

THE APPLICATION OF ATOMIC ABSORPTION SPECTROPHOTOMETRY
(AAS) FOR DETERMINATION OF THE CONTENT OF HEAVY METALS
IN FOOD PRODUCTS THE INLACQUERED TINPLATE TINS ARE
FILLED WITH

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Abstract: Due to possibility of contamination of food products caused by a rapid pollution of environment, as a consequence of incidents and accidents, it is necessary to exert a regular and systematic control of the content of heavy metals in tins filled with food products for the purpose of disease prevention and protection of public health. Foodstuffs, which can be of heterogenous chemical composition contain or a considerable quantity of water, organic acids, sodium-chloride, nitrates, anthocynes, etc. are added which are the potential corrodents of metals in contact with the contents of tins. The contamination of food products in tins can also occur because of a breakthrough of a protective tin lacquer, or a poor quality of a packaging material. The consequence of the corrosion of tins is the increase of concentration of metals, especially heavy metals, the deterioration of organoleptic characteristics of foodstuff and even the perforation of tins. The atomic absorbing spectrophotometer is widely used in practice for determining the content of heavy metals because of its high sensitivity (10^{-6} g and less), accuracy (about 1%), selectivity and the possibility of application in defining the contents of more than 20 elements.

The analysed tins were filled with pasteurized sour cherry, pasteurized apricot mash, pasteurized plum halves and sterilized peas. The aim of this research was to define the content of heavy metals in food kept in inlacquered tinplate tins.

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Furthermore, its aim was also to determine whether the content of heavy metals in foods, upon having been tinned for several months, changes and reaches the legal level and suchlike tins can be used in human nutrition.

Key words: heavy metals, inlacquered tinplate tins, atomic absorption spectrophotometry (AAS).

Introduction

Different packaging materials, such as tinplate and aluminium tin, glass, plastics, paper, wrapping paper and wrapping cardboard, wood and textile are used in food industry for packing food (Crnčević, 1980). These materials differ from each other not only by their composition and the way they are produced, but also by their chemical, physical-chemical, physical and mechanical properties, which enables their use for packing different foodstuffs in accordance with their composition, storage and transport means, market needs etc. Tinplate is the most widely employed material in tin packaging production (Paine, 1996; Uhlig, 1958), the greatest part of which is used for foodstuff packing (Crnčević, 1980). One of the final operations in tinplate production is its chemical protection - chromatization. During this operation a thin passivation film is formed on the metal surface. This film consists of tin oxide, chromic oxide and elementary chromium and its composition plays an important part in preventing the development of electrochemical corrosion process of metals in contact with the contents of tins (Sherlock, 1976).

Foodstuffs which can be of a heterogenous chemical composition contain or a considerable quantity of water, organic acids, sodium-chloride, nitrates, anthocyanes etc, are added to them which are the potential corrodents of metals in contact with the contents of tins. The consequence of the corrosion of tins is the increase of concentration of metals, especially heavy metals, the deterioration or organo-leptic characteristics of foodstuffs and even the perforation of tins.

Of all the elements in the periodic system, from the toxicological aspect, heavy metals are significant. The heavy metals group includes metals whose specific mass is greater than 5 g/cm^3 , and they are characterized by different chemical properties, and especially by the biological effect. Their classification is based on similar physical not chemical properties, so that is why their toxicological effect is the consequence of the different amount and the way of harmful action. However, since cells have a very complex chemical composition, it is not possible to draw a regularity regarding their biological effect, considering the fact that heavy metals are a very heterogeneous group of elements, but it is real that members of the same period behave similarly. Likewise, there are numerous compounds with heavy metals whose properties depend on the metal itself as well as on the kind of radicals and their mutual bonds. Toxicity of some elements usually rises with the increase of the specific mass (Rajković i Ćirić, 1999; Jakovljević i Blagojević, 1998).

Most heavy metals make complexes with ligands which contain O, S or N as donors of electrons. Since each cell has biologically important molecules which surely include functional groups (the ones found in the active centres of enzymes or which take part in the formation of bonds): -SH, -OH, -COOH, -NH, etc., a certain metal shows affinity for a certain group, bonds with it and disturbs the permeability of the cell membrane by inhibiting the enzyme systems. The penetration of heavy metals into the cytoplasm leads to further blockades of the enzyme systems of cell. For example, iron and zinc play a significant physiological part in an organism, while lead, cadmium, copper and arsenic are very toxic substances whose compounds are characterized by a very low biodegradability.

