendations supported by a scientific rationale. A qualitative approach was adopted given that, at the present time, very few consumers on the island actually use a temperature probe, thus making temperature recommendations of limited use. The document outlines the key safety issues related to each of the processes where temperature control is important for consumers. On the basis of these safety issues, a range of suitable consumer messages have been included which may be used in issuing advice to consumers. The messages produced in this document are simply examples of what can be used and the list is by no means exhaustive.

2. Where temperature control is important for consumers

To ensure food safety, the consumer needs to control time and temperature activities for the following processes: transport and storage; cooking; cooling; refrigeration; freezing; thawing; and re-heating.

2.1 Transport and storage

If there is a significant time delay in the transport of perishable food to the home following purchase, or incorrect storage of perishable food during transport from the home to picnics, barbeques or other events, there is increased potential for the growth of harmful organisms.

2.1.1 Key food safety issues

1. The temperature of perishable foods should not be allowed to rise above 10°C during transport.
2. Raw meat and poultry should be packed in separate bags or containers away from other food to avoid potential cross-contamination.
3. Food should be refrigerated, cooked or frozen as soon as possible following purchase. The use of insulated bags or freezer bags is recommended during transportation.

2.1.2 Useful messages for consumers

When you're doing a big shop, try to pick up chilled and frozen food last. When packing your shopping, put chilled and frozen food together, ideally in a cool bag, to help keep them cold. Put raw meat and poultry in a separate bag.

Take chilled and frozen food home as quickly as possible and put it in the fridge or freezer straight away. If you leave food at room temperature, or in a car, or carry it around for a long time, this could raise the temperature enough for harmful bacteria to grow, especially in hot weather.

Don't buy chilled or frozen food during your lunch hour unless you can keep it in a fridge until you go home.

2.2 Cooking

The objectives of cooking food are to alter its taste and texture and to render it safe by killing harmful organisms. With an increase in the proportion of the population who are vulnerable to harmful bacteria and the emergence of organisms such as *E. coli* O157, the importance of cooking in producing safe food is paramount (for further information see 3.2).

2.2.1 Key food safety issues

1. Poultry and pork products; minced meat or any type of product made from minced or comminuted meats (e.g. sausages, burgers); and meats which have been rolled or deboned or composed of reformed meat pieces, must be cooked to a core temperature of at least 70°C for 2 minutes or equivalent (75°C instantaneously i.e. the immediate temperature reading obtained on inserting a temperature probe into the centre of the food). Whole fish may be cooked to preference, but products made of minced fish (e.g. fish cakes) should always be cooked to a core temperature of at least 70°C for 2 minutes or equivalent (75°C instantaneously).
2. Beef steaks or whole beef joints, lamb steaks or whole lamb joints, may be cooked to preference although the risk of food poisoning could increase if the meat is undercooked.
3. Vulnerable consumers (including the elderly, the very young i.e. babies and toddlers, pregnant women and individuals who are immunocompromised) should avoid eating lamb or beef that is rare or pink, and shellfish and eggs which are undercooked.

2.2.2 Useful messages for consumers

You can eat beef steaks or whole joints of beef or lamb 'pink' or 'rare' in the middle because harmful bacteria can be on the outside but not in the middle. So, as long as the outside of the meat is cooked, any harmful bacteria should be killed.

You should always make sure that poultry, pork, rolled joints or any meat that has been minced or skewered, such as burgers, sausages, kebabs are cooked until they are piping hot all the way through with no pink meat left and until the juices run clear. This is because these types of meats can contain harmful bacteria throughout, so they must be cooked thoroughly to make them safe to eat.

When cooking eggs for elderly people, babies, toddlers, pregnant women or people who are unwell, make sure that they are cooked thoroughly until the yolk is solid. This is because eggs that haven't been thoroughly cooked can contain harmful bacteria and these groups of people are most likely to become seriously ill from food poisoning.

Foods containing raw or lightly cooked egg, such as home-made mayonnaise, Béarnaise and hollandaise sauces, ice cream, icing, mousse and some desserts, could also contain harmful bacteria. So you should avoid giving any food containing raw or lightly cooked egg to elderly people, babies, toddlers, pregnant women or people who are unwell.

