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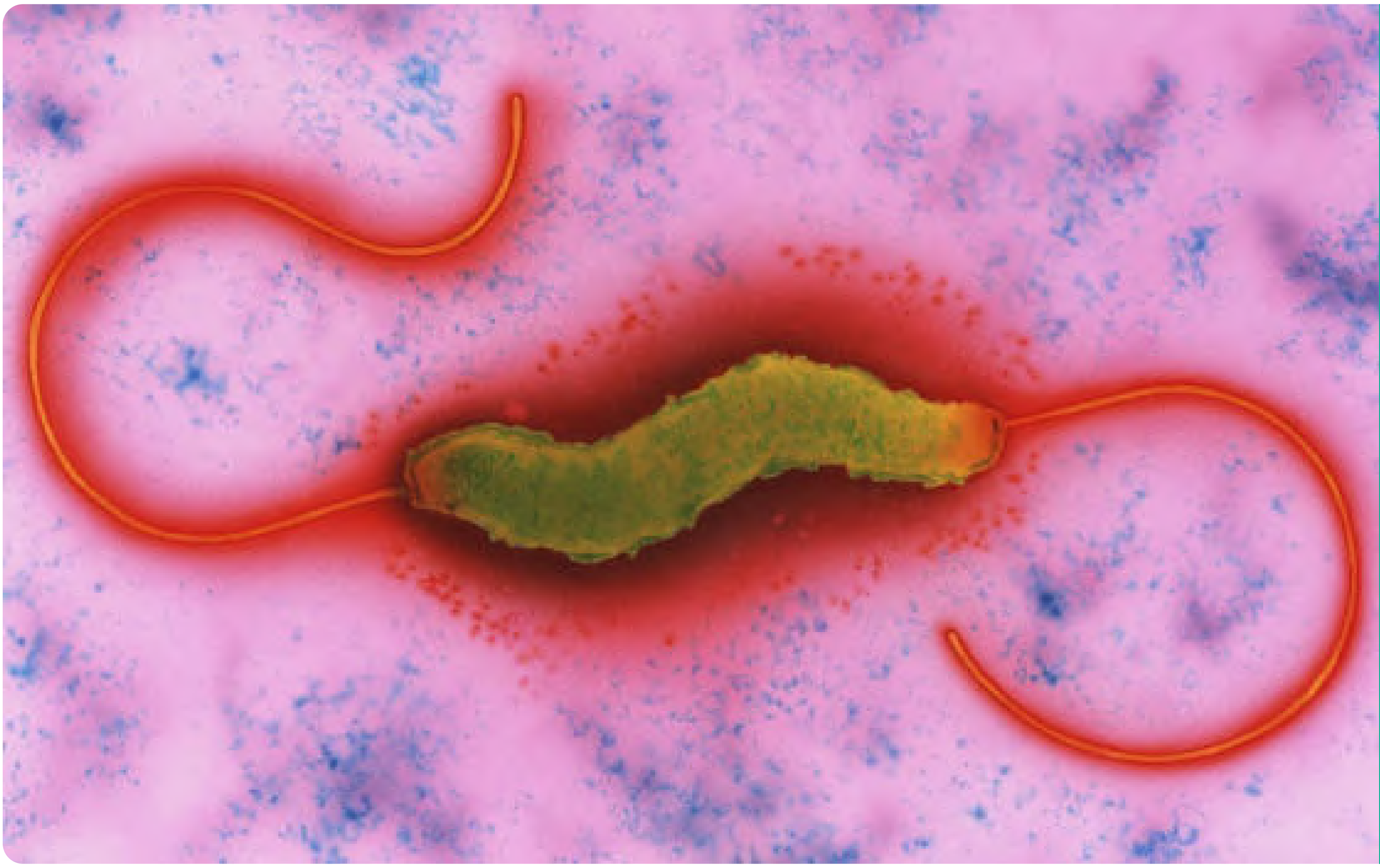
MICROBES AND FOOD

Education and Outreach Network

MICROBIOLOGY SOCIETY

MICROBES AND FOOD

The microbes associated with our food tend to have a bad name – food poisoning is often in the news. Yet while some make us ill and others can be a nuisance by spoiling our food, without the activities of microbes there would no bread, cheese, beer or chocolate. Friend or foe – food microbes are always on the menu.