Nowadays it is considered that a cell membrane presents a primary effect of action and damages in organism poisoning by heavy metals, while the damage of the systems of enzymes inside the cell in most cases occurs as a secondary phenomenon (Group of authors, 1997).

There are different methods of instrumental chemical analysis used for determining the content of heavy metals. These methods include: colorimetry, atomic absorption spectrophotometry (AAS), the method of induction compressible plasma (ICP), polarography, direct potentiometry (ionometry) etc. The atomic absorption spectrophotometer is mainly used to determine the heavy metals (Jakovljević i Blagojević, 1998; Alloway et al., 1995, Kirkbright and Sargent, 1974). The application of the atomic absorption spectrophotometry is widely used in practice because of its high sensitivity (a lot of elements can be determined in the concentration of 10^{-6} g and less), preciseness (about 1%), selectivity and the possibility of application in defining the content of a larger number of elements (by means of AAS method more than 20 elements can be defined: Zn, Cu, Mn, Ni, Fe, Ca, Mg, Na, K, Al, Pb, Si etc.) (Jakovljević i Blagojević, 1998).

A careful consideration is shown for determining the content of heavy metals in the food products in the world today. Of all the heavy metals, the most examined ones are lead (Zimdahl and Koeppe, 1977; Pacyna, 1987; Greninger, Kollonitsh and Kline, 1974), tin (Niketić-Aleksić, Bukvić, Vereš i Jakovljević, 1976), zinc (Greninger, Kollontish and Kline, 1974), arsenic (Niketić-Aleksić, Bukvić, Vereš i Jakovljević, 1976; Ferguson, 1990; Abernathy, 1983), copper (Niketić-Aleksić, Bukvić, Vereš i Jakovljević, 1976; Graham, 1981; Parker, 1981; Nriagn, 1979; Nriagn, 1979a; Shorrocks and Alloway 1987; Gatrell, 1981) and especially cadmium (Niketić-Aleksić, Bukvić, Vereš i Jakovljević, 1976; Aylett, 1979; Thornton, 1992; Nriagn, 1980; Jackson and Alloway, 1992; Chizhihov, 1966), which also represented the research basis in this paper.

The aim of this research was to define the content of heavy metals in foods which we kept in inlacquered tinplate tins. Furthermore, its aim was also to determine whether the content of heavy metals in foods, after having been tinned for 36 months, changes and reaches the legal level and suchlike tins can be used in human feeding.

Materials and Methods

The lacquered tinplate tins were used in this research. The tinplate was 0.26 mm thick and it was made in the factory for tinplate production „Sartid 1913” d.d. Beli limovi at Šabac. The tins were made in the factory „Limprodukt”, Novi Sad. Plating of tins was carried out by the electrolytical procedure in the average amount of 5.6/5.6 g/m². Chromatization of thus obtained tinplate was conducted by a chemical treatment in the bath of sodium bichromate (Na₂Cr₂O₇) - by Procedure 311 (Manual, 1979) and by spreading of oil DOS 5 mg/m². Tinplate was lacquered by spreading of golden yellow lacquer (tempera T-3) of 6 g/m². The volume of each tin was 5/l, dimension Ø 153 mm x 235 mm.

The tins were filled with the following contents: sample I - pasteurized sour cherry; sample II - pasteurized apricot mash; sample III - pasteurized plum halves; sample IV - sterilized peas. Pasteurized fruit is half processed fruit, prepared as a whole fruit, or cut, tinned by heat. After the usual preparation, sample I - sour cherry was washed, pits were removed, and covering with clean water was done. Sample II - upon the usual preparation the apricot mach was shortly cooked in order to destroy ferments, and then the product was covered with clean water. Pasteurization was performed at the temperature of 95-100°C for 30 minutes. Hermetically closed tin packaging of greater volume is used for pasteurized fruit, which, regarding the consistency, makes the spreading of heat difficult. Therefore, the pasteurization had been done before placing the product into packaging. Sample III - After the usual product preparation, which consisted of washing, inspection, removal of pits and cutting, plum halves were packed in tins and covered with clean water. The pasteurization was carried out at the temperature of 95-100 °C for 30 minutes. Sample IV - sterilized peas were, after the usual preparation, shortly cooked in order to destroy ferments, and then mashed. The products were covered with clean water to which 0.7 - 1% NaCl was added. The pasteurization was performed at the temperature of 121°C for 30 minutes. Because of the necessity of hermetical closure, the product was packed in tins of greater volume, 5/l (Niketić-Aleksić, 1994; Ćirić, Vujičić i Brajić, 1975; Bergant, 1975).