2.3 *Cooling*

Cooling is an important process in ensuring food safety and if carried out incorrectly food poisoning or toxin formation may result. In general, it is important that foods are cooled as quickly as possible. The temperature range of 63°C to 5°C is considered to be the 'danger zone' i.e. the temperature range in which harmful organisms can flourish, and it is recommended that food should not remain in this 'danger zone' for longer than 2 hours. The speed of cooling can be facilitated by portioning the food into smaller quantities. Food cools fastest at the surface and slowest at the centre of the thickest part. However, since it is the thickest part of the food that receives the least cooking, it is important that it reaches low temperatures to prevent the growth of any harmful organisms, which may have survived cooking. For example, the spores of certain bacteria can survive normal cooking and these can then germinate and begin to grow in foods that are not cooled and stored correctly (for further information see 3.2).

2.3.1 Key food safety issues

1. Cooked food, if not being consumed immediately, should be cooled and refrigerated to 5°C or less as quickly as possible after cooking.
2. Hot food should not be placed in a refrigerator until it has cooled.
3. Portioned food will cool faster, however, care should be taken to avoid cross-contamination while portioning.

2.3.2 Useful messages for consumers

When you have cooked food and you are not going to eat it straight away, cool it as quickly as possible (within two hours), cover it and put it in the fridge. It is important that leftover cooked rice is quickly cooled and then refrigerated. Dividing food into smaller portions and putting it in a shallow dish can help to make it cool more quickly. Remember to use clean dishes and utensils for cooked food.

Do not put food in the fridge when it is still hot, because it could raise the temperature of the fridge and allow other foods to get too warm.

When you are cooling a turkey or other large bird, removing the legs will help it cool more quickly.

2.4 *Refrigeration*

The objective of refrigerating food is to extend its shelf life and retard the growth of harmful organisms. Domestic fridges are designed to maintain food at low temperatures and are not designed to reduce the temperature of the food quickly (for further information see 3.3).

2.4.1 Key food safety issues

1. High risk, or perishable food, in which harmful organisms can grow, must be stored in a refrigerator.
2. Keep domestic fridges at temperatures of 5°C or below.
3. Do not use pre-packaged foods beyond the manufacturer's 'use by' date. Eggs should not be used beyond the 'best before' date.
4. Leftovers should be refrigerated within two hours of cooking.
5. The maximum length of time that home-prepared food should be stored at refrigerated temperatures is 3 days.

2.4.2 Useful messages for consumers

It is very important to make sure that your fridge is cold enough. If your fridge is too warm, it might not keep food safe. Ideally, keep a fridge thermometer inside your fridge and check the temperature regularly. Don't use a mercury thermometer because it could break and contaminate food. Aim to keep the coldest part of your fridge (usually the bottom shelf above the salad bin) at 5°C or below.

The fridge temperature is controlled by the thermostat. To change the fridge temperature you must use the thermostat dial, however, it is important to note that the numbers on the thermostat dial are not temperature degrees and they can differ for each model. In general the bigger the number on the dial, the colder the temperature of your fridge (check the user handbook).

Some foods need to be kept in the fridge to keep them safe, for example food with a 'Use by' date, food that you have cooked and won't serve immediately, or other ready-to-eat food such as prepared salads. If these foods are not kept cold enough, harmful bacteria can grow.

Remember not to overload your fridge. If there is too much food in your fridge, this can stop cool air from circulating freely, which could make the fridge get too warm.

Store raw meat and poultry in sealable containers at the bottom of the fridge, so it doesn't touch, or drip onto, other foods. This is to prevent harmful bacteria from spreading.

Don't use food after its 'Use by' date because it might not be safe to eat. Don't use eggs after their 'Best before' date.

Refrigerate leftovers and eat within three days.

2.5 *Freezing*

The aim of freezing is to facilitate the long-term storage of food. Once properly frozen there is no food safety concern with the food. There are time limits given for the storage of frozen food but these relate to quality and not safety issues (for further information see 3.4).

2.5.1 Key food safety issues

1. Providing that food is adequately frozen it will remain safe over long periods. Although many recommendations state that frozen food should be maintained at -18°C this target temperature is required for food quality rather than for food safety reasons. A domestic freezer should be capable of freezing food and maintaining it frozen over a period of months depending on the foodstuff.
2. The maximum length of time for the storage of food in the freezer is a quality and not a safety issue.

