MINERAL PROFILE OF SOME DRIED FRUITS

Milena Ivanović[1], Snežana Tošić[1], Snežana Mitić[1], Marija Petrović[1], Jelena Aksić[1]

Abstract: The aim of this work was to determine the content of 16 elements in the seven samples of dried fruits: plums (*Prunus domestica*), figs (*Ficus carica*), apricots (*Prunus armeniaca*), white and black raisins (*Vitis vinifera*), dates (*Phoenix dactylifera*) and cranberries (*Vaccinium oxycoccus*), which are available in local markets. Inductively coupled plasma optical emission spectrometry (ICP-OES) was used after wet digestion method. Potassium is the most common macroelement while boron and zinc are the most common microelements. As, Cd and Hg were not detected while the content of Pb is below the MAC. The obtained results were statistically analyzed and compared with the literature values.

Key words: minerals, dried fruits, ICP-OES, statistics

Introduction

Dried fruit is fruit where the majority of the original water content has been removed either naturally, through sun drying, or through the use of specialized dryers or dehydrators. Dry fruits, such as plant nuts, are widely consumed around the world during all seasons. They are traditionally an important component of the human diet because they contain a lot of biologically active substances that have beneficial effects on human health as antioxidants, anticancerogens, antimutagens and antibacterial compounds. Metals are essential for important biochemical and physiological functions and are necessary for maintaining health throughout life. It is well known that an excess or deficiency of trace metals present in the human body can cause harmful effects (Altundag and Tuzen, 2011; Mehta et al., 2014). The presence of heavy metals in higher concentration than the permissible limits is toxic and causes diseases. Fruits may contain and accumulate heavy metals, depending on the place of cultivation and the natural property of the plants (Manzoor et al., 2013; Aldjain et al., 2011).

Inductively coupled plasma optical emission spectrometry is a multi-element technique for the detection of major and minor elements in different complex samples. It combines qualities such as relatively low detection limits, high capacity for the simultaneous and precise detection for short intervals over wide concentration ranges.

[1]University of Niš, Faculty of Sciences and Mathematics, Višegradska 33, Niš, Serbia (milenai.chem@gmail.com).

Material and methods

Wet ashing method of mineralization was used to achieve the complete decomposition of the organic matrix. Fruits were comminuted and dried up to 105^0C for six hours and after that approximately 2 g of each sample were treated with 30 mL of conc. HNO_3, left overnight and heated on the hot plate up to 150°C until complete dissolution. The obtained solutions were filtered and diluted with deionized water up to a total volume of 50 mL.

Ultra scientific (USA) ICP multi-element standard solution of about 20.00±0.10 mg L^{-1} was used as a stock solution for calibration. Nitric acid (Merck, Darmstadt, Germany) was used for complete mineralization The overall analysis was conducted by an iCAP 6000 inductively coupled plasma optical emission spectrometer (Thermo Scientific, Cambridge, United Kingdom). Analytical balance Mettler Toledo (Switzerland) was used to measure the mass. High purity water (conductivity 0.05 μS cm^{-1}) was obtained using MicroMed high purity water system, Thermo Electron LED GmbH (Germany).

All measurements were carried out in triplicate and presented as mean ± standard deviation (SD). The hierarchical cluster analysis was done using a statistical package IBM SPSS 20, United States (Miller and Miller, 2005).

Results and discussion

The analytical emission lines for each of the element, based upon the tables of known interferences, baseline shifts and the background correction were selected under the optimal operating conditions for the instrument (RF power, flush and analysis pump rate, nebulizer, coolant and auxiliary gas flow) and given in the tables with contents.

Table 1. shows the content of essential macroelements. It is evident that K is the most abundant mineral in all dried fruits whereby plums have the largest and cranberries the smallest amount. The second most common metal is Mg and then Na and Ca. Also, figs are the fruit with the highest content of all metals (except K) and cranberries with the smallest content of all investigated macroelements. Mehta at al. (2014) determined 293.2 $\mu g g^{-1}$ of Mg and 279 $\mu g g^{-1}$ of Ca in dried plums.