Tins, filled with suitable contents of food industry, were pasteurized, sterilized and stored for 36 months, at the storage temperature of 35-37°C.

The content of iron, copper, tin, zinc, lead and cadmium was determined by the application of the atomic absorption spectrophotometer AAS PERKIN ELMER 420, of standard solutions within the range of concentration for the examined metals: Pb: 0.1-1.0 mg/dm³; Cu: 0.02-5.0 mg/dm³; Zn: 0.01-2.0 mg/dm³; Fe: 0.05-5.0 mg/dm³; Cd: 0.05-0.2 mg/dm³. A certain sample quantity was steamed to dry, then H₂SO₄ was added in order to destroy organic substances. After that HNO₃ was added because of oxidation, and then steaming to dry and removing of vapours of nitrogen oxides was carried out. Afterwards, the dry material was dissolved in water do a certain volume, then the samples were taken by a direct sick-

ing into the absorber, with the accuracy of 10^{-4} %. The content of arsenic was defined by the photometric analysis by applying ammonium heptamolibdates (Ćirić, Vujičić i Brajić, 1975); Bergant, 1975; Marjanović i Janković, 1983; Trajković, Mirić, Baras i Šiler, 1983).

Results and Discussion

The results of examination of the content of heavy metals in foods that the inlacquered tins were filled with showed their presence but in very small quantities. However, due to the transition from the tin to foods, their content changed during storage. Although the tins quality was in accordance with ISO standards (Euro-norme 77-63: E2; ISO 1111: E 5.6/5.6; ASTM 624: 50; necessary tin quantity on each side (g/m^2): 5.6/5.6, tin thickness on each side ($\text{mm} \cdot 10^{-4}$): 7.70/7.70), (Crnčević, 1980), the penetration of heavy metals was the consequence of the steel basis quality as well as of the protective role of the lacquer layer which was in direct contact with the tin content.

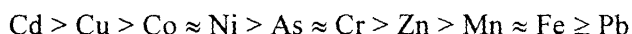
Almost all mineral substances necessary for the organism are found in fruit and vegetables. In Table 1 the review of the most important macro and microelements found in the examined, processed fruit and vegetables is given (except for apricot).

Tab. 1. - The content of some basic macro and microelements in the examined fruit and vegetables ($\text{mg}/100$ g of raw products and $\mu\text{g}/100$ g of raw products). (Rajković i Ćirić, 1999; Manual, 1992)

Products	Na mg	K mg	Ca mg	P mg	Mg mg	Fe mg	Zn mg	Cu μg	Mn μg	I μg	F μg	Cr μg	Se μg	Mo μg
Cherry	2	250	15	17	9	0.4	0.09	0.07	0.08	0.20	5	3.2	-	-
Plum	in traces	172	4	10	10	0.26	0.09	0.08	0.10	0.40	10	2	-	1
Peas	1	370	31	130	40	2	1.3	0.22	0.38	0.15	12	2	0.2	20