© A. Dowsett, Health Protection Agency / Science Photo Library The bacterium Campylobacter jejuni is a common cause of food poisoning. Contaminated poultry, meat and milk are sources of infection. It takes about 3 days for the symptoms of diarrhoea, stomach cramps and fever to develop.

FOOD POISONING

The number of cases of food-borne illness remains high with an estimated 1 million people in the UK becoming infected each year. The symptoms, including vomiting, diarrhoea, abdominal pain and fever, are not only unpleasant; they also cost an estimated £1.5 billion a year in lost working days and medical care. Most food-borne illness is preventable.

Preventing food poisoning is the responsibility of everyone in the chain from the plough to the plate. This includes farmers and growers, manufacturers, shops, caterers and consumers. The activities of food suppliers are governed by UK and EU food safety law. In the home correct hygiene, cooking and storage must be practised.

Some of the bacteria that can cause food poisoning

Name of bacterium	Original source	Risky foods	Time to develop	Symptoms
Bacillus cereus	soil	cooked rice and pasta; meat products; vegetables	1–5 hours	nausea, sickness and diarrhoea
Campylobacter jejuni	raw meat and poultry	undercooked meat and poultry; raw milk and cross-contaminated food	3–5 days of eating infected food	fever, severe pain and diarrhoea
Clostridium botulinum (very rare)	soil	faulty processed canned meat and vegetables; cured meat and raw fish	1–7 days	affects vision, causes paralysis and can be fatal
Clostridium perfringens	the environment	large joints of meat; reheated gravies	8–24 hours	nausea, pain and diarrhoea
Escherichia coli –E. coli 0157:H7 is a very nasty strain and it can be fatal	the gut of all humans and animals	contaminated water, milk, inadequately cooked meat, cross-contaminated foods	3–4 days	inflammation, sickness and diarrhoea
Listeria monocytogenes	everywhere	soft cheeses, paté, pre-packed salad; cook-chill products	varies	fever, headache, septicaemia and meningitis
Salmonella	gut of birds and mammals including humans - spread by faeces into water and food	poultry, eggs and raw egg products, vegetables	6–48 hours	diarrhoea, sickness and headaches
Staphylococcus aureus	the skin and noses of animals and humans	cured meat; milk products; unrefrigerated, handled foods	2–6 hours	sickness, pain and sometimes diarrhoea

An in-depth look at a bacterium that causes food poisoning: *Campylobacter*

The bacterium *Campylobacter* is part of the normal microbiota living in the intestines of healthy chickens and other animals. At the factory when a chicken is killed and gutted, the contents of its intestines, including the *Campylobacter*, could come into contact with the bird's skin. This means the raw chicken meat could become contaminated with *Campylobacter*.

