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Nitrate and nitrite accumulation in tomatoes and derived products

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Abstract

This research was developed as a consequence of European Union requirements regarding food safety and quality, with the aim to evaluate the levels of nitrate and nitrite in tomatoes and in derived products (tomato juice, tomato sauce). The analyzed tomatoes were grown in the greenhouse [cvs. L2 Minidelicia and Ailsa Craig (Mt)], in solarium [cvs. Cristal F1 and Marissa F1 (Mt)] and in the field (cvs. Buzau 2 and Buzau 4). The nitrate level in tomatoes ranged between 82.24-116.75 mg/kg and these values are under the safe limit set by Romanian legislation. In tomato juice the nitrate level ranges between 53.75-78.55 mg/kg, while in tomato sauce ranges between 131.15-193.85 mg/kg. The nitrite levels in all cases (tomatoes, juice and sauce) are under 1 mg/kg. The highest nitrate and nitrite concentrations were found in tomato sauce and the lowest were found in tomato juice.

Keywords: nitrate, nitrite, tomato, tomato juice, tomato sauce

Introduction

In recent years, an increasing interest concerning determination of nitrate levels in food products has been observed, essentially due to the potential reduction of nitrate to nitrite, which is known to cause adverse effects on human and animal health. Therefore, the monitoring and surveillance of the quality of vegetal products need to be enhanced.

Nitrates and nitrites may accumulate in plants tissues and are very dangerous substances for human health, leading to different health disturbances (methemoglobinemia, changes in vitamin level, thyroxin production and negative influence on reproduction). Some epidemiological studies linking intake of nitrate and nitrite with gastric cancer in humans indicated a positive correlation [1].

Nitrogen is absorbed by plants in the form of either ammonium (NH_4^+) or nitrate (NO_3^-), and its accumulation is influenced by a series of factors that are depending on the species, cultivar, age and soil conditions. Once nitrate is absorbed by plants, it has to be reduced by the enzyme nitrate reductase to ammonium and assimilated via glutamate [2]. The concentration and amount of nitrates levels in plants will vary depending on the type of vegetable, the temperature that it is grown at, the sunlight exposure, soil moisture levels and the level of natural nitrogen in the soil.

Vegetables tend to concentrate nitrate ions, especially if they are grown by using a high application of nitrogen fertilisers. If nitrate levels in vegetal products are too high, farmers must reduce the amount of nitrogen fertilizers they use, though the problem from the farmer point of view is that by reducing nitrogen applications is likely to obtain lower yields.

Also, it is known that molybdenum is a component of nitrate reductase enzyme, which has an important role in plant nitrate metabolism [3]. Lower concentrations of molybdenum in plants lead to nitrate accumulation in tissues and sometimes, a higher level of nitrate is a consequence of this aspect.

Our major intake of nitrates in foodstuffs comes from vegetables. Nitrates are natural constituents of plants, and are present in large quantities in many vegetables. Vegetables such as beets, celery, lettuce, radishes and spinach contribute with about 85–90% of an adult dietary intake of nitrate, with nitrate levels ranging from 1.7 to 2.4 g/kg food [4]. The concentration of nitrate in vegetables can vary considerably, reaching sometimes as much as 3–4 g/kg fresh weight, and these levels could have potential health impacts [5].

Because of the potential health hazards as a result of high intake of nitrate and nitrite, the determination of these ions content in vegetables has been considered and measured in many countries [6,7,8,9].

Material and methods

The present study attempts to analyse the levels of nitrate and nitrite from tomatoes and derived products and to corelate the obtained results with limits set by Romanian legislation. The tomatoes were provided by SCDL Buzau and were grown in greenhouse [cvs. L2 Minidelicia and Ailsa Craig (Mt)], in solarium [cvs. Cristal F1 and Marissa F1 (Mt)] and in the field (cvs. Buzau 2 and Buzau 4). It was not applied nitrogen fertilizers during vegetation period. These tomatoes were processed in order to obtain juice and sauce.

The quantitative nitrate and nitrite determinations were performed both on tomatoes and on derived products.

