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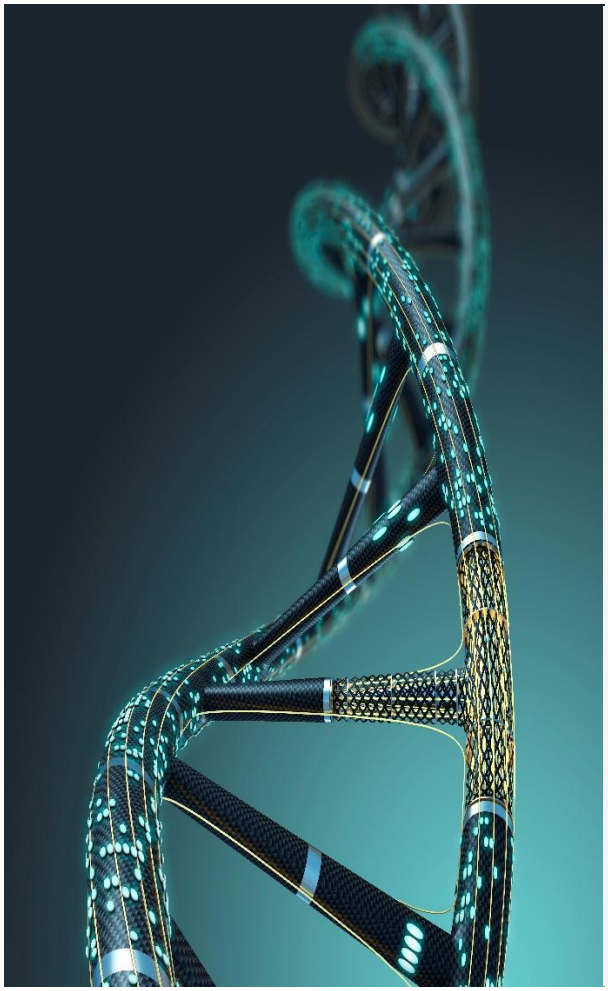

Nitrates: Toxins to Human Health

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8 December 2024

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Introduction

Nitrogen, whose chemical symbol is designated N on the periodic table, is an element that exists naturally on earth in the soil, water, and in the atmosphere. Nitrogen cycles in the atmosphere and in the soil and is important for healthy soil. These naturally occurring nitrates are not harmful to human health.

In the soil, nitrogen is converted to nitrates through a biochemical process known as nitrification, which is initiated by bacteria:

- Bacteria convert the nitrogen (N_2) to ammonium (NH_3)
- The ammonium (NH_3) is converted by soil bacteria to nitrite (NO_2)
- Nitrite (NO_2) is then converted by soil bacteria to nitrate (NO_3)

Nitrate concentration in plants varies depending upon the quality of the soil. Nitrate concentration will vary in the leaf, root, and stem of the plant. Fruits and vegetables such as spinach, lettuce, and cabbage contain nitrates. Alliums such as garlic and onion contain nitrates and sulfur; radishes and celery contain nitrates. Fruits such as watermelon, strawberries and apples contain low amounts of nitrates.

Chemical Structure and Conversion

There are different classes of processed nitrates, and each class has a different chemical structure. Chemical structure determines the nature of the behavior of the compound. The distinct nature of some chemical compound lies in chemical arrangements of atoms that create something called a functional group. In chemistry, functional groups are termed “R” and as mentioned, the functional group determines the behavior of the molecule. Once in the body, nitrate compounds are metabolically broken down into constituent parts and often the metabolic by-products can be harmful to cellular health. Toxic by-products can disrupt normal cellular processes and create cellular inflammation.

Conversion

Nitrogen containing organic compounds are referred to as NOCs. NOCs are divided into categories, and we will talk about one of the categories: Nitrosamines.