Table 2. shows the content of some trace elements. Some of them are essential and some are potentially toxic and toxic, according to the criteria of the World Health Organization (World Health Organisation, 1996). B and Zn are the most common trace elements. The dried cranberries contain the least quantity of all determined trace metals while dried plums contain the largest amounts of essential elements such as Fe, Zn, Mn.

Altundag and Tuzen (2011) have determined the content of Ba, Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn, Al, Fe and Sr in samples of dried yellow and black plum, fig, table grapes, apricot, apple and white mulberry. The samples were prepared by dry, wet and microwave digestion. The most abundant are Fe (from 12.16 $\mu g g^{-1}$ in figs to 37.45 $\mu g g^{-1}$ in white mulberry) and Zn (from 2.79 $\mu g g^{-1}$in table grapes to 6.54 $\mu g g^{-1}$ in apricots). Other trace metals are present at the levels: Cu (from 1.13 $\mu g g^{-1}$ in apple to 2.74 $\mu g g^{-1}$ in apricot), Co (from 0.3 $\mu g g^{-1}$ in plum to 1.77 $\mu g g^{-1}$ in fig), Mn (from 0.91 $\mu g g^{-1}$ in apple to 4.36 $\mu g g^{-1}$ in white mulberry), Ni (from 0.65 $\mu g g^{-1}$ in plum to 2.46 $\mu g g^{-1}$ in fig), Al (from 2.79 $\mu g g^{-1}$ in grapes to 6.54 $\mu g g^{-1}$ in apricot).

Tabela 1. Sadržaj esencijalnih makroelemenata ± SD* (μgg^{-1}) u analiziranim uzorcima

Table 1. The content of essential macroelements ± SD (μgg^{-1}) in analyzed samples*

Uzorci *Samples*	K** 769.896 nm	Na 589.592 nm	Ca 422.673 nm	Mg 202.582 nm
Šljive *Plums*	3.1±0.05	426±5	205±25	471±8
Smokve *Figs*	1.47±0.09	909±78	315±28	1062±17
Kajsije *Apricots*	1.92±0.06	710±20	232±12	430±3
Belo grožđe *White raisins*	1.39±0.05	138±4	23.8±0.8	311±3
Crno grožđe *Black raisins*	1.42±0.04	37.7±0.4	25.8±0.3	317±2
Urme *Dates*	1.07±0.02	30.6 ±0.2	24.1±0.5	417±4
Brusnica *Cranberries*	0.59±0.01	13.1±0.3	7.8±0.2	39.8±0.2

*Standard deviation for triplicate determinations, **mgg^{-1}

Mehta et al. (2014) analyzed dried plums and also found the highest concentrations of Fe (31.32 μgg^{-1}) and Zn (7.649 μgg^{-1}). The content of other investigated microelements are at the level of concentrations present in this paper (Cu 3.482 μgg^{-1}, Mn 1.933 μgg^{-1}, Ni 1.076 μgg^{-1}). The content of heavy metal Pb is slightly lower (0.208 μgg^{-1}). Also, toxic As was detected (0.278 μgg^{-1}).

The maximum allowable concentrations (MAC values) of Pb, Cd, Hg and As in dried fruits (3, 0.3, 0.1 and 1 mgkg^{-1}, respectively) are defined by national regulation- The provisions on maximal allowed amounts of pesticides, metals, metalloids and other toxic substances, chemotherapeutics, anabolics and other substances that can be found in food (The Official Gazette of the Republic of Serbia, No. 5/92, 11/92, 32/2002, 25/2010 and 28/2011). As, Cd and Hg were not detected in the analyzed samples while the content of Pb is below the MAC.

Manzoor et al. (2013) determined the concentrations of some heavy metals in ten samples of dry fruits. Excluding the samples of almond, hazelnut, cashew nuts, walnuts, peanuts and pistachio, the content of investigated metals in dates, raisins, apricots and figs are as follows: Co (from 0.107 μgg^{-1} in raisins to 1.568 μgg^{-1} in figs), Pb (from 0.924 μgg^{-1} in figs to 9.566 μgg^{-1} in dates), Cu (from 0.396 μgg^{-1} in apricots to 1.033 μgg^{-1} in figs), Cr (from 0.314 μgg^{-1} in apricots to 0.921 μgg^{-1} in dates), Ni (from 4.771 μgg^{-1} in figs to 5.447 μgg^{-1} in dates) and Cd (from 0.775 μgg^{-1} in raisins to 7.661 μgg^{-1} in figs). Significantly higher concentrations of heavy metals in the analyzed samples are evident in comparison with results of other studies. Also, microwave roasting and storage does not have an appreciable effect on the metal concentration of selected dry fruits.