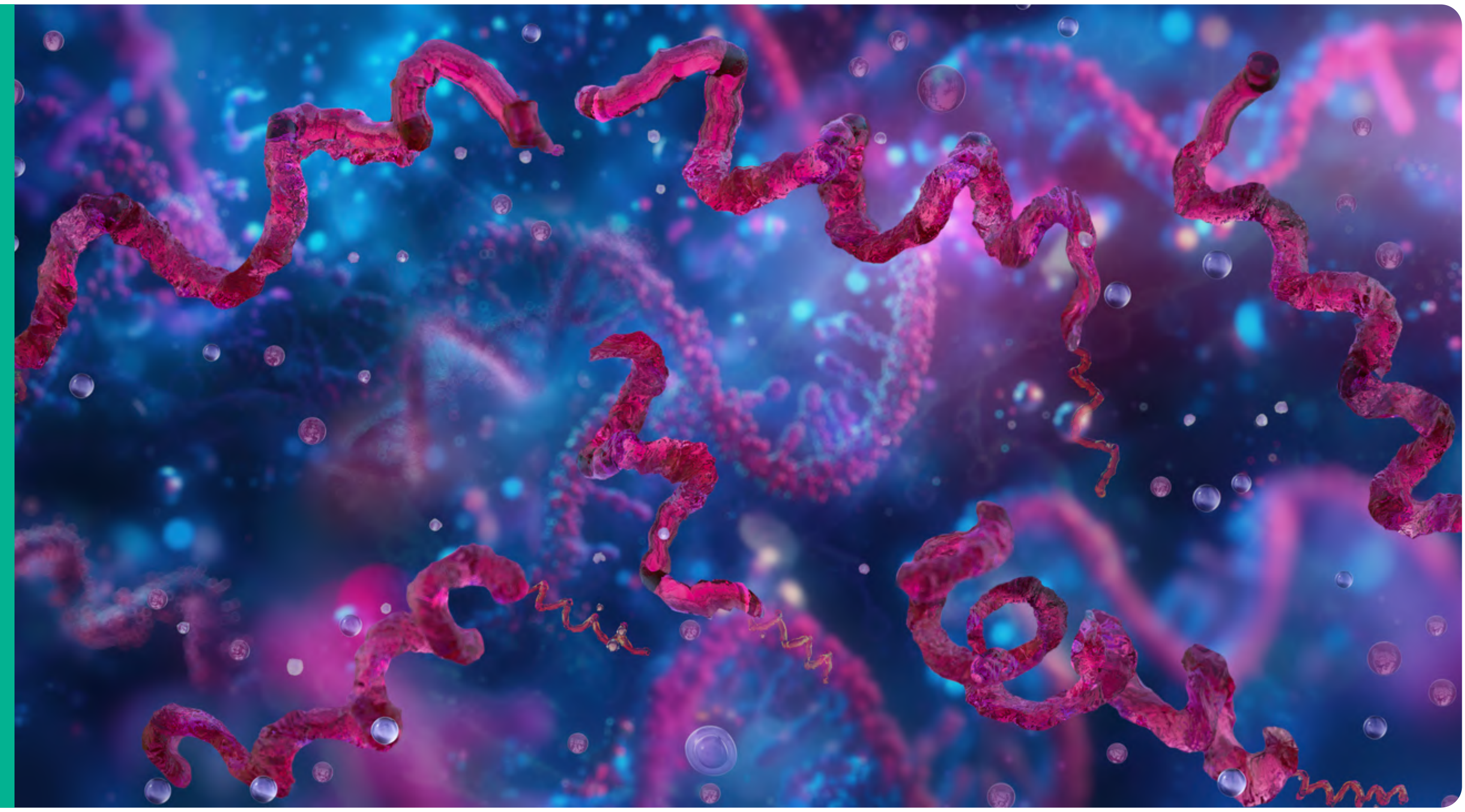
How do you make sure chicken is safe to eat?

Campylobacter is sensitive to heat so cooking the chicken properly will kill it and make the meat safe to eat. If the chicken is served undercooked, then the *Campylobacter* could survive and be eaten along with the chicken. After the bacteria have been swallowed, they multiply inside the person's intestine and cause the illness known as food poisoning. It takes about 3 days for the symptoms of diarrhoea, stomach cramps and fever to develop. The illness lasts between 2 days and a week.

Cross-contamination is the transfer of microbes from raw foods to prepared and cooked foods, it can take place by:

- raw food touching or splashing on cooked food;
- raw food touching equipment or surfaces that are then used for cooked food;
- or people touching raw food with their hands and then handling cooked food.

To prevent cross-contamination it is important to maintain good kitchen hygiene such as storing cooked and raw food separately and good personal hygiene by washing hands correctly and tying hair back.



3D illustration of *Campylobacter*. Image Credit: iStock/quantic69.

Antibiotic Resistance in the Food Chain

Antibiotic resistance is one of the most pressing public health challenges of our time, and recent research has shown that it is increasingly linked to the food we eat. Bacteria such as *Salmonella*, *Campylobacter*, and *Escherichia coli* are already well known as causes of food poisoning and are now being found in forms that are resistant to multiple antibiotics. Surveillance data from the World Health Organization (WHO) and the UK Health Security Agency (UKHSA) have highlighted a rise in multi-drug-resistant strains of these bacteria within the food chain.

This resistance makes foodborne infections harder to treat and more dangerous. Infections caused by antibiotic-resistant bacteria can last longer, cause more severe illness, and may not respond to standard treatments. In some cases, patients may require hospitalisation or stronger, last-resort antibiotics that come with more side effects.

One of the main ways these resistant bacteria enter the food chain is through farming. In some livestock production systems, antibiotics are used not just to treat sick animals, but also to prevent disease or promote growth. This frequent use creates an environment in which bacteria can evolve resistance. These resistant microbes can then be transferred to humans through the consumption of contaminated meat, unpasteurised dairy products, or produce fertilised with untreated manure. They may also enter soil and water systems, further contributing to the spread of resistance in the environment.