The tomatoes were washed with distilled water for air-pollutants removal and the samples were sliced and dried on a sheet of paper in order to eliminate the excess of moisture. After these procedures, precisely weighted samples (2.5 g) were grounded and treated with 50 ml of 2% acetic acid in order to extract nitrate and nitrite. Coloured samples were cleared with animal charcoal and the filtrate was used for nitrate and nitrite determination. Each sample was analyzed in duplicate and the result was expressed as mg/kg fresh weight.

The nitrate dosage was made through the spectrophotometric method by using phenol-2,4-disulphonic acid in basic medium (sodium hydroxide, 20%).Yellow nitroderivatives were obtained, that have absorption maxima at 420 nm [10].

The nitrites were determined spectrofotometrically as well, using Griess reagent that was prepared using sulphanilic acid in acetic medium and α- naphtylamine hydrochloride. Nitrite is quantitative determined using Griess method [11]. This reaction was firstly described in 1879 and due to its simplicity and precision was intensively used to determine the nitrites from biologic samples, soil, and food [12].

It was measured the intensity of the colour of azoic compound that was formed after the diazotation reaction between sulphanilic acid and nitrites, followed by coupling the reaction with naphtylamine. The measurements of pink formed complex were performed at 520 nm wavelength, after 20 minutes since the colour developed.

The calibration curves for nitrate and nitrite were linear for the studied concentration ranges.

Results and discussions

The goal of this research was to establish the levels of nitrate and nitrite from different varieties of tomatoes grown in various conditions (greenhouse, solarium and field) and from derived products (tomato juice, tomato sauce). Taking into account that nitrates and nitrites may accumulate in plant tissues and are very dangerous substances for human health, their concentrations were determined.

The results concerning nitrate and nitrite contents in tomatoes and derived products are shown in table 1.

Nitrate level in analysed tomatoes ranges between 82.24-116.75 mg/kg with an average of 104.69 mg/kg. The highest nitrate content was found in Marissa F1(Mt) (116.75 mg/kg) and the lowest was in Buzau 2 (82.24 mg/kg).

For tomato juice, the nitrate level ranges between 53.75- 78.55 mg/kg with an average of 68.65 mg/kg. All the values are lower than those for corresponding tomatoes.

For tomato sauce, the nitrate level ranges between 131.15-193.85 mg/kg with an average of 168.72 mg/kg. The nitrate levels in tomato sauce are higher than those for corresponding tomatoes due to the concentration process that takes place during tomato processing into sauce (figure 1).

According with Romanian legislation [13] the safe nitrate level in tomatoes grown in greenhouse and solarium is maximum 300 mg/kg and for those grown in the field the safe level is up to 150 mg/kg. All the analysed tomatoes and derived products present nitrate levels lower than those imposed by legislation. In conclusion, they meet the safe limits for toxic elements specified by the Romanian food standards and are safe to be marketed and consummated.

The nitrate content for tomatoes grown in greenhouse and solarium in comparison with maximum set limit is almost 2.6 times lower while for tomatoes grown in the field is 1.8 times lower. So, according with those above mentioned, we consider that these tomatoes are safe to be consumed.

Table 1. Nitrate and nitrite content in tomatoes and derived products

Tomato variety	Analyzed product	Nitrite NO_2^- (mg/kg)	Nitrate NO_3^- (mg/kg)
L2 Minidelicia	tomatoes	0.3	112.5
	tomato juice	0.19	73.15
	tomato sauce	0.49	180.12
Ailsa Craig (Mt)	tomatoes	0.37	114.57
	tomato juice	0.24	71.22
	tomato sauce	0.58	177.25
Cristal F1	tomatoes	0.32	115.98
	tomato juice	0.17	77.94
	tomato sauce	0.5	191.23
Marissa F1(Mt)	tomatoes	0.4	116.75
	tomato juice	0.26	78.55
	tomato sauce	0.62	193.85
Buzau 2	tomatoes	0.25	82.24
	tomato juice	0.16	53.75
	tomato sauce	0.39	131.15
Buzau 4	tomatoes	0.21	86.15
	tomato juice	0.14	57.32
	tomato sauce	0.33	138.75

The nitrite levels in tomatoes and derived products are very low, under 1mg/kg (figure 2). Anyway, nitrite contents in vegetal products are generally lower than nitrate ones. The transformation processes of nitrate in plants lead to nitrite and this step is a transitory one because the nitrites are reduced very rapidly by nitritreductase to nitrogen oxides.