2.5.2 Useful messages for consumers

Don't put food in the freezer when it's still hot. Cool it as quickly as possible (within two hours), cover and put in the freezer.

Remember to keep the freezer door properly closed and only open when necessary.

Do not freeze any foods after their 'Use by' date, because they might not be safe to eat.

If you have a power cut, keep the freezer door shut. Afterwards, throw away any food that has started to defrost. If you're not sure what to do in this situation, contact your local Environmental Health Department or you can call the ***safefood*** *Helpline on 0800 085 1683 (NI) or 1850 40 4567 (ROI).*

2.6 *Thawing*

In the domestic environment thawing is not an easily controlled process as it can be difficult to prevent large fluctuations in temperature. For this reason, food thawed in the home should never be re-frozen (for further information see 3.5).

2.6.1 Key food safety issues

1. Unless the manufacturer stipulates otherwise, food must be thawed throughout before cooking while maintaining all parts of the food at a temperature of 5°C or below. In the home, this is best achieved by defrosting food in the refrigerator for as long as necessary, keeping it covered at all times. It is particularly important that ready-to-eat food, which will not be cooked after thawing, is thawed in a fridge.
2. At least 24 hours of thawing time should be allowed for every 2-2.5 kg (4-5 lbs) of food, to ensure that it is fully thawed while in the fridge.
3. In the domestic environment, thawed food must not be re-frozen.
4. Because of uneven heating, microwaves should not be used to thaw food unless the food is to be cooked and consumed immediately.

2.6.2 Useful messages for consumers

The safest way to defrost food is in the fridge. Allow at least 24 hours for every 2-2.5 kg (4-5 lbs). When defrosting raw meat or poultry, put it on the bottom shelf of the fridge on a plate or tray and make sure it cannot drip onto other food. This is to help prevent harmful bacteria from spreading.

Make sure that poultry has thawed completely before cooking. You can check whether the meat feels frozen by using a fork or skewer. When defrosting a whole bird, make sure there are no ice crystals in the cavity. If poultry is still partially frozen when you start to cook, it will cook more slowly and might not reach a high enough temperature to kill harmful bacteria.

When you have defrosted food, cook or eat it within 24 hours. Don't refreeze.

Don't defrost food in the microwave unless you are going to cook and eat it straight away. This is because when food is defrosted in the microwave it can get warm enough to allow harmful bacteria to grow.

With pre-packed foods, always follow the manufacturers' instructions. If a food label tells you to cook the food from frozen, you should do this – don't defrost it.

2.7 Re-heating

Food that has previously been cooked, cooled and stored may need to be re-heated before consumption. The primary purpose of re-heating is to make the food more palatable for consumption. However, re-heating can also be an opportunity to kill any organisms that may have contaminated the food after cooking or that may have grown on the food during poor cooling or storage (for further information see 3.6).

2.7.1 Key food safety issues

1. In the home both solid and liquid cooked food should be re-heated to an internal temperature of at least 70°C. This temperature could be lowered if the cooking, cooling, storage and handling of the food were controlled. However, these controls are often not possible in the domestic environment.
2. Foods that have been cooled and stored incorrectly should not be consumed. This is due to the possible presence of toxins which may not be eliminated by reheating. This is particularly important in the case of rice and foods subjected to excessive handling (e.g. chopped, cooked meats).

2.7.2 Useful messages for consumers

Always reheat leftovers until they are piping hot all the way through and NEVER reheat food more than once.

Reheat soups, sauces and gravies until they start to boil. Keep stirring to make sure they reheat evenly.

When reheating food in the microwave, stir it at intervals to make sure it heats up evenly. Always make sure food is piping hot all the way through before eating it. When microwaving ready-prepared meals, follow the manufacturer's instructions.

3. Theoretical background

3.1 Key safety issues of cooking

Bacteria die when they are subjected to sufficient heat. At a certain lethal temperature the numbers of bacteria decrease in a logarithmic manner with respect to time. Hence, if a population of 1 million bacteria is reduced to 100,000 in 5 minutes at 65°C, then it would reduce to 10,000 after another 5 minutes and 1,000 after a further 5 minutes at the same temperature. Scientists use the term D-value to describe the time taken to reduce the number of bacteria by a factor of 10 or 1 $\log_{10}$ at a given temperature. In the above example a D-value at 65°C of 5 minutes is given.