On the basis of the presented results, it is obvious that the content of Fe, Zn, Cu and Mn in peas is considerably higher in fruit, so it can be expected that their content will be the highest in tins filled with peas. Other metals: Pb, Cd, Sn and As are found in fruit and vegetables exclusively in traces and for that reason they are not in the Table and their recorded content originates from the transition from tinplate that the tins were made of. For example, the content of Cd in food varies from 10-100 ppb. The World Health Organisation has prescribed that the weekly allowed amount of cadmium taken with food is 400-500 μm per person (Chizhiov, 1966). Cadmium reaches the liver and then the nerves and kidneys through blood. Since it is very slowly exuded, it is a cumulative poison, which represents the greatest danger of its presence. Its biological half-life is about 40 days in blood, up to 20 years and more in the liver and kidneys. Major toxic effects caused by Cd are neuropathological problems and kidney dystrophy as well as cancer. Therefore, the content of Cd must be reduced to the lowest possible

degree, and in the EU countries its presence is even forbidden. Phytotoxicity of the analysed heavy metals decreases in the following order: (Greninger, Kollonitsh and Kline, 1974)



The presence of heavy metals in the analysed samples is the result of the process of tin dissolution due to the corrosion of tinplate in tins, or to the protective layer perforation. Tin thickness in electrolytical tinning is 300 μm . Tin coating is not without pores. The increase of lacquer enables the contact with tin coating. The porousness of tin coating and lacquer enables the contact with iron in the steel basis.

The intensified corrosion of tins results from the increased content of oxygen in tins. Poor vacuuming or oxidation additives also stimulate the corrosion effect in tins.

It is known from experience that the corrosion resistance in relation to lacquer thickness shows exponential dependance. The increase of the lacquer thickness to a practically nonporous surface is not economically justified. The acceptable lacquer thickness is 5-6 μm .

Table 2 shows the examination results of the content of heavy metals in tins filled with pasteurized sour cherry at the beginning of filling and after the storage for 12 and 36 months.

Tab. 2. - The content of heavy metals in tins filled with sour cherry

Content of heavy metals (mg/kg)	Storage time (months)		
	0	12	36
Sn	0.6	3.8	29.5
Fe	1.0	3.2	20.0
Zn	0.22	0.40	0.65
Pb	0.05	0.17	0.26
Cd	0.01	0.01	0.01
Cu	0.12	0.18	0.32
As	in traces	in traces	in traces

Since sour cherry, due to the content of organic acids: 0.02-0.4% lemon acid, 0.61-1.84% apple acid, 0.008% oxalic acid and 0.004% salicylic acid, (Ćirić, Vujičić i Brajić, 1975; Bergant, 1975), is a very aggressive material, it should be expected that the content of heavy metals in foods the tins are filled with will also be the highest. Therefore, tins filled with sour cherry must, by all means be inlacquered. On the basis of the results shown in Table 2 it can be seen that, apart from As and Cd, the content of heavy metals in tins with pasteurized sour cherry increases during the storage time, but, even after 36 months, the defined values are far below the allowed amount of metals in foodstuff, in accordance with the statutory values (Regulation, 1992), shown in Table 3.

Tab. 3. - Statutory values of heavy metals in fruit and vegetable products (mg/kg) (Regulation, 1992)

Sort of products tinplate tins are filled	Pb	Cd	Zn	Sn	As	Cu	Fe
Vegetable products	1	0.05	20	150	0.5	5	20
Fruit products	1	0.05	20	150	0.5	10	30

Due to the aggressiveness of the interior of the tin filled with pasteurized sour cherry, the increase of tin and iron content is expected, and the examination results have also shown that, especially in the period of storage for 12 to 36 months, but the measured values are below the statutory values. The content of cadmium is constant and is five times lower than the allowed value, and arsenic is present in traces.

Table 4 displays the examination results of the content of heavy metals in tins filled with pasteurized apricot mash at the beginning of filling and after the storage during 12 and 36 months.

Tab. 4. - The content of heavy metals in tins filled with pasteurized apricot mash

Content of heavy metals (mg/kg)	Storage time (months)		
	0	12	36
Sn	3.12	4.95	28.5
Fe	1.35	1.50	17.5
Zn	0.50	0.59	0.69
Pb	0.11	0.19	0.29
Cd	in traces	0.015	0.036
Cu	in traces	in traces	in traces
As	in traces	in traces	in traces

Regarding the content of heavy metals, apricot mash is a far less aggressive material (1-1.1% apple acid), (Ćirić, Vujičić i Brajić, 1975; Bergant, 1975), so that a reduced presence of heavy metals in relation to a tin filled with pasteurized sour cherry should be expected. On the basis of the results shown in Table 4, it is clear that copper and arsenic are present in traces, while the content of cadmium, having been present in traces at the beginning of filling, increased to the value of 0.036 mg/kg, which is near the legally allowed value. This fact is not surprising because it is the consequence of the poor quality of manufactured tins, because the content of Sn, Fe, Zn and Pb was already considerably higher during the filling, compared to tins filled with pasteurized sour cherry. The values of all the other heavy metals are below the statutory values and it should be pointed out that in this sample, too, the presence of heavy metals, upon the storage of 12 to 36 months, increased.