The rise of antibiotic resistance in foodborne bacteria is a clear example of how closely linked human health, agriculture, and microbial ecology really are. It highlights the importance of using antibiotics responsibly in farming, only when necessary and under strict guidance. Reducing the use of antibiotics in animals, improving hygiene and animal welfare standards, and developing alternatives, including vaccines, probiotics, or natural biopreservation techniques. These are essential steps in preventing the spread of resistance.

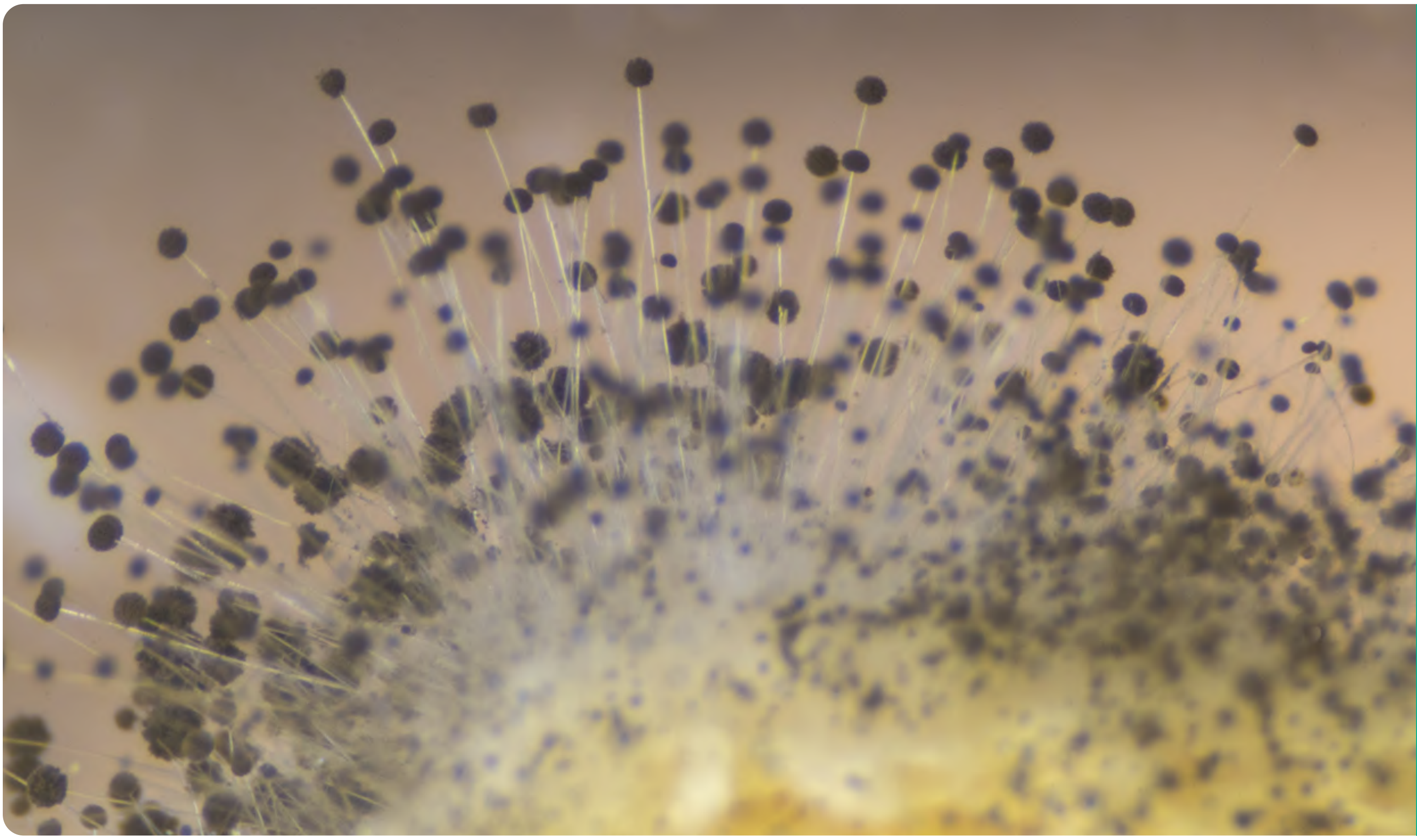
For consumers and young scientists alike, understanding the role of microbiology in food safety is more important than ever. Simple actions such as cooking meat properly, avoiding cross-contamination in the kitchen, and supporting producers who follow best practices can all help reduce the risks. Tackling antibiotic resistance is a global challenge, but one where informed individuals and communities can play a real part.