In addition, as a lethal temperature increases, the time it takes to kill a certain number of bacteria decreases and this is also a logarithmic relationship. Hence, considering the previous example where 1 million bacteria reduced to 1,000 bacteria after 15 minutes at 65°C, depending on the type of bacteria, the same reduction could be achieved in 1.5 minutes at 70°C or in only 0.15 minutes at 75°C. In this example, for each 5 degree Celsius rise in cooking temperature the time it takes to kill the bacteria decreases by a factor of 10. The term z-value is used to describe this step and is the number of degrees that a D-value reference temperature must move up to reduce the D-value by a factor of 10 or move down to increase the D-value by a factor of 10. In the example a z-value of 5 Celsius degrees is given.

Bacteria die extremely quickly at high temperatures over very short time periods. The magnitude of these generalised trends are modified by the properties of the food thus it is important to note that bacteria tend to die more quickly as the pH of the food goes down and the acidity increases. Conversely, bacteria tend to die more slowly as the salt or sugar content of food increases. Under these circumstances a single 'catch all' cooking recommendation is not easy to define.

As a general recommendation foods should be cooked until the centre of the thickest part of the food has received a temperature of 70°C for 2 minutes (if a temperature of 75°C is measured at the centre of the food it is considered equivalent to achieving 70° for 2 minutes). This is based on a 6 log reduction of *Listeria monocytogenes* with a z-value = 7.5 Celsius degrees [1].

Recommended cooking times and temperatures should ensure that the numbers of the most heat-resistant harmful bacteria that may be anticipated in the food are reduced. If consumers follow these recommendations the food should be safe. However, where the taste, texture, nutritional or visual requirements of the food dictate that lower temperatures, and/or lower time periods for cooking are necessary, then the safety of the food will depend on the initial level of contamination and the type of food being cooked.

Certain foods, if undercooked, present a higher risk of food poisoning than others. For example, beef and poultry are considered to pose a greater risk than fish or lamb. In general minced or rolled joints of meat are considered to be a higher risk than whole joints and steaks of the same meat. Hence, foods such as minced beef should always be cooked thoroughly to ensure they are safe, whereas fish or beef steaks may be cooked to preference.

Cooking recommendations aimed at consumers should identify the foodstuffs that must always be cooked to the recommended time/temperature and those that may be cooked to preference. However, it should always be made clear that there is usually a greater risk of food poisoning from foods cooked to preference below the recommended time/temperature. It may also be necessary to point out that this risk is greater for vulnerable consumers, such as older people, infants, pregnant women and those with reduced immunity.

3.2 Key safety issues of cooling

All bacteria have a range of temperatures over which they can grow. Growth is greatest at the optimum temperature and slows as the upper and lower extreme of the temperature range is approached. As the maximum and minimum growth temperatures are exceeded, the bacteria may enter a state of survival whereby they are neither growing nor dying but as the temperature proceeds upwards or downwards the bacteria may start to die off. This will happen very slowly, if at all, at low temperatures and much faster at high temperatures. When cooling, it is important to ensure that the food does not remain at temperatures within the growth range of bacteria for any protracted length of time. Growth, like death in bacteria is a function of the temperature they are exposed to and the time over which they experience that temperature.

Table 1 shows the maximum, minimum, and optimum growth temperatures for the key pathogenic bacteria. It demonstrates that the maximum temperature at which a pathogenic bacteria has been known to grow under otherwise optimal conditions is 55°C, whereas, the lowest temperature under otherwise optimum conditions is -0.4°C. However, growth at these extremes is very slow.

Table 1: Growth temperatures for the key pathogenic bacteria*

	Temperature (°C)		
Bacteria	**Minimum**	**Maximum**	**Optimum**
Cl. botulinum group 1	10		30-40
Cl. botulinum group 2	3.3		25-37
Salmonella spp.	7	49.5	35-43
Staph. aureus	7		35-37
B. cereus	10 (some 4)	55	30-40
Bacillus spp.	5		25-55
Clostridium spp.	8		25-55
Campylobacter spp.	30	45	42-45
L. monocytogenes	-0.4	45	30-37
Yersinia spp.	0	42	32-34
Vibrio parahaemolyticus	5	43	37
Cl. perfringens	15	50	43-45
E. coli O157	7	46	37
Shigella spp.	6	47.1	37
Aeromonas spp.	2	45	28-35

* Data from [2], [3] and [4].

