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ANALYSIS OF THE CHEMICAL TOXIC AND ESSENTIAL ELEMENTS IN FRUIT JUICES

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Abstract

Due to the complexity of the issues are taken more extensive research to determine the quality of food, especially in terms of their contamination with different pollutants. By applying the flame and electrothermal atomic absorption spectrometry, in this work is done determining the presence and content of toxic elements and essential elements in seven types of fruit juices produced by five different manufacturers in Macedonia.

Examination of the contents of lead and cadmium in fruit juices was performed by electrothermal AAS, of copper, iron and zinc by flame AAS, and of arsenic with system VGA77. Preparation of samples of fruit juices for analysis by AAS is thermal decomposition of the organic matrix by oxidation.

Results show that only in two cases the presence of lead (in two the juices of apricot and pear) is above the maximum allowable concentration, but the presence of elements in juices ranges under the maximum allowable concentration (MAC), and therefore the juices are safe for consumption.

***Key words**: AAS, toxic elements, essential elements, fruit juices.*

1. Introduction

The emergence and development of spectrometry analytical methods, especially flame atomic absorption spectrometry (FAAS) and electro thermal atomic absorption spectrometry (ETAAS), are used to provide the necessary information on the content and importance of many biologically significant chemical elements. According to their role in biological processes, the elements are divided into: essential and non-essential. It is considered that 26 elements are essential for biological organisms (Tsalev and Zaprianov [1], Christian and Reilly [2]). Unlike the basic building elements (C, N, O, H, Na, K, Mg, Ca, P, S, Cl), other essential elements (F, I, Se, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Si, Sn, As) in organisms are present in very low concentrations (so called trace elements).

Beside the intake of essential elements through the process of respiration, water or food consumption, there is a possibility of toxic elements input, which lead to a range of pathological changes in the organism. For example, lead can hinder the synthesis of hemoglobin, lead to disturbance of the heart functions, increase blood pressure etc. Other metals such as cadmium, arsenic, etc. can also lead to disturbances in the organism. Copper and zinc, however, are beneficial, when present in low concentrations in the body, since they are part of some enzymes; although, higher concentrations do lead to health disorder.

The main constituents of food products are water, proteins, carbon hydrates and fats, as well as enzymes, hormones, vitamins and inorganic salts. Their presence in the organism, either in lower or higher concentration, compared to the normal concentration, also causes disruption of the consumer's biological processes (Belitz *et al*. [3]).

The above stated shows that the familiarity with the contents of non-organic elements and, particularly, determining the presence and concentration of toxic elements in the food, is of vital importance. Due to the complexity of the issue, more and more extensive researches are being undertaken, to determine quality of the groceries, especially in terms of their contamination by various pollutants.

Fruit, along with fruit juices, is very important and irreplaceable foodstuff, which provides the organism

with biologically important and necessary components for proper function. Fruit can be considered as the basis for the healthy diet, because of its high water content, fiber and organic acids that are essential for proper digestion of other kinds of food. Fruit also contains significant amounts of essential bio-elements, such as vitamins (C, B1, B2, B6, PP etc,) minerals (calcium, iron magnesium, phosphorus, sodium, potassium, etc,) and enzymes which make the life functions possible (Kaič-Rak and Antonič [4]).

2. Materials and Methods

2.1 Experimental conditions

In this occasion the presence of lead, cadmium, arsenic, copper, iron and zinc has been examined in following seven different types of fruit juices produced by five different manufacturers:

- Sludgy: apricot, peach, pear and cocktail;
- Fuzzy: Orange and multivitamins, and
- Clear: apple juice.

The examination of the contents of lead and cadmium in fruit juices was done with electro thermal AAS; the one of the contents of copper, iron and zinc by Flame AAS, and the arsenic contents with hydride system VGA 77.

2.2 Instruments

For quantitative determination of these metals presence in the juice samples, the following instruments were used:

- Atomic absorption spectrometer Varian, model SpectrAA 55, with deuterium corrector;
- Atomic absorption spectrometer Varian, model SpectrAA 220Z, with Zeeman corrector, graphite furnace GTA 100 and auto sampler;
- VGA77 hydride system.

Hollow cathode lamps were used as a source of radiation.

2.3 Reagents

In order to determine the content of lead, cadmium, arsenic, copper, iron and zinc, basic standard solutions of $Pb(NO_3)_2$ with mass concentration of lead 1 g L^{-1}, $Cd(NO_3)_2$ with mass concentration of cadmium 1 g L^{-1}, $As(NO_3)_3$ with mass concentration of arsenic 1 g L^{-1}, $Cu(NO_3)_2$ with copper mass concentration of 1 g L^{-1}, $Fe(NO_3)_2$ with a mass of iron concentration of 1 g L^{-1} and $Zn(NO_3)_2$ with zinc mass concentration of 1 g L^{-1} were used, all manufactured by Merck.

The working standards were being prepared shortly before usage, by diluting the basic standard, with redistilled water. Afterwards, nitric acid was used, Tracepur ®, 69% (m/V), and for the analysis of arsenic with hydride system, hydrochloric acid p.a. and sodium boron hydride p.a. were used, all of them manufactured by Merck.

2.4 Preparation and material testing

Commonly applied method for fruit juices samples preparation for AAS analysis is decomposition of the organic matrix using oxidation. However, a complete decomposition of the matrix is not necessary for the analysis of some elements when using flame AAS, and especially ETAAS, since the additional decomposition of the matrix occurs in the flame, i.e. in the graphite furnace.

