

CONTENT OF ESSENTIAL AND TOXIC ELEMENTS IN FRUIT OF RASPBERRY CULTIVAR 'MEEKER'

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Abstract: Raspberries are one of the most important export products from Serbia. In order to evaluate the fruit quality of raspberry cultivar 'Meeker', in this study, contents of essential and toxic elements were analysed by means of inductively coupled plasma–optical emission spectrometry (ICP–OES). The most abundant essential elements in the fruit were K, Ca and Mg (2019.86, 310.28 and 275.37 mg kg⁻¹, respectively). To assess the safety of dietary intake of elements through the consumption of 'Meeker' fruits, the estimated weekly intake (EWI) for Al, Cu, Mn, Ni, Pb and Zn was calculated and compared with the provisional tolerable weekly intake (PTWI). EWI for Ni (0.033) was on the upper limit value.

Key words: raspberry fruit, 'Meeker', essential elements, toxic elements, ICP–OES analysis

Introduction

Raspberry (*Rubus idaeus* L.) was known among the ancient Greeks and Romans as a wild plant. Its fruits were collected in forests and used as food and as cure. Nowadays, raspberry is among the most important berry fruits grown worldwide and one of the most important export products from Serbia (Nikolić and Milivojević, 2015). Raspberries are an excellent natural source of active ingredients with antioxidant properties that have beneficial effects on human health (Dragišić Maksimović et al., 2017).

In Serbia, cultivation of raspberry began at the end of the 19th century. Initially it was planted as an ornamental plant, whilst commodity production started after World War I. Raspberry was produced primarily for the needs of the local market. The two most widespread varieties were 'Marlboreau' ('Valjevka') and 'Trnavska' ('Jelička'). The introduction of new varieties with large fruits and high fertility ('Willamette', 'Gradina', 'Malling Exploit', 'Meeker') has improved the raspberry production in Serbia (Nikolić and Milivojević, 2015).

'Meeker' was created in the United States, by crossing varieties 'Willamette' and 'Cuthbert' and its production started in 1967. In Serbia it was introduced in 1994 after which it began to spread rapidly. 'Meeker' is classified as economically important raspberry variety (besides 'Willamette', 'Tulameen' and 'Glen Ample' varieties). It has

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a large (~4 g), and uniform fruit of bright red colour, suitable for table use, freezing and making jams (Nikolić and Milivojević, 2015).

Mineral nutrients are basic for the proper functioning of every living organism. Their essential daily quantities are small, especially when compared with nutrients such as carbohydrates and lipids. Dietary minerals comprise essential and essential trace elements. Essential elements (Ca, K, Fe, Mg, Na, Zn) are those that could be found in the body in small quantities (mg per kilogram) (Zand et al., 2015). Essential trace elements (B, Co, Cu, Cr, I, Mn, Mo, Se), however, are required in milligram and sub-milligram quantities and their presence in human diet allows normal physiological functions. (Zand et al., 2015; Pizzorno, 2015). The non-essential elements (Al, As, Ba, Cd, Hg, Ni, Pb, Sb) are food contaminants with cumulative properties and are thus considered potentially dangerous (toxic) for the consumer (Alegria-Torán et al., 2015). Given the public concern about food safety, it has become necessary to monitor the quality of different types to ensure the benefits of its consumption.

Bearing this in mind, the main goals of this study were to evaluate the quality of ‘Meeker’ fruit by analysing the content of essential and toxic elements, and to estimate the weekly intakes of toxic and potentially toxic elements through its consumption.

Material and methods

The present study was conducted on raspberry fruits of ‘Meeker’ variety grown at commercial plantation in Igrište village (43° 11’ N latitude and 21° 08’ E longitude, at an altitude of 938 m). The village is situated on the administrative border with Kosovo and belongs to the municipality of Kuršumlija, Southern Serbia (Figure 1).

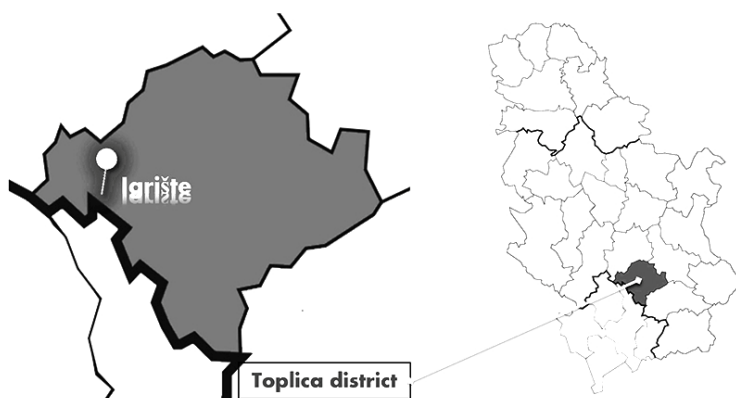


Figure 1. Geographical position of Igrište village within Toplica district

Slika 1. Geografski položaj sela Igrište u Topličkom okrugu

Raspberry was planted in a row system (Figure 2) on the ranker soil type developed on flysch sediments. Rows were oriented north-south and the distance between rows and seedlings was 2.8×0.25 m, respectively. Two different parent materials were

mapped on the geological map on location Igriste; sandstones and conglomerates are the dominant unit, whereas aleurolites, sandstones and marls are also found.