Nitrosamines

Amines are compounds that contain additional nitrogen groups. Nitrosamines have a backbone molecule that contains two hydrogens, and two nitrogens bound to an oxygen (H_2N_2O). Different “R” groups will be added and determine the nature of the compound. In the body, nitrosamines are derived from nitrates via a series of reactions that converts nitrate to nitrite, and nitrite is converted to nitrosamines in foods. In other cases, the synthetic nitrosamine is already an existing compound directly manufactured in foods,

cosmetics, and industrial products. Below is a table with some common nitrosamines, the chemical symbol, where the toxic nitrosamine is found, and associated cancers:

Table 1

Nitrosamines

Nitrate Compound	*Acronym*	*Where we find it*	*Cancer Association*
N-nitrosmethylamine C2H6N20	NDMA	Processed meats, processed cheeses, alcohol, cigarettes, cosmetics, personal products, pesticides	Bladder, liver, lung, prostate, stomach
N-nitrosobutylamine C8H18N2O	NDBA	Cosmetics, personal products, water, pork, pesticides, pharmaceutical products	Bladder, leukemia, lung
N-Nitrosodethylamine C4H10N2O	NDEA	Lubricants, plastics, gasoline, pharmaceuticals	Bladder, liver, prostate, stomach
N-Nistrosopiperidine C5H10N2O	NPIP	Cured meats, cheese, fish, alcohol, cigarettes, pesticides, pharmaceuticals, and used as the preservative sodium nitrate spices	Esophageal, liver, lung, stomach
N-nitrosomorpholine C4H8N2O2	NMOR	Water supply, rubber, manufacturing, found in wax that covers fruit, cigarettes	Liver, lung, nasal cavity, kidney
N-nitrsopyrrolidine C4H8N2O	NPYR	Cured meats, cigarettes	Liver, lung, nasal cavity

Note. Processed and cured meats include bacon, sausage, hot dogs, beef, chicken, turkey. Notice the number of nitrates found in cigarettes. The list of cancers reflects cancers reported in the literature. However, other cancers are possible. Many of the uses and applications of nitrates are FDA approved.

Regulation of Nitrates

Nitrates Regulated in the Water Supply

There are allowable levels of nitrates in foods, bottled water and city water. The EPA regulates nitrates in public water at the maximum contaminant level (MCL). Note that nitrates are not removed from drinking water: 10 parts per million of nitrate is considered contaminated and 1 part per million of nitrite is considered contaminated. Bottled water also contains both nitrate and nitrite and the levels are set at 10mg/L for nitrate and 1mg/nitrite.

Nitrates Regulated in Food Products

The USDA states that less than 200 ppm can be contained in meats. The WHO standard for nitrates in food products is 0 to 3.7mg per kg of body weight.

Synthetic and Manufactured Nitrates

Synthetic and manufactured nitrates are harmful to human health. Nitrates are used to preserve food, to prevent the growth of bacteria, and to provide flavor and color to food. Nitrates are added to food in the form of sodium nitrate.

Nitrates to Prevent Bacterial Growth

Nitrites are added to foods to prevent bacterial growth. Most notably nitrates are added to prevent the growth of *Clostridium botulinum*, a spore forming gram negative bacteria that causes botulism. Nitrites also prevent the growth of *Staphylococcus* species. Staphylococcus species are gram positive bacteria and can contaminate many foods including poultry, meat, and dairy products.

Nitrites for Preserving Food Color

Nitrites are used to preserve food color. This process is accomplished via two different processes of the nitrites binding to proteins in the meat. One process occurs when the nitrite is converted to nitric oxide (NO). The nitric oxide (NO) combines with the iron containing muscle protein myoglobin. The nitric oxide binds to the iron in myoglobin via an oxidation reaction to forms nitrosylmyoglobin, which contributes to the iron sustaining the red color of the meat. The nistrosylmyoglobin converts to nitrosohemochrome when heated.

In another process, the nitric oxide (NO) and myoglobin form a compound named metmyoglobin and through oxidation metmyoglobin turns the meat brown i.e. metmyoglobin makes meat look brown. Different types of meats contain different amounts of myoglobin. For example, pork contains about 2mg/g of myoglobin and beef contains

about 8 mg/g of myoglobin. Additionally, differences in myoglobin exist depending on the type of muscle the meat is taken from.