Methods of the hygienic-chemical laboratory of the Military Medical Center-Skopje, Center for Preventive Medicine have been applied while preparing this labor.

Fruit juices samples were prepared for analysis by decomposition and wet digestion at appropriate temperature.

3. Results and Discussion

Fruit juices are usually a complex, homogeneous organic matrix that is problematic from an analytical point of view, due to changes that occur within the matrix itself during its storage, the possibility of contamination during sample preparation and interpretation of the results obtained. The presence of toxic metals (arsenic, cadmium and lead) in fruit juices is usually a consequence of the pollution in the environment where the fruit was cultivated. The rapid circulation of the water in the nature provides intensive mechanical and chemical interaction with rocks, stones and other materials, where some of the components present convert in solution, providing the water with a certain quality. Furthermore, in the production plants through the mechanical procedures of washing, cutting, draining, transport through pipe systems and conveyor belts, to the addition of other ingredients (such as water, sweeteners, acids, etc.) and packing, there is a possibility of the fruit juice being exposed to contamination with toxic metals. However, with the introduction of modern equipment (such as stainless steel, inert packaging materials, etc.) in the production process, and with constant monitoring of the fruit origin and quality of the additional input materials, the presence of these metals in fruit juices can be reduced significantly (Tailor *et al*. [5]).

Detection limits of the techniques used are: arsenic 0.002 mg L^{-1}; copper 0.003 mg L^{-1}; iron 0.006 mg L^{-1}; zinc 0.001 mg L^{-1}, lead 0.28 mg L^{-1} and cadmium 0.01 mg L^{-1}. The contents below the detection limit are marked as "nd" (not detected). The results of the tests are shown in the Table 1.

Table 1. Pb, Cd, As, Zn, Cu and Fe content in different types of juices

Type of juice	*Parameters*					
	Pb **mg L^{-1}**	***Cd*** **mg L^{-1}**	***As*** **mg L^{-1}**	***Zn*** **mgL^{-1}**	***Cu*** **mg L^{-1}**	***Fe*** **mg L^{-1}**
Apricot						
1	0,052	0,001	nd	0,43	0,35	0,604
2	0,014	nd	nd	0,42	0,08	0,56
3	0,02	nd	0,012	0,448	0,3	0,74
4	0,025	0,003	0,002	0,601	0,217	0,602
5	0,01	0,002	0,002	0,704	0,17	nd
Peach						
1	0,017	0,003	nd	0,055	0,024	2,006
2	0,008	0,002	nd	0,17	0,03	0,563
3	0,025	0,001	nd	0,558	0,352	0,852
4	0,008	0,001	nd	0,39	0,09	0,78
5	0,021	0,002	0,004	0,24	0,331	0,454
Orange						
1	0,037	0,001	nd	0,32	0,174	0,692
2	0,035	0,001	nd	0,231	0,23	1,072
3	0,024	0,004	nd	0,276	0,173	0,716
4	0,04	0,002	0,017	0,31	0,23	0,834
5	0,009	0,001	nod	0,46	0,07	0,97
Pear						
1	0,051	0,002	nod	0,58	0,51	0,417
2	0,031	0,004	0,008	0,479	0,436	1,606
3	0,036	0,004	0,016	0,5	0,4	2,905
4	0,02	nod	nd	0,420	0,421	1,012
5	0,016	nd	nd	0,344	0,389	0,710
Apple						
1	0,009	0,003	nd	0,034	0,143	0,219
2	0,022	0,003	nd	0,184	0,135	0,273
3	0,029	0,001	nd	0,190	0,190	0,508
4	0,010	nd	nd	0,110	0,091	0,502
5	0,012	0,002	nd	0,082	0,072	0,420
Cocktail						
1	0,026	0,001	nd	0,24	0,12	0,711
2	0,055	0,006	nd	0,51	0,633	0,454
3	0,001	nd	0,008	0,317	0,185	0,97
4	0,007	0,001	0,013	0,228	0,081	0,604
5	0,017	0,002	0,002	0,11	0,031	0,602
Multivitamin						
1	0,009	0,003	nd	0,308	0,17	0,78
2	0,013	0,002	0,008	0,35	0,181	7,78
3	0,008	0,001	nd	0,31	0,33	0,61
4	0,026	0,002	nd	0,445	0,203	1,046
5	0,022	nd	nd	0,430	0,211	0,642

To parallel the results obtained, the values of maximum permissible concentration (MAC) of the metals tested are presented in the Table 2, according to the "Sluzbeni list SFRJ" no. 59/83 [6] and "Sluzben vesnik na RM" 118/2005 [7].

Table 2. Legally maximum allowed concetration of Pb, Cd, As, Zn, Cu and Fe in juices

Pb **mg** L^{-1}	***Cd*** **mg** L^{-1}	***As*** **mg** L^{-1}	***Zn*** **mg** L^{-1}	***Cu*** **mg** L^{-1}	***Fe*** **mg** L^{-1}
0,05	**0,03**	**0,05**	**5**	**5**	**15**

The comparison of the results obtained to the maximum permissible concentration, demonstrates that only in two cases the presence of lead (in the apricot and pear juices) minimally exceeds the maximum permissible concentration.

4. Conclusions

The analysis of seven samples of fruit juices: apricot, peach, pear, cocktail, orange, multivitamin and clear apple juice, produced by five different producers from the Republic of Macedonia, has shown that the concentration of the toxic elements: lead, cadmium and arsenic and the essential elements: copper, zinc and iron, is below the maximum level permitted, which proves that the analyzed samples are health safe.

5. References

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