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ORIGINAL RESEARCH

Nitrites and nitrates in food: risks and benefits

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1. ABSTRACT

The analyzed study is a narrative review on the food sources, metabolism, potential risks, and possible benefits of nitrates and nitrites. The passage relevant to the narrative of “The Choice to Live in Health or Illness” by Dr. A. Colonnese and R. Panzironi concerns the possibility that nitrates, after conversion to nitrites, participate in the formation of nitrosamines in the gastrointestinal tract. The publication does not directly test this process in a new population, but synthesizes chemical, experimental, clinical, and epidemiological studies.Independent evidence shows that, in healthy volunteers, increased exposure to nitrates can increase fecal markers of N-nitroso compounds, especially in the context of specific diets. Meta-analysis of observational studies also report an association between higher intake of nitrites or certain nitrosamines and a higher frequency of gastric cancers or other gastrointestinal tumors. However, the association does not apply indiscriminately to all nitrates or all food sources: analyses dedicated to plant-based sources do not show a significant overall increase in risk. The book's narrative is therefore moderately supported if read as a chain conditioned by context, not as an inevitable effect of consuming vegetables containing nitrates.

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MISSION

LIFE Science Hub – Journal of Science was founded with the aim of making scientific knowledge accessible without giving up methodological rigour, quality of sources and authoritativeness of content. The journal promotes the dissemination of knowledge in the health, nutrition, medical and longevity sciences, building a bridge between the world of research and society.

Through articles, reviews, in-depth analyses and expert contributions, the Journal champions evidence-based medicine and science, fostering a correct interpretation of scientific data and countering misinformation. Every piece of content is developed with the aim of translating the complexity of research into understandable, useful and applicable information, while keeping intact the principles of accuracy, transparency and scientific independence.

Free from political, industrial and commercial influence, the journal stands as an authoritative and independent editorial space, dedicated to promoting scientific culture, professional development and the growth of health awareness among the public.

2. ANALYZED STUDY

The research question was whether nitrates and nitrites present in food could have unfavorable consequences, particularly through nitrosative stress (a condition in which reactive nitrogen molecules capable of modifying cellular components increase), despite also having useful physiological functions. The hypothesis relevant to the book's section is that nitrate can be converted into nitrite and that nitrite, under specific conditions in the digestive tract, can react with other molecules to form N-nitroso compounds, including some compounds classified as nitrosamines.The relevance to section 1.2.4 is therefore precise: the study is not used to demonstrate that every plant-based food containing nitrates increases the risk of gastrointestinal tumors. Instead, it documents the biological pathway through which nitrates and nitrites can enter a chain of reactions that, in the presence of nitrosatable precursors such as certain amines, promotes the formation of potentially harmful compounds. The publication is a review and cannot demonstrate clinical causality in individuals, nor can it quantify the risk attributable to the nitrates contained in a specific vegetable.

3. MATERIALS AND METHODS OF THE ORIGINAL STUDY

The original study is a literature review. The authors state that they conducted a search in the Web of Science database by combining terms related to nitrates, nitrites, nitrosative stress, and cancer, supplemented by a manual search of the bibliographies of articles deemed relevant.The publication examines dietary sources of nitrates and nitrites, their metabolism in the body, the formation of reactive nitrogen species, the possible formation of N-nitroso compounds, associations with tumors, and the use of nitrites in meat processing. There is no new population recruited by the authors, no overall number of included studies is reported, and no complete inclusion or exclusion criteria are described. This information is not provided in the available material. Furthermore, there is no pre-registered protocol, standardized risk-of-bias assessment of the included studies, or original meta-analysis.To understand the central mechanism, the authors describe that a portion of the nitrate ingested through the diet can be reduced to nitrite by bacteria present primarily in the oral cavity. In the acidic gastric environment, nitrite can generate reactive nitrogen species and react with amines and amides. This reaction is not automatic: it depends on the quantity of available substrates, acidity, the presence of heme iron, antioxidants, and other dietary and individual factors.