Table 5 shows the results of examination of the content of heavy metals in tins filled with pasteurized plum halves at the beginning of filling and after their storage for 12 and 36 months.

Tab. 5. - The content of heavy metals in tins filled with pasteurized plum halves

Content of heavy metals (mg/kg)	Storage time (months)		
	0	12	36
Sn	2.50	3.21	26.40
Fe	0.98	1.10	10.42
Zn	0.54	0.87	1.26
Pb	0.25	0.35	0.68
Cd	0.031	0.041	0.068
Cu	0.20	0.30	0.41
As	0.11	0.11	0.14

In contrast with the analysed tins filled with pasteurized sour cherry and apricot, both arsenic and copper were measured in these tins but in the quantities which were below the statutory value.

The content of Sn, Fe, Zn and Pb increased in time of storage but it is extremely surprising to find out that the content of Cd in the tins upon having been tinned for 36 months exceeds the statutory values, which means that the tins are useless for nutrition. As the content of heavy metals originates exclusively from tins i.e. the quality of tins, the possible explanation is that the steel basis has not been of a satisfactory quality or more exactly, that the perforation of the lacquer has taken place. This sudden rise in Cd content is a warning that the content of heavy metals must be regularly tested. Since the presence of Cu and As has also been recorded, it confirms the assumption about the poor quality of the steel basis of tins.

Table 6 shows the results of testing of the content of heavy metals in tins filled with sterilized peas at the beginning of filling and after their storage for 12 and 36 months.

Tab. 6. - The content of heavy metals in tins filled with sterilized peas

Content of heavy metals (mg/kg)	Storage time (months)		
	0	12	36
Sn	5.00	5.90	17.90
Fe	5.90	5.70	6.40
Zn	1.70	1.90	1.80
Pb	0.10	0.24	0.48
Cd	in traces	0.005	0.035
Cu	in traces	in traces	in traces
As	in traces	in traces	in traces

The tin filled with sterilized peas is the least aggressive medium and, therefore its effect on the tinplate the tin is made of is the lowest. The obtained results have shown that the content of Cu and As is in traces in this sample and that the content of Sn, Fe, Pb and Cd increases during the storage. However, compared to other samples it is the lowest and the content of Zn is higher than the value record-

ed in other samples, which is the consequence of higher zinc content in peas than in the other analysed samples (Table 1). All the measured values are considerably below the legally allowed ones. The results of examination of heavy metals in foods, the lacquered tinplate tins are filled with, have shown a good agreement with the results presented in domestic (Jakovljević i Blagojević, 1998) and foreign literature.

Conclusion

The examination results have shown that the content of heavy metals in the analysed tins, filled with different foods, is very low and that after having been stored at the temperature of 35-37°C for 36 months, it is within the limits of statutory values, which means that the tested samples are acceptable for human nutrition.

The exception is the content of cadmium in the sample of a tin filled with pasteurized plum halves, which is practically useless in human nutrition, due to high amount of cadmium.

Due to the possibility of contamination of food products caused by rapid pollution of environment, as a consequence of incidents and accidents, it is necessary to exert a regular and systematic control of the content of heavy metals in tins filled with food products for the purpose of disease prevention and protection of public health. Likewise, the contamination of food products in tins can also occur because of a breakthrough of a protective tin lacquer, or of a poor quality of a packaging material.

The latest accidents recorded in the world only confirm this consideration and the need to conform the quality of domestic products to ISO standards.

