

2. NITRATES, NITRITES AND NITROSAMINES IN FOOD

Three chemically related names can refer to very different situations. Nitrates are natural constituents of the nitrogen cycle and may accumulate in vegetables; nitrites may form through the conversion of nitrates or be used, under regulated conditions, to preserve certain foods. Nitrosamines, by contrast, are a family of compounds that may arise through specific chemical reactions. Understanding these differences is essential to interpreting food analyses and the associated health risks correctly.



NITRATES: FROM SOIL TO VEGETABLES

The nitrate ion (NO_3^-) is a form of nitrogen taken up by plants. It arises from the mineralisation of organic matter, soil microbial processes and fertiliser inputs. Its presence in a vegetable therefore does not, by itself, prove pollution. Accumulation depends on species and variety, nitrogen availability, light, season and growing conditions.

Leafy vegetables, particularly rocket, lettuce and spinach, are among the foods in which relatively high concentrations may occur. Under low-light conditions, plants may take up nitrate more rapidly than they can use it in metabolic processes; this contributes to

differences between seasonal crops and protected cultivation. The values in any particular batch cannot, however, be deduced from the appearance of the leaves or their geographical origin.

NITRITES: NATURAL CONVERSION AND USE AS PRESERVATIVES

The nitrite ion (NO_2^-) may result from nitrate reduction through microbial activity or processes that also occur in the human body. Nitrites are also authorised additives in certain food categories, especially meat products, because they help control some microbiological hazards, including those associated with *Clostridium botulinum*, as well as influencing colour and product characteristics.

The additives potassium nitrite (E 249), sodium nitrite (E 250), sodium nitrate (E 251) and potassium nitrate (E 252) are subject to different conditions of use. It would be incorrect to claim that their use has no health-related justification; it would be equally incorrect to ignore the need to limit exposure and possible secondary reactions. Industrial practice must balance microbiological safety against minimisation of unwanted compounds.

FROM NITRITES TO NITROSAMINES: NOT AN INEVITABLE CONVERSION

Some nitrosamines can form when nitrosating species, which may derive from nitrites, react with particular nitrogen-containing compounds, such as amines, under favourable conditions. Acidity, temperature, time, food composition and the presence of inhibitors affect the reaction. It is therefore scientifically incorrect to equate a given nitrate or nitrite concentration with a predictable quantity of nitrosamines.

Nitrosamines may occur in different food matrices and can form during certain processing and preparation operations. EFSA's 2023 assessment considered ten nitrosamines found in foods to be genotoxic and carcinogenic, and concluded that dietary exposure raises a health concern. Processed meat products were among the largest contributors to estimated exposure in the assessment; uncertainty in the available data remains significant.

NITRATI, NITRITI, NITROSAMMINE

Tre gruppi da distinguere, non una trasformazione inevitabile

1

NITRATI · NO_3^-

Suolo → vegetali

Possibile accumulo in rucola, spinaci e lattughe

2

NITRITI · NO_2^-

Riduzione dei nitrati / additivi

Uso regolamentato in alcuni prodotti carnei

3

NITROSAMMINE

Reazioni in condizioni favorevoli

La formazione dipende da ammine, pH e processo

4

CONTROLLO

Tre analisi diverse

Il nitrato non predice una quantità di nitrosammine

NITRATI $\neq$ NITRITI $\neq$ NITROSAMMINE

WHAT DO WE KNOW ABOUT HEALTH EFFECTS?

Dietary nitrate may be partly converted into nitrite. High nitrite exposure can impair haemoglobin's ability to transport oxygen through the formation of methaemoglobin; infants are a particularly sensitive group in certain exposure scenarios. Risk assessment nevertheless depends on dose, food matrix, age, other sources and individual circumstances.

For genotoxic and carcinogenic nitrosamines, the issue is different: a threshold of exposure known to be completely without risk cannot be assumed. Assessment bodies use approaches such as the margin of exposure to identify public-health priorities, without treating this as an individual's probability of developing disease.

The overall dietary context also matters. EFSA has highlighted that the benefits of eating vegetables as part of a balanced diet generally outweigh the potential risks associated with their nitrate content. An interpretation that encourages people to eliminate vegetables indiscriminately would therefore be misleading.

EUROPEAN LEGISLATION: TWO REGIMES THAT MUST NOT BE CONFUSED

For nitrates occurring as contaminants in certain plant-based foods, Regulation (EU) 2023/915 sets specific maximum levels. It covers, for example, spinach, lettuce, rocket

and certain foods intended for young children. Values applicable to lettuce and rocket can vary with season and cultivation method: there is no single universal limit 'for all vegetables'.

When nitrates and nitrites are deliberately added as preservatives, food-additives legislation applies, particularly Regulation (EC) No 1333/2008 and the amendments introduced by Regulation (EU) 2023/2108. The latter reduced several authorised amounts and introduced provisions on residual levels and specifications, with different application dates. Compliance therefore requires checking the food category, technological function, units used, date and legislation in force.

Contaminants legislation and additives legislation must not be confused: measuring naturally occurring nitrate in rocket is not equivalent to checking the amount of nitrite added to cured meat. Moreover, a limit for nitrates or nitrites does not automatically constitute an analytical limit for nitrosamines.

ANALYSIS: WHAT DOES A NUMBER IN A LABORATORY REPORT MEAN?

Nitrates and nitrites may be measured using validated instrumental methods, including chromatographic techniques. Nitrosamines require targeted analyses capable of identifying and quantifying them at often very low concentrations. The method depends on the food and the analytes of interest; there is no single 'nitrogen test' that describes the entire issue.

A test report should state the analytes measured, the matrix, units, limits of quantification and, where relevant, measurement uncertainty. A result below the limit of quantification must also be distinguished from absolute absence. Representativeness of sampling matters when checking a batch.

HOW TO INTERPRET THE ISSUE WITHOUT ALARMISM

A nitrate-rich food is not automatically rich in nitrosamines; cured meat made with authorised preservatives is not automatically dangerous, but requires sound process management; a legally compliant result does not necessarily mean zero concentration. Useful information arises from considering chemical composition, formation conditions, exposure data, analytical controls and risk assessment together.

For consumers, a varied diet rich in vegetables remains sensible, rather than simplistic judgements based on a single contaminant. For food businesses, good production practices, appropriate use of additives, control of processing conditions and relevant analyses remain decisive. The next chapter will discuss compounds of different origins: chlorates and perchlorates.

SCIENTIFIC AND REGULATORY REFERENCES

EFSA (2023) – Nitrosamines in food raise a health concern [↗ Source](#)

EFSA (2008) – Risks and benefits of dietary nitrate from vegetables (historical assessment) [↗ Source](#)

Regulation (EU) 2023/915 – Maximum levels for certain contaminants in food [↗ Source](#)

Regulation (EU) 2023/2108 – Amendments to authorised uses of nitrates and nitrites [↗ Source](#)

Regulation (EC) No 1333/2008 – Food additives [↗ Source](#)