As in the case of cooking, the growth of bacteria during cooling depends on the temperature, the time, and the nature of the food (pH, salt content etc.). For example, bacteria also have a pH and a salt range over which they can grow. There is an optimum value for maximum growth and then, as with temperature, growth slows towards the extremes of the range. Hence, as the pH moves towards the lower part of the growth range for a bacterium, the bacteria may grow slowly even at its optimum growth temperature and probably not at all beyond a very narrow temperature range around this optimum value. The presence of acids as well as the physical structure of the food can also change the bacteria's ability to grow.

For the consumer it is very difficult to understand the complex inter-relationship of the nature of the food and temperature to determine a safe cooling time. Therefore, generalised recommendations have been made. Often the temperature range of 63°C to 5°C is considered to be the 'danger zone' in which bacteria have the greatest chance of growing but as can be seen from Table 1 this could be narrowed down still further to 55°C to 5°C. Furthermore, it has been recommended that food should not remain in this 'danger zone' for longer than 2 hours. However, this is a very conservative time period since we are taking the extremes of the growth ranges for harmful bacteria into account in combination with the fact that other conditions for bacterial growth in the food are rarely optimal. Considering these facts a true 'danger zone' with a restriction of 2 hours has been suggested as lying between 55°C and 15°C [5].

For large cuts of meat it is often not possible to adhere to the 2 hour recommendation for cooling. In this case the cooling times outlined in Table 2 are recommended.

Table 2: Recommended cooling times for whole meat products exceeding 2.5kg in weight and/or 100mm in thickness or height*

Temperature Range (°C)	Best Practice Cooling Times (minutes)
70 to 55	≤60
55 to 12	≤240
12 to ≤5	≤60
Total Cooling Time	**360**

* Adapted from [5].

3.3 Key safety issues of refrigeration

The growth of bacteria was discussed in detail in the cooling section of this report (see 3.2). Some harmful bacteria of particular concern with respect to refrigeration are *Listeria monocytogenes*, *Yersinia enterocolitica* and *Aeromonas hydrophila*, all of which can grow slowly at refrigeration temperatures. Therefore, food cannot be left for long periods of time in a refrigerator and still be expected to be safe. It is important that the length of time that food is refrigerated is restricted and that consumers are made aware of how long food may be stored in the refrigerator.

Since, the majority of harmful bacteria cannot grow below 5°C or only do so slowly (see Table 1), a combination of a recommended maximum storage temperature and maximum storage time should ensure refrigerated food remains safe.

The maximum length of time that home-prepared food should be stored at refrigerated temperature is 3 days. This is based on model predictions for a 1 log increase in the numbers of *Listeria monocytogenes* in conditions of low salt (0.5%) and a temperature of 5°C [6].

3.4 Key safety issues of freezing

The common temperature recommendation for frozen food and domestic freezers is to maintain them at less than -18°C. This ensures that chilled food is frozen in a reasonable period of time thus preserving its quality. However, there is no food safety concern providing that all parts of the food are frozen or maintained at less than -1°C. A small safety margin below this temperature may be necessary to ensure that frozen temperatures are maintained at the food surface during freezer unit automatic defrost cycles (not applicable in the domestic environment), situations where freezer doors are left open for inappropriate lengths of time, or during the introduction of unfrozen food for freezing.

As with refrigeration, it is important that hot or warm food is not placed in the domestic freezer. This will result in a localised increase in temperature that could thaw neighbouring stored frozen food raising its surface temperature to a level where bacteria could grow (albeit very slowly). In this regard, it is best to cool food, following the cooling recommendations, before placing it in the freezer.

Chilled food should not be frozen once it has reached or is close to the manufacturer's use by date. These foods are likely to contain higher numbers of bacteria than chilled foods at the start of their shelf life. The bacteria may multiply when the food is thawed and handled prior to preparation and if the number of bacteria in the product is already high they are more likely to reach unsafe levels.