REFERENCES

1. Abernathy, J. R. (1983): in „Arsenic - industrial, biomedical, environmental perspectives”, eds. W. H. Lederer and R. J. Tensterheim, Reinhold Publ. Corp., New York.
2. Aylett, B. J. (1979): in „The Chemistry, Biochemistry and Biology of Cadmium”, ed. Webb, M. Elsevier, Amsterdam, pp. 1-43.
3. Bergant, S. (1975): Priručnik o kontroli limenki za konzervisanje voća, povrća.
4. Chizhihov, D. M. (1966): Cadmium, Pergamon, New York.
5. Crnčević, V. (1980): Ambalaža za životne namirnice, Privredni pregled, Beograd.
6. Cumiff, P. (1995): Official Methods of Analysis of AOAC International, 16th edition, Volume II, AOAC International, Arlington, Virginia.
7. Ćirić, D., Vujičić, B., Brajić, Ž., (1975): Priručnik za kontrolu kvaliteta sirovina i proizvoda od voća i povrća, Tehnološki fakultet, Novi Sad.
8. Ferguson, J. E. (1990): The Heavy Elements: Chemistry, Environmental Impact and Health Effects, Pergamon Press, Oxford.
9. Gatrell, J. W. (1981): in „Copper in Soils and Plants”, eds. J. F. Loneragen, A. D. Robson and R. D. Graham, Academic Press, New York, pp. 313-349.

10. Graham, R. D. (1981): in „Copper in Soils and Plants”, eds. J. F. Loneragan, A. D. Robson and R. D. Graham, Academic Press, Sydney, pp. 141-163.
11. Greninger, D., Kollonitsh, V., Kline, C. H. (1974): Lead Chemicals, International Lead Zinc Research Organisation, New York.
12. Grupa autora (1997): Teški metali u životnoj sredini, Urednik R. Kastori, Naučni institut za ratarstvo i povrtarstvo, Novi Sad.
13. „Heavy Metals in Soils” (1995): Edited by B. J. Alloway, Second edition, Blackie Academic & Professional.
14. Jackson, A. P., Alloway, B. J. (1992): Transfer of cadmium from soils to the human food chain, in D. C. Adriano, „Biogeochemistry of Trace Metals”, Jewis Publisher, Baton Rouge, Fla., pp. 109-158.
15. Jakovljević, M. D., Blagojević, S. D. (1998): Određivanje sadržaja teških metala u prehrambenim proizvodima”, III jugoslovenski simpozijum prehrambene tehnologije, Beograd, 04-06. februar 1998. god., Sekcija VII - Analitika u prehrambenoj tehnologiji. Podsekcija: Teški metali u namirnicama prehrambene tehnologije, Zbornik radova, Sveska V, 185-190
16. Jones, J. B., Case, V. W. (1990): Sampling, Handling and Analyzing Plant Tissue Samples In: „Soil Testing and Plant Analysis”, Westerman, R. L. (ed.), Soil Science Society of America, Medison-Springvale, Australia.
17. Kirkbright, G. F., Sargent, M. (1974): Atomic Absorbtion and Fluorescence Spectrometry, Academic Press, London.
18. Marjanović, M., Janković, J. (1983): „Instrumentalne metode analiza”, Univerzitet u Novom Sadu, Tehnološki fakultet, Novi Sad.
19. National Research Council (NRC). (1979): In "Zinc", 1-18, Univ. Park Press, Baltimore, MD.
20. Niketić-Aleksić, G. (1994): Tehnologija voća i povrća, Poljoprivredni fakultet, Beograd-Zemun.
21. Niketić-Aleksić, G., Bukvić, B., Vereš, M., Jakovljević, M. (1976): Sadržaj makro i mikroelemenata u sokovima od voća i povrća, Hrana i ishrana, 17 (5-6), 219-227.
22. Nriagn, J. O. (1979): ed. „Copper in the Environment. Part I. Ecological Cycling”, John Wiley, New York.
23. Nriagn, J. O. (1979a): ed. „Copper in the Environment. Part II. Health Effects”, John Wiley, New York.
24. Nriagn, J. O. (1980): ed. „Cadmium in the Environment. Part I. Ecological Cycling”, John Wiley, New York.
25. Pacyna, J. M. (1987): in „Lead, Mercury, Cadmium and Arsenic in the Environment”, eds. T. C. Hutchinson and K. M. Meema SCOPE 31, John Wiley&Sons, Chiechester.
26. Paine, F. A. (1996): The Packing User's Handbook, Blackie Academic & Professional, London.
27. Parker, A. J. (1981): in „Copper in Soils and Plants”, eds. J. F. Loneragen, A. D. Robson and R. D. Graham, Academic Press, Sydney, pp. 1-22.
28. Pravilnik (1992): Dozvoljene količine metala, nemetala i nekih specifičnih kontaminenata u namirnicama izražene u mg/kg odn. mg/l (1992), Službeni list SRJ, broj 5., 83-85.
29. Priručnik za liniju za elektrokalisjanje (1970): United States Steel Corporation (prevod).
30. Rajković, M. B., Ćirić, I. (1999): Hemija elemenata, Poljoprivredni fakultet, Zemun.
31. Sherlock, J. C. (1976): Proc. First Int Tinplate Conf. London.
32. Shorrocks, V. M., Alloway, B. J. (1987): Copper in Plant, Animal and Human Nutrition, Copper Development Assn., Potfers Bor.
33. Thornton, I. (1992): Sources and pathways of cadmium in the environment, in G. F. Nordberg, L. Alessio and R.F.M. Herber, „Cadmium in the Human Environment”, International Agency for Research on Cancer (IARC), Lyon.
34. Trajković, J., Mirić, M., Baras, J., Šiler, S. (1983): Analize životnih namirnica, Tehnološko-metalurški fakultet, Beograd.

