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Researches regarding the origine, influence and levels of nitrite and nitrat from meat products

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Abstract

Due to the toxicological implications of nitrites and nitrates used in the production of meat products, in this paper we referred to two aspects, one regarding the origin of nitrites/nitrates in meat products, and second the risk involved by the use of this substances as food additives. We also present the results of research undertaken within two months of analysis of meat products samples collected from three meat processing units from Cluj county and conclusions resulting from this study.

Determinate values showed fluctuations in nitrite content from one processor to another and also in the same processor, depending on the analyzed product type.

Keywords: nitrite, nitrate, meat products, processor, daily intake, exceeding levels

1. Introduction

Besides the fact that foods provide the body with nutrients needed to ensure the necessary energy used in the vital processes, for the synthesis of own substances used in repairing processes, and also for the formation of active substances (hormones, enzymes) that ensures normal metabolic processes, a good nutrition requires the fulfillment of another essential condition: the consumed products to be free of hazard agents or the concentration to be in the legal limits, so that they do not harm the body. There are some situations when food products contain these harmful agents, and so becoming factors that undermine the human health causing even disease. Some of this agents have biological origin (bacteria, viruses, parasites), and others are chemical substances that have toxic, mutagen and carcinogen effects.

Toxic substances from food products have always concerned specialists, but in the last decades, agricultural chemical processing, environmental pollution, industrialization of food products, that involves the use of different additives, have given a new dimension to this problem, that has direct impact on consumer health. The presence of these substances is more and more diverse and complex.

Although there are different methods to establish the toxicity of some substances, none gives satisfactory results, because it is difficult to test all the chemical products manufactured until know or those in progress. Also, it is possible to put a substance in one of the toxicity class, indicating the risk of acute poisoning, but not the danger that results from long-term exposure, because there is no correlation between daily intake and acute toxicity value. Therefore, in addition to the direct effect should be taken into account the cumulative effects of small doses, apparently harmless.

Nitrate and nitrite are natural components of soil, that form during mineralization of nitrogen organic matter of plant or animal origin, primarily due to the existing microorganism in the soil, this process is taking place with maximum intensity during summer.

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A part of nitrate and nitrite is absorbed by plant roots and serves as raw material for synthesis of protein and other nitrogen compounds, and another part is driven by the surface water or the water that is crossing the soil, so that these substances can be found in rivers, lakes and groundwater. Naturally, between the nitrates and nitrites from soil, water and plants is established an equilibrium, that can be interrupted by the intensive use in agriculture of natural organic fertilizers (manure), and especially the synthetic nitrogen substances, degradation products can enrich the soil and accumulate in the crop to hazard levels for consumer. Through feed and water, nitrates and nitrites enter the animal's body, whose products are used in the human diet.

Both substances are used as food additives in meat products and sometimes in milk used for cheese production, to improve the sensory characteristics and to extend the product storage time (preservative effect).

Although animals can ingest high quantities of nitrates from feed and water, still the levels of nitrates and nitrites from meat is very low, because the nitrates that reach the small intestine are easily absorbed, pass in the blood and are excreted by the kidneys. In the case of herbivorous ruminant animals, most of the existing nitrates from feed are used as raw material for synthesis of nitrogen organic substances by the microorganisms that inhabit their stomachs.

In meat products (ham, salami, sausages, etc.) nitrates and nitrites are used to obtain the pink-red color and because of their preservative effect (bacteriostatic/bactericidal) in particular against anaerobic bacteria. Salt and the acidic pH enhance the bacteriostatic effect.

To ensure a uniform diffusion in the meat, nitrates and nitrites are added usually mixed with dry salt (salting mixture type A – with 0.8 kg nitrate + 0.2 kg nitrite/100 kg salt or salting mixture type B – with 0.5 kg nitrite/100 kg salt) or in brine. Under the influence of the reducing flora from meat and the salting mixture/brine, nitrates are reduced to nitrites. They oxidize the myoglobin from muscular tissue and the hemoglobin from residual blood to nitrosomyoglobin and nitrosohemoglobin, which are stabilized under heat treatment to nitrosocromogens that give, in section, the pink-red color of the finished product. In their absence the meat product would have a gray color.

Since nitrite is the active element, today's trend is to use only this compound, under the name "hard nitre". Nitrates ("soft nitre") or the mixture of nitrates-nitrites are recommended for sausages with a long process and storage time (eg. raw salami like "Sibiu", pemmican, etc.).

