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FOOD SAFETY AND RISK ANALYSIS THROUGH EXAMINATION OF TOXIC METALS IN FOOD PRODUCTS

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Abstract: Nutrition is one of the most important elements that affect human health, work ability and length of life. That is why it is necessary that the food products which are consumed daily are of high quality, but also safe, that is, do not contain substances harmful to the body. Food safety in all branches of food industry (production, processing, packaging, storage, transport and sale) is of increasing importance. International quality and health conformity standards establish norms for the chemical composition of food products and define the minimum and maximum amounts of certain parameters. Each state applies the prescribed standards through the adoption of appropriate laws and regulations. Heavy metals in food can be present as environmental contaminants or as residues from treatments used at all stages during production. If they are present in food products above the maximum allowable values, they can have a toxic effect. In this paper, using the AAS technique, the metals lead and cadmium were analysed in 37 food products that are used in the collective diet of the members of the North Macedonia Army. The results showed that the obtained parameters correspond to the valid regulations for the examined metals and that they are safe to use.

Key words: food products, food safety, standards, AAS, lead, cadmium

Introduction

Food safety is one of the basic interests of the modern human. The products used in daily diet are called livelihood or food products. According to their origin, they are divided into animal, vegetable, and inorganic products, and according to their role in the body, into energy, building, and protective products. They contain nutrients, as well as other substances that are added for preservation, repair of their organoleptic properties such as taste, smell, appearance, etc. In order to satisfy the increased demand and food consumption, chemicalization is carried out in agriculture, which, in addition to the

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increasing pollution of nature and the environment, poses a danger to human health and the survival of life on earth in general.

The quality regulations determine the norms regarding the chemical composition of the products, as well as other qualitative properties characteristic of the respective food product. Regarding the chemical composition, the minimum quantities of the substances that the food must contain, the maximum quantities of those substances that it may contain, as well as the substances that must not be present are defined. The tendency in all developed countries in the world is to recognize certain risks and reduce them to the lowest possible level by applying modern scientific methods.

Due to the increasing demands of consumers, the increased responsibility of producers and commerce, globalization and the tightening of legal obligations, the need to develop standards for ensuring food quality and safety is emphasized. These standards refer both to the quality and to the hygienic conformity of food products that directly affect consumer health.

Health safety control is a very important measure that ensures that food products meet the hygienic requirements for the content of microorganisms, parasites, chemical and other foreign substances. The risk to the consumer health can be effectively reduced by identifying the points of risk in food production, and therefore the international codes and standards including GlobalGAP, ISO 22000 and Codex Alimentarius are characterized with a preventative approach.

GLOBAL GAP (Good Agricultural Practice) is put into the function of consumer protection with the motto that everyone has the right to quality, and first and foremost, safe food. The overall system for the control of food production in the European Union (a possibility for food monitoring from field to table) has significantly changed with the introduction of new and stricter legal regulations.

ISO 22000:2005 is a food safety system and it is the first international standard that specifies the requirements for a food safety management system so that every organization in the food chain (primary producers, processors, transport and storage, retailers, as well as manufacturers of equipment, packaging, cleaning agents, additives, food ingredients, etc.) must demonstrate the ability to recognize and control critical points of hazard and ensure that the product is safe for consumption.

Codex Alimentarius is a collection of internationally recognized standards, rules and practices, guidelines and recommendations relating to food production and safety. The Codex Alimentarius Commission (CAC) adopts standards and recommendations for their use based on chemical specifications and health safety assessment through its committee. The purpose of the Commission is to protect the health of consumers, ensuring good practice in international food trade by prescribing rules for the regulation of agriculture and the food industry and complete control of food, regardless of whether it is processed, semi-processed or raw. EU member states are obliged to incorporate those standards and recommendations into their legislation.

Food safety in our country is regulated by the Law on Food Safety published in the Official Gazette of the Republic of Macedonia [1], and the prescribed international standards are selectively applied through appropriate regulations [2].

Food safety is defined as an acceptable level of consumer protection, where the food does not pose a risk to their health, if it is prepared and consumed in the intended way for its use. In order to ensure food safety and security, it is necessary that the level of hazard be below the maximum allowable concentrations determined by international and national legislation.

By applying food safety methods, the risk for the individual using the respective food is not determined, but the safety level of the population is identified. One of the most important tools is the risk analysis methodology. Risk analysis is a process consisting of three interrelated components: risk assessment, risk management and risk communication, and is carried out in order to achieve a high level of protection of the life and health of consumers.

