

# Nitrates and Nitrites: The Science Explained

Information on the science behind nitrates and nitrites.

Nitrates and nitrites are naturally occurring chemicals made of nitrogen and oxygen. They are found throughout the environment – in soil, water, and many foods we eat including meat, and are also used as food additives. Most of the nitrates in our diet come from vegetables, especially leafy greens such as spinach, lettuce and rocket as well as beetroot and celery. These plants absorb nitrates from the soil as they grow.

## Why nitrates and nitrites are added to food

Nitrates and nitrites are used as additives mainly in processed meats such as bacon, ham, and cured sausages. They can play an important role in preventing the growth of harmful bacteria like *Clostridium botulinum*, which can cause botulism, a potentially life-threatening illness. They also help preserve the pink colour and characteristic flavour of cured meats.

## What happens when we eat nitrates and nitrites?

When we eat foods containing nitrates and nitrites, either those present naturally or as additives, some of these compounds are processed in the body. In the case of nitrates, these are first converted to nitrites (often by bacteria in our mouths) and then these in turn are converted to other nitrogen-containing compounds, including nitrosamines.

Nitrosamines are a group of chemicals formed when nitrites react with amino compounds (found in protein rich foods) or amines (nitrogen-containing compounds). They can be produced in the body as part of the digestive process, but also through other processes, including high temperature cooking, for example when frying bacon. Some nitrosamines are known to increase risk of cancer.

The extent to which nitrosamines form depends on several factors, including the type of food, how it is cooked, stomach acidity and the presence of certain bacteria. This makes it difficult to predict how much nitrosamine formation occurs in any one person.

## Nitrates from meat and from vegetables: not all are equal

Although naturally occurring nitrates from vegetables and added nitrates in meat are chemically the same, their effects in the body differ due to other chemicals present:

- Vegetables provide nitrates alongside beneficial nutrients such as vitamin C, polyphenols and fibre. These nutrients help to reduce the formation of harmful nitrosamines.
- Meats, on the other hand, contain proteins and amino compounds that can react with nitrites to form nitrosamines – particularly when cooked at high temperatures.

This difference could explain why high consumption of processed meat is linked to an increased risk for bowel (colorectal) cancer, in contrast to diets rich in vegetables, which are linked to a healthy diet.

## What the research shows

Studies consistently link processed meat consumption to bowel cancer. In 2018, the World Health Organisation (WHO) classified processed meat as carcinogenic to humans, with sufficient evidence for colorectal cancer. Red meat was classified as “probably carcinogenic” based on more limited evidence (IARC, 2018).

The question is: what makes processed meat increase cancer risk? Is it one factor or several? And specifically, what role do nitrates/nitrites play?

The WHO looked at meat components that could potentially cause cancer. These include haem iron, fat oxidation products, chemicals formed during cooking (heterocyclic aromatic amines (HAAs) and polycyclic aromatic hydrocarbons (PAHs)) and N-nitroso compounds (including nitrosamines). No single component can be identified as the cause – and meat isn’t the only source of exposure to these compounds. (IARC, 2018).

Meat processing (like curing and smoking) and cooking methods (especially high-temperature frying, grilling, or barbecuing) can produce carcinogenic chemicals. The amounts formed vary significantly depending on the type of meat, cooking method, temperature, and time. (IARC, 2018).

In its report on ingested nitrates and nitrites (naturally occurring and added), the WHO (IARC, 2010) reviewed the scientific evidence and concluded:

- There was insufficient evidence to conclude whether nitrate in food causes cancer in humans
- For nitrites in food, there was limited evidence of carcinogenicity
- When conditions favour nitrosamine formation, nitrite consumptions have been linked to increased stomach cancer risk
- Overall, ingested nitrate or nitrite is probably carcinogenic to humans under conditions that lead to nitrosamine formation
- Specific nitrosamines (e.g. NDMA and NDEA) are probably carcinogenic to humans
- Other nitrosamines (e.g. NDBA, NPIP, NPYR, NMOR and NDPA) are possibly carcinogenic to humans

A recent French study ([Chazelas et al., 2022](#)) suggested a possible association between nitrite additives and breast and prostate cancers, but the authors emphasised these findings are tentative.

## Limitations and uncertainties

It can be difficult to draw firm conclusions from human studies. People are exposed to many chemicals in their diet and environment, and dietary recall is often imperfect (i.e. we often struggle to remember exactly what we have eaten over time). Hence, while laboratory and animal studies suggest some potential mechanisms for cancer risk, it is not possible to say these are the same in humans.

It’s also possible that other aspects of processed meat – such as saturated fat or salt, or compounds formed during smoking or charring – play a role in cancer risk.

# Current understanding

The science is still developing, and there is no definitive evidence that nitrates or nitrites themselves are the direct cause of cancer. What we do know is that:

- Eating too much processed meat increases the risk of cancer, especially bowel cancer
- There's no evidence that processed meats made without nitrate or nitrite additives are safer. Removing nitrate and nitrite additives from processed meats can also create food safety challenges, as these preservatives help prevent the growth of dangerous bacteria, so need to be replaced by other methods of preservation
- Cardiovascular disease is also linked to increased red and processed meat intake, but not specifically to nitrates or nitrites

## FSA's position

The Food Standards Agency recognises both the important role of nitrates and nitrites in food safety and the ongoing scientific investigation into their potential health risks. As a result:

We fully support the NHS guidance that people who eat more than 90 grams of red or processed meat per day should cut down to no more than 70 grams per day. To give context, some portion sizes of meat include:

- Cooked breakfast (2 standard British sausages, around 9cm long, and 2 thin-cut rashers of bacon) – 130g
- A small beefburger – 78g
- A slice of ham – 23g

Nitrate and nitrite additives must be used within strict legal safety limits.

We will continue to monitor and review new scientific evidence, working with UK and international partners, to ensure food safety regulations remain based on the best available science.

## In summary

Nitrates and nitrites occur naturally in many foods and, as additives, play an important role in preventing foodborne illness. Under certain conditions however they can form compounds that are potentially harmful.

The overall evidence shows that processed meat consumption – rather than nitrates or nitrites alone – is linked with an increased risk of cancer. As a result, the FSA supports NHS advice that people who eat more than 90g of red or processed meat a day should cut down to no more than 70g.

The science continues to evolve, and the FSA keeps this area under review to ensure consumers are protected and well informed.

## Footnote

### Nitrosamines:

- NDMA - N-Nitrosodimethylamine
- NDEA - N-Nitrosodiethylamine
- NDBA - N-Nitrosodi-n-butylamine

- NPIP - Nitrosopiperidine
- NPRY - N-Nitrosopyrrolidine
- NMOR - N-Nitrosomorpholine
- NDPA - N-Nitrosodi-n-propylamine

## References:

Chazelas E., et al., 2022. Nitrites and nitrates from food additives and natural sources and cancer risk: results from the NutriNet-Sante cohort. International Journal of Epidemiology, 2022, 1106–1119 <https://doi.org/10.1093/ije/dyac046>. Available at: [Nitrites and nitrates from food additives and natural sources and cancer risk: results from the NutriNet-Santé cohort - PubMed](#)

IARC (International Agency for Research on Cancer), 2010. Ingested Nitrate and Nitrite, and Cyanobacterial Peptide Toxins. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 94. IARC, Lyon. Available at: [IARC Publications Website - Ingested Nitrate and Nitrite, and Cyanobacterial Peptide Toxins](#)

IARC (International Agency for Research on Cancer), 2018. Red Meat and Processed Meat. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 114. IARC, Lyon. Available at: [IARC Publications Website - Red Meat and Processed Meat](#)