Find out more about the Microbiology Society's Knocking Out AMR project here.

KNOCKING OUT AMR

SPOILERS

Microbes like all living organisms need food for energy and growth. Sometimes microbes get in or on our food and start to break it down to provide them with energy and nutrients. Microbial growth causes the food to look, taste and/or smell disgusting. The food becomes unfit for humans to eat and must be thrown away.



Rhizopus (bread mould) under the microscope. Image Credit: iStock/Sinhyu.

Mouldy fruit

A mould is a type of fungus. Fungal spores (these are like the seeds of a plant) are all around us in the air. These spores can land on the fruit. If it is warm and moist the fungal spores grow. They send out very fine thread-like structures called hyphae. The moulds that grow on fruit and vegetables produce enzymes that weaken the protective outer skin allowing penetration by the hyphae. The hyphae grow down into the fruit, digest it and absorb the nutrients. These threads criss-cross each other to form a large tangled structure known as a mycelium. The hyphae produce stalks that grow upwards. Spores form at the end of the stalks and are released into the air to start the process over again. Eventually the fruit becomes covered in a furry coat and is not fit to eat.

Food preservation

Food preservation reduces the rate at which food decays by slowing down the rate of growth of microbes or eliminating them. It can affect the flavour and texture of the food. Preservation techniques include: refrigeration, freezing, drying sterilisation and pasteurisation.

Microbes, Food Waste and Sustainability

Microbial spoilage is a major cause of global food waste, especially in fruits, vegetables, dairy, and ready-to-eat meals. When microbes grow on or in food, they can cause changes in smell, texture, colour and taste that make it unfit to eat — even if it's not dangerous. Food waste doesn't just waste food — it wastes the energy, water, packaging and transport used to grow and deliver it. Reducing food spoilage is therefore a key sustainability challenge.

KEY FACT

The UK throws away nearly **6.4 million tonnes** of edible food each year, much of it **due to spoilage**.

How microbiology helps reduce food waste

Smart packaging uses technology to monitor the condition of food in real-time. It helps detect spoilage early or alert consumers when food may no longer be safe to eat instead of relying only on expiry dates.

Smart packaging: Smart packaging helps consumers and retailers make more informed decisions, reduce unnecessary food disposal, and maintain food safety standards. New food packaging can now include:

- **Freshness sensors:** These chemical or biosensors are built into packaging and can change colour in response to gases released by microbial activity in spoiling food, especially meat and fish products.
- **Time–Temperature Indicators (TTIs):** These visual tools show whether perishable food has been stored within the correct temperature range throughout its journey from farm to fridge. If the cold chain has been broken, the indicator changes colour permanently.
- **pH indicators:** Found in some packaging for fresh produce, these react to changes in the acidity (pH) of food, which may signal microbial activity or degradation.

Biopreservation: This uses beneficial microorganisms and natural antimicrobials (e.g., bacteriocins produced by harmless bacteria) to slow down the growth of microbes that cause spoilage, extending the shelf life of food without the need for artificial preservatives.

These techniques help make food last longer, stay safe, and reduce the amount thrown away — good for our plates and the planet.

PRODUCERS

Micro-organisms have been used since ancient times to make bread, cheese, yoghurt and wine. Food manufacturers continue to use micro-organisms today to make a wide range of food products by a process known as fermentation. Fermentation not only gives food a good taste, texture and smell, but it causes changes that reduce the growth of unwanted food microbes. This improves the food's storage life and safety. Nowadays fermentations are used to make an amazingly wide range of food and drink.

Fungi have been used as sources of food and for food processing for thousands of years. In addition to eating edible fruiting bodies, such as mushrooms, directly, various fungi have been used to supplement and add flavour to foods. Yeasts are used in the fermentation of fruits to produce wines, cereals to make beer, in bread manufacture and flavouring in the form of yeast extract. Filamentous fungi are used in traditional processes for the ripening of cheeses and in the production of enzymes used in the food industry.

As scientific and public interest in the gut microbiome continues to grow, fermented foods and probiotic-rich products are being explored not only for their taste and preservation benefits, but also for their potential to support health by improving digestion and strengthening the immune system. Probiotics are live microorganisms that, when consumed in adequate amounts, are thought to benefit health — particularly by supporting the balance of the gut microbiota. Fermented foods such as yoghurt, kimchi, sauerkraut, and kombucha naturally contain probiotic bacteria, especially lactic acid bacteria like *Lactobacillus* and *Bifidobacterium*.