Nitrites Add Flavor

Nitrates add flavor to food preventing the oxidation of lipids (fats) and some proteins that are found in the meat. Fat makes food flavorful. When nitrates combine with lipids, they prevent oxidative processes and create additional compounds that contribute to the flavor.

Nitrites are added for flavor to meats through dry curing, immersion curing, smoking, and injection. Smoking meat involves the process of smoking. Dry curing involves adding the nitrate as a salt. Immersion involves immersing the meat in liquid to absorb the nitrites. Nitrates can also be directly injected into the meat.

Nitrates and Cancer

Nitrates have been linked to many types of cancer. Among the top cancers: Colon cancer, colorectal cancer, prostate cancer, pancreatic cancer, gastric cancer, lymphoma and the list goes on. Nitrosamines are associated with cancer in the digestive system such as the liver, stomach, and esophagus. Brain and urinary cancers are also associated with nitrosamines. The mechanism by which nitrates cause cancer is due to a process where the nitrates create entities known as DNA adducts. The adduct is created when the nitrogen compound binds to the DNA. Chemicals that bind to DNA can damage DNA. Adducts in DNA lead to mutations and mutations in DNA lead to cancer. Additionally, nitrates are also toxic to the liver and can cause liver damage. Damage to the liver can result in impaired detoxification and liver inflammation, both of which have implications to overall health.

Conclusion

Our foods are full of additives and nitrates are one additive that can have a negative impact on human health. To protect health and decrease the risk of cancer, avoid processed and cured meat. Reduce consumption of meat and meat products such as cold cuts, hot dogs, sausages, bacon, lunch meat and deli meat, canned meat, and even some seafood. If you are going to buy meat read labels and look for nitrate free meats. Stay informed. Stay healthy and well.

References

Ferysiuk K, Wójciak KM. Reduction of Nitrite in Meat Products through the Application of Various Plant-Based Ingredients. Antioxidants (Basel). 2020 Aug 5;9(8):711. doi: 10.3390/antiox9080711. PMID: 32764511; PMCID: PMC7464959.

Kontominas, M.G. (2014). PACKAGING | Modified Atmosphere Packaging of Foods. *Encyclopedia of Food Microbiology* (Second Edition), P 1012-1016.https://doi.org/10.1016/B978-0-12-384730-0.00432-8.

Shakil MH, Trisha AT, Rahman M, Talukdar S, Kobun R, Huda N, Zzaman W. Nitrites in Cured Meats, Health Risk Issues, Alternatives to Nitrites: A Review. Foods. 2022 Oct 25;11(21):3355. doi: 10.3390/foods11213355. PMID: 36359973; PMCID: PMC9654915.

Shimokomaki, M., Youssef Youssef,E., & Terra, N.N. (2003). CURING, Encyclopedia of Food Sciences and Nutrition (Second Edition. Pages 1702-1708, https://doi.org/10.1016/B0-12-227055-X/00316-3.

ΓΚΟΒΑΡΗ, Μ. & Pexara, Andreana. (2018). Nitrates and Nitrites in meat products. Journal of the Hellenic Veterinary Medical Society. 66. 127. 10.12681/jhvms.15856.

Wang B, Shi Y, Tejero J, Powell SM, Thomas LM, Gladwin MT, Shiva S, Zhang Y, Richter-Addo GB. Nitrosyl Myoglobins and Their Nitrite Precursors: Crystal Structural and Quantum Mechanics and Molecular Mechanics Theoretical Investigations of Preferred Fe -NO Ligand Orientations in Myoglobin Distal Pockets. Biochemistry. 2018 Aug 14;57(32):4788-4802. doi: 10.1021/acs.biochem.8b00542. Epub 2018 Jul 27. PMID: 29999305; PMCID: PMC6474360.