The nitrite content in tomatoes varies between 0.21-0.4 mg/kg with an average of 0.3 mg/kg. The nitrite content in tomato juice is lower than for corresponding tomatoes, while in tomato sauce is higher due to sample concentration during tomato processing.

Similar data, concerning nitrate contents in different types of vegetables, are presented in the literature. Low nitrate contents (below 6 mg/kg) were found in tomatoes by Susin et al. [9]. Zhong et al. [14] analyzed the contents of nitrate and nitrite in potato, cabbage, Chinese cabbage, celery, cucumber, tomato, eggplant and found that the nitrite content was low, while a great variation was recorded for nitrate.

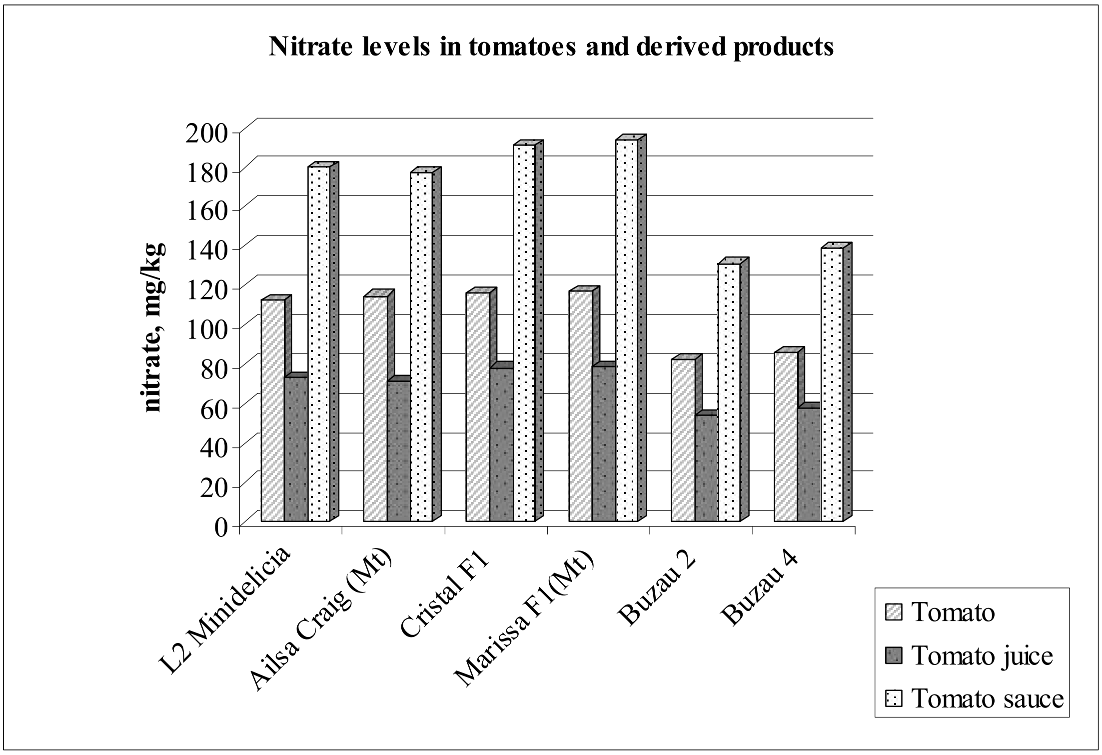

Figure 1. Nitrate levels in tomatoes and derived products

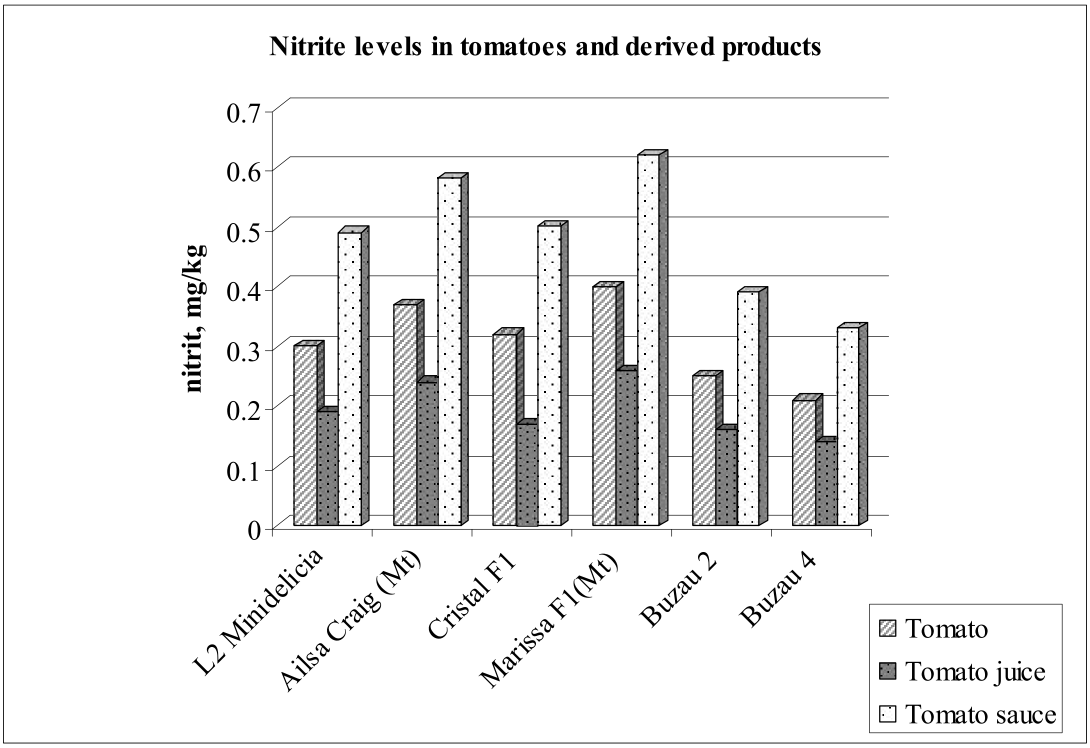

Figure 2. Nitrite levels in tomatoes and derived products

Significant differences regarding nitrate contents were observed between tomatoes grown in the field in comparison with those grown in solarium and greenhouse (lower in the field in comparison with those from greenhouse and solarium, of 1.3 times and 1.4 times respectively). Between nitrate contents for tomatoes grown in greenhouse and solarium and between tomato varieties there are not major differences.

Conclusions

Nitrates and nitrites are among the chemical indicatives monitored by different organisations that are concerned about environment pollution and safety of food products. So, the surveillance of nitrate and nitrite levels in food products is recommended.

According with this, the objective of the present study was to determine whether the amount of nitrate and nitrite present in tomatoes grown in greenhouse, solarium and field as well as in derived products might be sufficient to cause the associated health problems and to establish if these vegetables are safe for human health.

Six tomato varieties were analysed and the tomato juices and tomato sauces processed from these tomatoes were analysed from the same point of view.

The nitrate content for tomatoes grown in greenhouse and solarium in comparison with maximum approved limit is almost 2.6 times lower, while in tomatoes grown in the field is 1.8 times lower. The average level in nitrate and nitrite of analysed tomatoes and derived products are under safe limits set by Romanian legislation and the vegetables are safe from this point of view.

Also, low concentration of nitrates in tomatoes indicates that it was used proper quantities of nitrogen fertilisers and the plants grew in optimal conditions. Analysing the obtained results, it can be noticed that tomatoes grown in greenhouse and solarium and derived products contain higher quantities of nitrate and nitrite in comparison with those grown in the field.

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