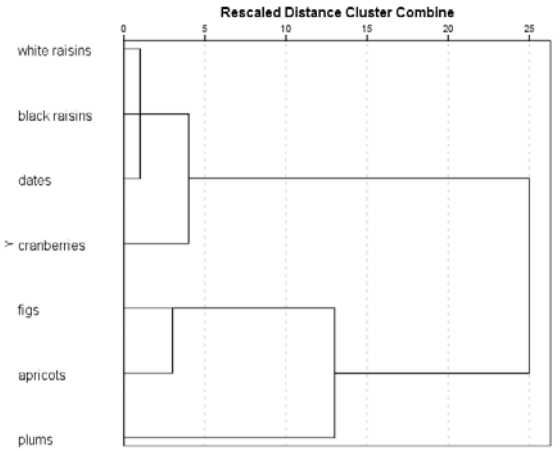
Tabela 2. Sadržaj mikroelemenata ± SD* ($\mu g g^{-1}$) u analiziranim uzorcima

Table 2. The content of microelements ± SD ($\mu g g^{-1}$) in analyzed samples*

Uzorci *Samples*	Fe 259.940 nm	Zn 202.548 nm	Cu 224.700 nm	Mn 257.610 nm	Ni 231.604 nm	Pb 182.205 nm	Co 237.862 nm	Al 396.152 nm	B 208.959 nm
Šljive *Plums*	2.2± 0.4	24.9±0.5	3.52± 0.04	1.6± 0.3	0.72± 0.02	0.92±0.06	0.135±0.008	0.72± 0.01	24.2±0.7
Smokve *Figs*	0.63±0.07	7.3± 0.2	3.09± 0.05	0.56±0.06	1.07± 0.02	0.41±0.03	0.19± 0.02	0.32± 0.02	12.8±0.3
Kajsije *Apricots*	0.81±0.02	5.41±0.03	3.297±0.008	0.33±0.02	0.397±0.003	0.72±0.02	0.33± 0.02	0.77±0.03	24.1±0.4
Belo grožđe *White raisins*	0.49±0.02	2.38±0.04	3.97± 0.04	0.37±0.02	0.15± 0.01	0.64±0.02	0.22± 0.03	0.33±0.03	32.6±0.5
Crno grožđe *Black raisins*	0.55±0.02	3.89±0.03	3.74± 0.04	0.292±0.003	0.090± 0.002	1.16±0.08	0.27± 0.01	0.632±0.005	23.1±0.4
Urme *Dates*	0.222±0.008	5.05±0.03	2.28± 0.03	0.222±0.008	0.082±0.005	0.71±0.02	0.080± 0.001	0.36± 0.04	5.88±0.04
Brusnica *Cranberries*	0.210±0.008	3.01±0.02	1.32± 0.02	0.215±0.008	0.052±0.008	0.93±0.02	0.022± 0.004	0.17± 0.03	0.35±0.03

* Standard deviation for triplicate determinations

Cluster analysis of the samples (Figure 1) based on the content of all investigated metals shows existence of two main clusters. Both clusters contain two subclusters. One of them is plums as fruits with the highest content of the most elements and another is cranberries with the smallest content of all investigated elements.



Sl. 1. Hijerarhijski dendrogram analiziranog suvog voća na osnovu sadržaja metala
Fig. 1. Hierarchical dendrogram for analyzed dried fruits based on metals' contents

Conclusion

Potassium is the most common macroelement while boron and zinc are the most common microelements in analyzed samples of plums, figs, apricots, raisins, dates and cranberries. As, Cd and Hg were not detected while the content of Pb is below the MAC. Cranberries have the smallest content of all investigated elements. The results obtained for investigated elements in analyzed food samples are acceptable to human consumption at nutritional and toxic levels.

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