4. RESULTS

The most relevant result is the reconstruction of a plausible biological pathway. In simple terms, nitrate can act as a starting material; nitrite is the most reactive intermediate; certain amines present in the gastric or intestinal content can act as reaction partners; the final product may include N-nitroso compounds. Among these are nitrosamines which, based on experimental and toxicological data discussed by the authors, raise concerns due to their carcinogenic potential.The review reports that approximately 5–7% of dietary nitrate and about 20% of salivary nitrate can be reduced to nitrite in the oral cavity. It also reports that the nitrosation process, i.e., the formation of N-nitroso compounds, is favored by the acidic environment of the stomach and the availability of nitrosatable precursors; vitamin C and vitamin E, on the other hand, are considered factors that can inhibit this reaction. These values describe general metabolic processes and do not demonstrate that a given dose of vegetables produces nitrosamines in every individual.The authors also distinguish between nitrates and nitrites based on their source. Vegetables constitute the main dietary source of nitrates, while processed meat products can contribute to nitrites and, together with proteins and heme iron, provide a different chemical context. The review emphasizes that the available epidemiological studies are inconsistent: nitrate intake from plant-based foods may also reflect the presence of fiber, vitamins, and polyphenols, substances that make it difficult to attribute any health effect to nitrate alone.

5. INTERPRETATION

The biological message is that nitrate and nitrite are not synonymous with nitrosamine and are not, in themselves, proof of harm. Instead, they represent components of a metabolic system that can have different outcomes. On one hand, the

nitrate-nitrite-nitric oxide conversion can contribute to the regulation of blood circulation. On the other hand, when conditions favorable to nitrosation are present, nitrite can participate in the formation of N-nitroso compounds.The sequence documented by the publication subject to the Evidence Review is therefore: dietary nitrates nitrites possible nitrosation in the presence of precursors N-nitroso compounds. The subsequent step, namely the increased risk of gastrointestinal tumors, is not causally demonstrated by the analyzed study alone: it requires independent epidemiological and experimental data. The book's formulation is scientifically consistent if interpreted as a conditional possibility and as a risk association, not as a certainty that plant-based nitrates cause gastrointestinal tumors.

6. INDEPENDENT CONFIRMING EVIDENCE

A dietary trial conducted on 20 healthy volunteers provides direct confirmation of the chemical-intermediate step in the chain. For two weeks, participants consumed either processed red meat or unprocessed white meat; in the second week, the drinking water was adjusted to a nitrate content corresponding to the acceptable daily intake. The increase in nitrates in the water significantly increased the apparent total N-nitroso compounds in the stool, with a more pronounced increase in the group consuming processed red meat. The study measures biomarkers of nitrosation, not the onset of tumors; it therefore confirms the mechanism, not a clinical effect [1].A meta-analysis of 22 articles, including 49 epidemiological comparisons, links the downstream step of the narrative to gastric risk. Compared to the lowest exposure categories, the highest categories of nitrite intake were associated with a higher frequency of gastric cancer, with a relative risk of 1.31 and a 95% confidence interval from 1.13 to 1.52. Higher intake of N-nitrosodimethylamine, a nitrosamine known as NDMA, was also associated with a higher frequency of gastric cancer, with a relative risk of 1.34 and a confidence interval from 1.02 to 1.76. Conversely, nitrate intake was associated with a lower frequency of gastric cancer. Since the included studies were observational and used different methods to estimate diet, these associations do not prove causality [2].Another systematic review with meta-analysis of 40 articles obtained convergent results for nitrites and N-nitroso compounds. Higher nitrite intake was associated with a higher overall frequency of gastrointestinal cancers, with a relative risk of 1.18 and a confidence interval from 1.07 to 1.29. For gastric cancer, the association with dietary nitrites was 1.33, with a confidence interval from 1.02 to 1.73; for NDMA, an association with a higher frequency of colorectal cancer was reported, with a relative risk of 1.36 and a confidence interval from 1.18 to 1.58. Here, too, the result concerns associations between estimated exposures and disease, not the demonstration that a single food causes cancer [3].Taken together, these independent studies reconstruct a convergent chain: the human trial shows that exposure to nitrates can increase markers of nitrosation under defined dietary conditions; the meta-analyses show that higher exposure to nitrites or specific nitrosamines is associated with a higher frequency of certain gastrointestinal cancers. It remains essential to separate this framework from overall vegetable consumption, which includes many potentially protective substances and is not equivalent to isolated exposure to nitrites or nitrosamines.