The researches highlighted the toxic action of nitrates and nitrites, otherwise known for a long time. The problem has become particularly topical since there have been reported, frequently, cases of acute and chronic nitrates and nitrites poisoning in young children that consumed vegetable food products and water with high concentrations of nitrites and nitrates. Thus, the toxic potential of nitrates and nitrites was correlated with the age of the consumer, the currently existing concentrations in foods of animal origin present no health hazard for adults and children, but attention was drone to the risk for infants, especially in the first three months of life.

The toxicological implications of these chemical substances become more complex after demonstrating the cumulative effect and the possibility to form nitrosoamines with carcinogenic effect.In our country, the nitrites concentration in finished products is limited to maximum 10 mg/100 g finished product. In many other countries, there are accepted higher limits, up to 20 mg/100 g and even more. The risk of nitrosoamine formation has led into actuality this problem, with the aim to review these standards and to reduce the accepted limits.

Nitrates, as such, have a low toxicity. In order to cause disorders (nauseas, vomiting, cramps, diarrhea), a person has to ingest high quantities of nitrates (up to 10 g, single dose). In cases of an intake that is not exceeding normal limits, nitrates are almost entirely absorbed in the first part of the small intestine and are excreted in the saliva, gastric juice and urine.

As long as the nitrates are not transformed in nitrites, they show a weak bacteriostatic effect, acting through a mechanism similar to sodium chloride (osmotic pressure change). Nitrites, much more toxic than nitrates, can be found in small amounts in foods, as a natural compound. But their concentration can increase up to dangerous levels, through the reductive action of microorganism on nitrates.

Moreover, the nitrites from finished food products may come also from nitrates and nitrites used as food additives.

The transformation of nitrates to nitrites is achieved by enzymatic reduction reaction in food; reduction as an action of the existing microflora in the food product; bacterial reduction in the oro-gastro-intestinal tract etc. So, under the action of enzymes secreted by the digestive tube bacteria, nitrate-reductase and nitrite-reductase, nitrates are reduced to nitrites which, if nitrite-reductase activity keeps up with nitrate-reductase activity, nitrites do not accumulate, because they are degraded in simpler products (nitrogen oxides, ammonia and nitrogen). But usually, nitrate-reductase activity is more intense than the nitrite-reductase.

Usually, nitrite quantities formed in the large intestine are low, because the majority of nitrates are absorbed in the small intestine and are excreted in urine. The formation and transportation into blood and tissue of higher quantities of nitrites it is facilitated by a series of factors, including digestive disorders (colitis, enterocolitis, reduction or absence of gastric acid etc.) or consumption of food and water with high concentration of nitrates and possibly nitrites.

2. Materials and methods

There were analyzed as a physico-chemical aspect, regarding the content of nitrites, 77 meat products samples collected from three meat processing units from Cluj county (32 samples from processor A, 22 samples from processor B and 23 samples from processor C), as presented in table 1.

Table 1. The finished product samples used for examination

Type	No. of samples		
	Unit A	**Unit B**	**Unit C**
Vară salami	12	7	8
Trandafir sausage	8	9	10
Frankfurters	12	6	5
Total	**32**	**22**	**23**

The samples were collected from manufacturing lots (in sterile plastic bags) and were analyzed within 6 hours from sampling.

Nitrites content was determined using Griess method, measuring the intensity of the pink nitric compound formed from the reaction of nitrates in the deproteinized aqueous extract and Griess reagent (with UV-VIS spectrophotometer using Griess reagent and a standard curve).

3. Results and Discussion

The results represent parameters recorded in 2008, during two months, for three type of meat products ("Vară" salami, "Trandafir" sausage and frankfurters) produced by the three studied units (unit A, B and C), the main objectives of the research aimed at determining possible nitrites content breach in the analyzed samples and the meat group in which the levels were significant.

The results of the nitrite content in the analyzed samples, for each type of meat product were as follows:

Table 2. The results of nitrite content for the analyzed samples (for each type of meat product) from unit A

Type	**No. of analyzed samples**	**Accepted levels (mg/100g, max) OMS 975/1998**	**Positive samples**		**Exceeded levels (mg/100 g)**
			No.	%	
Vară salami	12	7	2	16.66	7.2-8.7
Trandafir sausage	8		1	12.50	7.9-8.4
Frankfurters	12		3	25	7.6-8.1
TOTAL	32		6	18.75	7.2-8.7

Table 3. The results of nitrite content for the analyzed samples (for each type of meat product) from unit B