35. Uhlig, H. H. (1958): The Corrosion Handbook, John Wiley & Sons, Inc., New-York.
36. Vučetić, J., Vujin, S, Izrael, A. (1998): Mineralne supstance voća i povrća i njihov značaj u ishrani, Hemijski pregled, 39 (3-4), 89-96.
37. Zimdahl, R. L., Koeppel, D. E. (1977): in „Lead in the Environment“, ed. W. R. Boggess National Science Foundation, Washington D. C., 99-104.

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PRIMENA METODE ATOMSKE APSORPCIONE SPEKTROFOTOMETRIJE (AAS) ZA ODREĐIVANJE SADRŽAJA TEŠKIH METALA U PREHRAMBENIM PROIZVODIMA KOJIMA SU NAPUNJENE KONZERVE OD LAKIRANOG BELOG LIMA

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Rezime

Usled mogućnosti kontaminacije prehrambenih proizvoda zbog rapidnog zagađenja životne sredine, kao posledica incidenata i akcidenta, neophodno je vršiti redovnu i sistematsku kontrolu sadržaja teških metala u konzervama napunjenim prehrambenim proizvodima, u cilju prevencije i zaštite zdravlja stanovništva. Namirnice, koje mogu biti heterogenog hemijskog sastava sadrže, ili im se dodaje znatna količina vode, organskih kiselina, kuhinjske soli, nitrata, antocijana i dr., koji su potencijalni uzročnici korozije metala u kontaktu sa sadržajem konzervi. Do kontaminacije prehrambenih proizvoda u konzervama može doći usled proboja zaštitnog laka konzerve ili lošeg kvaliteta ambalažnog materijala. Kao posledica korozije konzervi, dolazi do povećanja koncentracije metala, naročito teških metala, do pogoršanja organoleptičkih svojstava namirnice, pa i perforacije konzervi. Za određivanje sadržaja teških metala veliku primenu u praksi ima atomski apsorpcioni spektrofotometar, zbog visoke osetljivosti (10^{-6} g i manje), preciznosti (oko 1%), selektivnosti i mogućnosti primene za određivanje sadržaja preko 20 elemenata. Ispitivane konzerve punjene su pasterizovanom višnjom, pasterizovanom kašom kajsije, pasterizovanom polutkom šljive i sterilisanim graškom. Cilj ovoga rada bio je utvrđivanje sadržaja teških metala u prehrambenim proizvodima koji su se nalazili u konzervama od lakiranog

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belog lima. Takođe, cilj rada bio je da se utvrdi da li se sadržaj teških metala u prehrambenim proizvodima, nakon višemesečnog stajanja u konzervama, menja i dostiže zakonom dozvoljeni nivo i da li se takve konzerve mogu koristiti u ljudskoj ishrani.

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