7. CONFLICTING EVIDENCE

Important contextual evidence comes from a meta-analysis specifically dedicated to plant-based nitrates and nitrites. Thirteen articles were analyzed, involving a total of 897,585 participants and 10 types of digestive tract cancers. Compared to low consumption, neither high consumption of plant-based nitrates nor high consumption of plant-based nitrites was found to be statistically significantly associated with a higher overall frequency of digestive tract cancers. For plant-based nitrates, the relative risk was 0.92 with a confidence interval of 0.82 to 1.03; for plant-based nitrites, it was 0.91 with a confidence interval of 0.84 to 1.00 [4].This evidence does not disprove the chemical possibility of the nitrate-nitrite-nitrosamine conversion. However, it scales back a generalized interpretation that the nitrate contained in vegetables inherently leads to an increased oncological risk. The authors also note that, in the dose-response analysis, a higher average intake of plant-based nitrates was associated with a lower frequency of gastric cancer. Fiber, vitamin C, vitamin E, and polyphenols present in plant foods can modify the context of nitrosation; furthermore, nutritional

studies are subject to errors in intake estimation and confounding factors [4].

8. QUADRO COMPARATIVO E SINTESI DELLE EVIDENZE

The table distinguishes the publication that is the subject of the review from independent research that confirms or defines the narrative of the book's paragraph.

Quadro comparativo

Reference	Study type	Population or model	Main result	Direction of evidence	Strength of evidence
Original study	Narrative literature review	Literature on sources, metabolism, and risks of nitrates and nitrites	Describes nitrate-to-nitrite conversion and the potential formation of N-nitroso compounds under favorable conditions	biologically consistent evidence	moderate
[1]	Human pilot dietary intervention	20 healthy volunteers	Nitrates in water at the acceptable daily intake increased apparent fecal N-nitroso compounds	direct confirmation	moderate
[2]	Meta-analysis of observational studies	22 articles, 49 studies on gastric cancer	Higher intake of nitrites and NDMA associated with higher frequency of gastric cancer	indirect confirmation	moderate
[3]	Systematic review and meta-analysis	40 articles on gastrointestinal cancers	Nitrites associated with higher frequency of gastric cancer; NDMA associated with higher frequency of colorectal cancer	indirect confirmation	moderate
[4]	Systematic review and meta-analysis	13 articles, 897,585 participants; plant sources	Plant-based nitrates and nitrites not associated with higher overall frequency of digestive cancers	discordant evidence	moderate

9. SINTESI EDITORIALE E CONCLUSIONI

CONCLUSIONS

The analyzed publication correctly supports the point that nitrates and nitrites can participate in the formation of nitrosamines in the gastrointestinal tract. This process is well-supported at a chemical and mechanistic level, while the extent to which it translates into oncological risk depends on exposure conditions and the food matrix.Independent evidence confirms that higher exposure to nitrites and certain nitrosamines is associated with a higher frequency of specific gastrointestinal cancers. However, the consumption of nitrates from plant sources does not show a significant overall increase in risk and can be included in a dietary context rich in compounds that limit nitrosation. The most balanced conclusion is therefore that the biological chain is moderately supported, but requires further prospective validations capable of precisely distinguishing between sources, doses, and dietary combinations.

Aggiornato al 17/11/2026. Questo contenuto riflette una sintesi divulgativa delle evidenze scientifiche al momento della pubblicazione e non sostituisce il parere medico.

10. TRANSPARENCY AND SCIENTIFIC RESPONSIBILITY

Artificial Intelligence was used solely as a tool for editorial and documentary support. All content, interpretations, bibliographic citations and conclusions have been verified, reviewed and approved by the author, who assumes full scientific responsibility for them.

The manuscript was also subjected to independent peer review prior to publication.

To ensure the greatest transparency, the complete history of the article, including the dates of submission, revision, acceptance and publication, as well as information on the peer review process, is available on the dedicated Article History page.

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