3.5 Key safety issues of thawing

Thawing poses greater risks for food safety than freezing. With respect to time/temperature recommendations it is important that when a food is thawed no part of the food reaches a temperature greater than 5°C since this may allow any harmful bacteria present to grow.

When water is in its crystalline state (frozen) it takes a considerable amount of energy to change it to the liquid state and during this time the temperature will not rise above 0°C. However, once in its liquid state the same amount of energy will result in a measurable temperature rise. Hence, the problem with thawing is that of maintaining the outside of the

food at less than 5°C whilst imputing enough heat energy to defrost the frozen interior. This delicate balance is best achieved at low temperatures (less than 5°C) over long times (24 hours or longer). For this reason most recommendations indicate that food should be thawed in a refrigerator. In a manufacturing environment where specialist equipment is available, temperature-controlled environments are used for the purpose of thawing.

Food that is thawed in a domestic refrigerator, so that no part is allowed to exceed 5°C, can be kept in the refrigerator for a maximum of three days. This includes the thawing time and, hence, where thawing takes longer than 3 days the thawed food should be cooked or consumed immediately. If other thawing methods are used that do not provide the guarantee of temperature control, then the food should be cooked as soon as thawing is complete as the growth of harmful bacteria is likely. Thawing in uncontrolled temperature conditions is not safe for ready-to-eat food that will not receive any cooking prior to consumption. This is due to the increased risk of the growth of harmful bacteria without the cooking step to kill them.

From a cooking standpoint correct thawing is also important. If food is not completely thawed, cooking will take considerably longer and may result in undercooking, particularly when meat thermometers are not used. Incorrect thawing is a well-documented cause of food poisoning from cooked foods. However, where manufactured foods carry instruction for cooking from frozen, it is safer for the consumer to follow these instructions than thaw the food before cooking.

3.6 Key safety issues of re-heating

There is no difference between the way that bacteria die during re-heating and the way they die in cooking. The difference exists in the number of bacteria that must be killed and where they are located in the food. Current re-heating recommendations are actually re-cooking recommendations based on the assumption that cooking, cooling, storage and handling were inadequate prior to reheating. However, providing that good hygiene practice has been observed, along with the recommendation for best practice in cooking, cooling, and storage, contamination with harmful bacteria should be low and confined to the exterior of solid foods. Re-heating recommendations should therefore use target temperatures that aim to remove a realistic number of the most heat resistant harmful bacteria from where they are most likely to be found.

An example of an adequate re-heating regime would be the re-heating of solid foods (e.g. whole joints) to a minimum **external** temperature of at least 70°C for 40 seconds. This would ensure a 2 log reduction in the number of *L. monocytogenes* [1] and in doing so would reduce the number of other pathogens by an even greater degree. However, it is difficult, if not impossible, in the domestic environment to measure the surface temperature of a solid food and, therefore, whilst scientifically correct the recommendation lacks practicality.

In the domestic environment, adherence to strict cooling and storage guidelines for solid foods, such as meat joints, will prove difficult. In this case, incorrect cooking may provide more of an opportunity for bacteria to survive, or poor hygiene may provide more opportunity for bacteria to cross-contaminate cooked food and grow during cooling and storage. For this reason, a more practical and severe re-heating recommendation would be to re-heat the food to a minimum core temperature of 70°C. Given the time taken to achieve this temperature in the domestic environment it is likely that this would ensure a core temperature equivalent to at least 70°C for 40 seconds. This would result in a 2 log reduction of *Listeria monocytogenes* in liquid foods and a much greater kill at the surface of solid foods where the bacteria are more likely to be situated.

However, it should be noted that when poor hygiene and cooling/storage practices have been used with starchy foods, like pre-cooked rice, and foods that may have been subject to excessive handling post cooking, there is a risk of toxin production from *Bacillus cereus* or *Staphylococcus aureus*. These toxins will not be eliminated by normal cooking practice. Therefore, these foods should not be consumed at all if poor hygiene and cooling/storage practices are suspected.

Only in the case of breakdown in the hygiene and practice of cooking, cooling and storage, will a complete re-cooking of the food be necessary. However, if a food can stand such a process without altering its texture, taste or nutritional content then this is the safest recommendation.

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