Risk assessment is a science-based process that is founded on available scientific evidence and is conducted in an independent, objective and transparent manner. It consists of four stages: hazard identification, hazard characterization, exposure assessment, and risk characterization.

Three methods are used for the exposure assessment (qualitative and quantitative assessment of probable intake of the agent through food and other sources or total daily intake of the chemical substance in the human body EDI – Estimated Daily Intake [3]): examination of dietary intake through daily meals, examination of exposure per capita and results of the consumer basket analysis (through individually selected food products) and total food intake. The third method is the subject of the experimental part of this paper.

Food contamination with toxic elements, such as heavy metals, is a serious problem, starting from its production (contaminated land, water and air), through processing, packaging and storage, to preparation for use. The salts of the elements normally enter in the natural composition of the environment, and through it also into many products. Those concentrations are minimal and harmless. However, industry, traffic, the irrational use of artificial fertilizers and pesticides pollute the ecosystems with additional amounts of contaminants which, through products of plant and animal origin, are introduced into the human body. Those pollutants are resorbed in the digestive tract and cause damage at the level of body organs and tissues. On the other hand, some toxic elements, such as lead and cadmium exhibit toxic properties even in relatively low concentrations and have the ability to gradually accumulate in tissues [4].

Lead is the most abundant of all heavy metals in nature. The human can be exposed through: sources of industrial origin, the metal industry, industrial waste, tetraethyl-lead in gasoline, lead-based paints, through the packaging of food (cans) containing lead and others. Lead is deposited in the bones, liver, kidneys and soft tissues. Lead poisoning adversely affects the brain and nervous system function, reduces the

degree of intelligence, power of observation and memorization. In the most severe cases, it leads to death.

Cadmium in nature is usually present in the soil, but in food it also comes from the use of some fertilizers. It can be found in cereals, potatoes and other root vegetables, but also in animal internal organs. It is deposited in the liver, kidneys and bones. It causes anemia, bone deformation, elevated blood pressure, damage to the heart and kidneys, and has a carcinogenic effect [5].

Material and methods

Atomic absorption spectrometry is an analytical technique that enables the quantitative determination of about 70 elements (metals and metalloids) in low concentrations. It is applied in all areas of analytical chemistry practice. It is an economical, easily adaptable technique and enables the solution of a large number of problems that used to require long-lasting procedures or the use of expensive and inaccessible equipment. It is one of the most significant applicable methods for the analysis of the elemental composition of various materials and samples.

For quantitative determination of the presence of the examined elements in the samples, the following instruments were used:

-Varian Atomic Absorption Spectrometer, model SpectrAA 220Z, with Zeeman corrector, GTA 100 graphite furnace and auto sampler;

-Sartorius CP 3245 scale;

- Adrona Crystal E deionized water device.

In the process of electrothermal atomization, two types of graphite furnaces were used: pyrolytic coated tubes and tubes with a centrally fixed L'vov platform.
Hollow cathode lamps were used as a source of radiation. They are optimized about 15 minutes before starting the analyses.

In order to achieve greater sensitivity and better precision, before starting the analysis, optimal instrumental conditions are determined for each element individually. The methods and procedures applied in the experimental work are determined by the regulations in the field of food testing, by the operating manuals of the corresponding instruments recommended by the manufacturer, as well as by the methods published in the works resulting from the previous scientific research or taken from papers cited in the literature.

The calibration method is applied on a sample to which a standard additive has been previously added. The calibration samples were prepared in duplicates and with concentrations at three points covering the measurement range of each element respectively.

The food product samples, immediately upon their reception in the laboratory, are prepared for analysis and are converted into a solution by wet decomposition with an oxidizing agent at a suitable temperature [6].

The analytical methods correspond to the methodology for determining the concentration of toxic elements in food products [7].

In order to determine the concentrations of lead and cadmium, basic standard solutions of: cadmium nitrate $Cd(NO_3)_2$ and lead (II) nitrate $Pb(NO_3)_2$ were used, with a mass concentration of 1 g/L of cadmium and lead, respectively, manufactured by Merck, Germany.

The working standards are prepared immediately before use by dissolving the basic standard with ISO3696 Grade I deionized water (conductivity to 0.1 microS/cm). Nitric acid, Tracepur®, 69% (m/V) produced by Merck, Germany was used as an oxidizing agent.