Type	**No. of analyzed samples**	**Accepted levels (mg/100g, max) OMS 975/1998**	**Positive samples**		**Exceeded levels (mg/100 g)**
			No.	%	
Vară salami	7	7	1	14.29	7.2-7.5
Trandafir sausage	9		2	22.22	7.1- 7.8
Frankfurters	6		1	16.66	7.3-8.2
TOTAL	22		4	18.18	7.1- 8.2

Table 4. The results of nitrite content for the analyzed samples (for each type of meat product) from unit C

Type	No. of analyzed samples	Accepted levels (mg/100g, max) OMS 975/1998	Positive samples		Exceeded levels (mg/100 g)
			No.	%	
Vară salami	8	7	2	25	7.5 -8.9
Trandafir sausage	10		3	30	7.7- 9.2
Frankfurters	5		2	40	8.2-9.6
TOTAL	23		7	30.43	7.5-9.6

Table 5. The exceeding situation of nitrites content in the analyzed samples from the three meat processing units

Unit	No. of analyzed samples	Accepted levels (mg/100g, max) OMS 975/1998	Positive samples		Exceeded levels (mg/100 g)
			No.	%	
A	32	7	6	18.75	7.2-8.7
B	22		4	18.18	7.1-8.2
C	23		7	30.43	7.5-9.6

As shown in the tables above, the nitrite content from the samples varied from one processor to another and from one type of product to another, from a low level of 7.1 mg/100 g (in the case of *Trandafir* sausage from unit B) to a maximum of 9.6 mg/100 g (in the case of the frankfurters produced by the unit C), the higher variation limits being recorded for the products manufactured at the unit C (7.5 - 9.6 mg/100 g).

4. Conclusion

The results show variations of nitrites content of meat products from one processor to another and within the same processor from one product type to another, unit C having the most frequently limit breaches reported to the number of samples analyzed (30.43%) and the higher maximum values recorded (7.5 – 9.6 mg/100 g).

In conclusion, even though it is necessary to use of these additives in the technological manufacturing process of meat products, it is desirable to follow the maximum values allowed by the legislation. These maximum levels can have multiple causes, the technological ones being due to:

- non-compliance with the manufacturing recipe of the salting mixture (nitrite quantity should not exceed 0.5 kg/100 kg salt) or of the brine (the composition should be correlated with dose/mixing proportions and type/quality of the salted raw material);
- non-compliance with the salting proportions/percentages of the raw materials, which can result in an incorrect dosage of nitrites (so there will not be 50 g nitrite/400 kg meat);
- incorrect mixing with the salting mixture/brine (which can cause a heterogeneous dispersion of the compounds in the mass of raw material);
- improper storage conditions for the curing of semi-products: temperature 0…4°C; minimum duration 18 hours (if the product was pre-chopped using Volf machine)/24 hours (if the product is not pre-chopped with Volf), optimum 48 – 72 hours; air relative humidity 85 – 90%;
- missing or insufficient reducing substances (ascorbic acid/sodium ascorbate, reducing sugar) used in the manufacturing process (transformation of nitrite into NO and therefore, ineffective formation and stabilization of the color);
- improper heat treatment (ineffective transformation of the salting pigments into nitrocromogens with high stability, that give the red color to the meat products).

It should also be noted that even if the amounts of these additives are in compliance with the maximum limits, there must be taken into account the cumulative effects of the small doses actions, apparently harmless.

Based on the results we can make the following recommendations:

- establishing the nitrites/nitrates needed for salting based on the myoglobin and hemoglobin content from meat, $NaNO_3$/$NaNO_2$ amount that is actually involved in the coloring process of meat and residual $NaNO_3$/$NaNO_2$ established by law;

- the use of reducing substances in the manufacturing process of meat products, which reduce from the beginning the amount of nitrite added, which ultimately leads to a smaller amount of unchanged nitrite and so, reducing the risk of nitrosoamine formation (which have carcinogenic effect);
- banning the use of nitrate in the salting of raw materials, its degradation being dependent on many factors, nitrate-reducing microflora activity is favored by higher temperatures (≈10°C), longer salting time (72 hours) and pH>5.8 so that it is impossible to establish the exact level of residual nitrate in the final product.

Product quality control represents an imperative of progress, meeting the needs and requirements of consumer, and also taking into account the health of consumers, ensuring the distribution on the market of products that cover the nutritional values and energy needs essential to the vital processes, without becoming hazard agents that undermine the body's health or cause illness.

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