Scientists are still studying exactly how these microbes work, but early research suggests that eating a variety of fermented foods may support healthy digestion, reduce inflammation, and help maintain a strong immune system. These benefits depend on the type of food, the live microbes present, and how regularly they are consumed.

Fermented food collection, cucumber pickles, coconut milk yogurt, kimchi, sauerkraut, red beets, apple cider vinegar.
Image Credit: iStock/marekuliasz.

Yeast used to make bread. Yeast is a single-celled fungus. It is able to ferment sugar, producing alcohol and carbon dioxide in the process. It has long been used to make beer and wine as well as bread (the carbon dioxide causes the dough to rise).
Image Credit: iStock/Liudmila Chernetska.

Rising with Microbes: The Science of Bread Fermentation

A yeast called *Saccharomyces cerevisiae* is mixed with sugar, flour and warm water to make bread. The yeast uses the sugar, and the sugars present in the flour as its food. It breaks them down to provide the yeast with energy for growth. The yeast grows by budding and bubbles of the carbon dioxide are produced in the dough. The bubbles make the dough expand and rise. This is because the dough is extremely sticky and it traps the bubbles, preventing them from escaping. When the dough is baked, the heat kills the yeast and the dough stops expanding.

From Milk to Microbes: The Fermentation of Yoghurt

Yoghurt is a fermented milk product in which milk is inoculated with a starter culture containing two different types of 'lactic acid bacteria' called *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. First the milk is heated to a very high temperature of 85–95°C for 15–30 minutes. This kills off any unwanted microbes that may be present. The milk is cooled, and the mixture of lactic acid bacteria is added. As the bacteria grow, they use the milk sugar lactose as an energy source and produce lactic acid. The milk is kept at 38–44°C for 12 hours to allow the two microbes to grow. Initially *S. thermophilus* ferments the lactose as the level of acid accumulates it is suppressed. *L. bulgaricus*, which is more acid tolerant, continues to ferment the remaining lactose.

During this process the pH drops from 6.5 to around 4.5. This inhibits the growth of spoilage microbes. Consequently, yoghurt keeps well in the fridge for some days. The presence of lactic acid causes the structure of the milk protein to change, giving yoghurt its special thickened texture. The lactic acid also gives the yoghurt its sharp taste. Other fermentation products such as acetaldehyde give the yoghurt its characteristic smell. Fruit and flavourings can then be added and the yoghurt packaged in the familiar pots.

Fermentation in Focus: The Science Behind Kimchi

Microbes have long played an essential role in transforming raw ingredients into safe, nutritious, and flavourful foods. While bread and yoghurt are well-known fermented products in many parts of the world, they represent just a fraction of the global picture. In fact, fermented foods are central to diets across cultures, with microbial processes adapted to suit local ingredients, environments, and tastes.

One powerful example is *kimchi*, a traditional Korean dish made by fermenting vegetables — most commonly cabbage — with salt, garlic, chilli, and a complex community of beneficial microbes. Lactic acid bacteria such as *Lactobacillus plantarum* and *Leuconostoc mesenteroides* thrive in this environment, converting sugars in the vegetables into lactic acid. This acid not only gives kimchi its characteristic tang, but also acts as a natural preservative by lowering the pH and preventing the growth of spoilage organisms and pathogens.

What makes kimchi especially relevant today is its alignment with modern food values. It is plant-based, nutrient-rich, long-lasting without artificial preservatives, and supports gut health due to its live cultures, characteristics that are increasingly sought after in sustainable and vegan diets. Like yoghurt, kimchi showcases how microbial activity can enhance texture, taste, safety and shelf-life, while also contributing to health.

Understanding fermentation through examples like kimchi helps students appreciate the universal role of microbes in food, while expanding awareness beyond Western contexts. It also highlights how traditional knowledge and microbiological science intersect — offering inspiration for future innovation in food production, nutrition, and sustainability.

Kimchi - Image Credit: iStock/Nungning20.

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The Microbiology Society is a membership charity for scientists interested in microbes, their effects and their practical uses. It has a worldwide membership based in universities, industry, hospitals, research institutes, schools, and other organisations. Our members have a unique depth and breadth of knowledge about the discipline. The Society's role is to help unlock and harness the potential of that knowledge.

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