Three samples from each of the different units of 37 food products that are in daily use within the collective diet of the Army members of North Macedonia were tested.

Results and discussion

In order to implement food safety methods in our country, the tool for risk analysis methodology through exposure assessment by analysing the amount of heavy metals (lead and cadmium) in food products from the consumer basket (through individually selected food products) was applied to achieve a high level of protection of the life and health of consumers, users of collective nutrition in the Army of North Macedonia.

As part of the regular work of the laboratory at the Department of Preventive Health Care in the Military Medical Centre Skopje, the uncertainty of the methods is calculated on the measurements of the middle point of the calibration curves. The methods have been validated by the method added found (spiked samples) for several samples [8].

Table 1 shows the mean values of the obtained results for each product from the consumer basket.

Table 1. Obtained results from the examination of the amount of lead and cadmium in samples of certain food products from the consumer basket used for collective nutrition in the Army of North Macedonia.

Examined food products	Cd mcg/kg	Pb mcg/kg
Rice	25.67	47.67
Flour	9.00	69.33
Bread	6.67	36.00
Pasta	2.67	30.00
Tea biscuit	1.33	53.00
Beans	16.67	15.33
Carrot	1.33	14.67
Potato	44.67	5.00
Onion	8.67	45.00
Cabbage	3.33	12.67
Spinach (fresh)	7.00	253.33
Tomato puree	43.33	696.67
Champignon mushrooms	2.67	115.00
Ground paprika	17.03	466.67
Black pepper	0.10	148.33
Parsley	22.00	286.67
Spice mix	43.33	696.67
Cocoa powder	0.10	108.00
Salt	0.40	28.33
Chicken soup	8.00	158.33
Apple	3.33	14.00
Orange juice	5.33	32.00
Plum compote	0.10	36.00
Chicken	16.33	92.00
Pork sausage	79.33	145.00
Beef sausage	12.00	216.33
Chicken eggs	1.67	112.67
Mayonnaise	1.37	49.33
Canned sardines	5.67	131.33
Sterilized milk 3.2% m.f.	2.37	16.33
Yoghurt	0.73	12.67
White cheese	0.73	64.67
Yellow cheese	0.10	62.00
Butter	0.73	67.33
Sunflower oil	5.00	27.33
Mustard	9.33	80.67
Honey	4.00	14.00

In the food samples, the amount of cadmium and lead was determined, which is below the limits of the maximum allowable concentrations MAC, determined by the

current legal regulation [1, 2]. All are considered correct and safe to use in terms of the parameters tested.

The highest amounts of cadmium were measured in the group of vegetables, followed by food products in the group of grain and grain products. The lowest amounts of cadmium were measured in foods in the group of eggs and products. The highest amounts of lead were measured in the group of meat and products, while the lowest amounts were measured in foods in the group of fats and oils.

Conclusion

"Everything is poisonous and nothing is poisonous, it is all a matter of dose." Claude Bernard 1813 - 1878

The measured amounts of heavy (toxic) metals of interest for this paper, lead and cadmium, in the examined food products were below the maximum allowable concentrations according to the current legislation [1, 2].

In the implementation of food safety methods within the framework of collective nutrition in the Army of North Macedonia, the tool: methodology for risk analysis through exposure assessment by analysing the amount of heavy metals (lead and cadmium) in food products from the consumer basket (through individually selected food products), showed that all the tested foods were correct and safe for use in relation to the tested elements.

The results of this research point to the necessity of regular examination of products intended for collective consumption of the Army members of North Macedonia and timely response and removal of those measured with higher amounts of contaminants than the maximum allowable according to the current legislation. With this type of examination, an important step is taken towards achieving a high level of protection of consumer life and health, since all food products are purchased from the regular market of the country.

In order to facilitate the production and provision of high-quality and safe food, international standard norms for its hygienic conformity and quality are being created. For the application of those norms in each country, it is necessary to develop adequate methods and criteria. The methods and procedures for determining the prescribed properties (qualitative and quantitative) should follow the contemporary scientific and professional technological achievements. For this purpose, it is necessary at the national level to develop well the established international norms and apply them for the health conformity and quality of food distinctive to each country, and to adequately and precisely develop the criteria and methods for examination of food products, especially for examination of the quality of some product groups. Hence, the application of different test methods in the analysis and superanalysis of food products and the possible obtaining of different results that may lead to confusion and unwanted consequences will be avoided.

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