Fruit samples (Figure 2) were collected at the beginning of July 2016. The composite sample was made of ~500 g harvested fruits, and it was prepared for inductively coupled plasma–optical emission spectrometry (ICP–OES) analysis as previously described by Popović–Dordević et al. (2017). Fruits were analysed for the content of twenty-two elements using ICP–OES Spectroblue, SPECTRO Analytical Instruments GmbH, Germany equipped with Smart Spectro Analyzer software for data processing. US EPA Method 200.7 was applied (U.S. Environmental Protection Agency, 1994). Chemicals were acquired from Merck (Darmstadt, Germany) with maximum purity. High purity de-ionised water was used.

The weekly intake of Al, Cu, Mn, Ni, Pb and Zn through ‘Meeker’ berry consumption was calculated according to literature and expressed as estimated weekly intake (EWI) (Vlahović et al., 2005; Popović–Dordević et al., 2017).



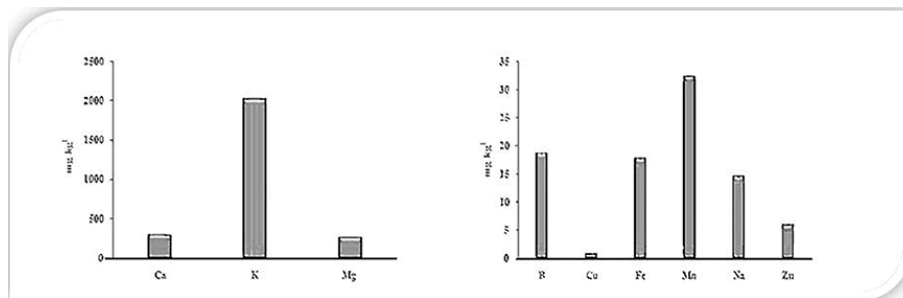
Figure 2. Raspberry orchard and fruits of ‘Meeker’ variety
 Slika 2. Zasad maline i plodovi sorte Miker

Results and discussion

The chemical composition of the plants in general reflects the elemental composition of the land on which they are grown, and their relationships are affected by different factors. In general, plants easily adopt elements that are present in the soil in dissolved forms, in ionic or helical and complex forms (Kabata-Pendias, 2011). Most of biogenic elements that are necessary for the proper nutrition of raspberry are deposited in the fruits and the leaves. Among them, K is the most important element in the fruit (Nikolić and Milivojević, 2015).

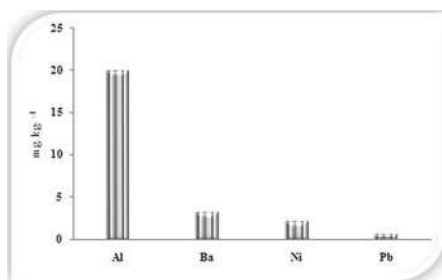
The contents of Al, As, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Sb, Tl and Zn and were analysed in the fruit of ‘Meeker’ variety. Among these elements, concentrations of As, Bi, Cd, Co, Cr, Li, Mo, Sb and Tl were below the limit of detection (LOD). The obtained results are shown in Graphs 1 and 2.

The most abundant essential elements in fruit were K, Ca and Mg with the average concentrations of 2019.86, 310.28 and 275.37 mg kg⁻¹, respectively.



Graph 1. Mineral composition of ‘Meeker’ fruit
Graf. 1. Mineralni sastav ploda maline Miker

The other essential elements were measured in lower concentrations from 1.00 mg kg⁻¹ (Cu) to 32.42 mg kg⁻¹ (Mn) (Graph. 1). It should be emphasized that the concentration of essential and non-essential elements depends on soil characteristics, plant physiology, water composition for irrigation, as well as the composition of fertilizers and plant protection products used in plantations (Niro et al., 2017).



Graph 2. Content of toxic elements in ‘Meeker’ fruit
Graf. 2. Sadržaj toksičnih elemenata u plodu maline Miker

This study revealed that Al (19.88 mg kg⁻¹), Ba (3.10 mg kg⁻¹), Ni (2.05 mg kg⁻¹) and Pb (0.50 mg kg⁻¹) were present in the fruit of the examined variety (Graph. 2). According to the national Regulations, the maximum allowed concentration (MAC) for Pb in fresh berries is proposed to be 1.0 mg kg⁻¹, meaning that the obtained result was within the MAC (Official Gazette, 2010/2011).

It is important to evaluate weekly intake (EWI) of toxic elements through food consumption, as these elements accumulated in fruits and vegetables, especially in their edible parts and consumed by humans could cause a range of health problems. On the other side, excessive intake of some essential elements such as Cr, Cu, Fe, Mn, Mo and Se could result in their toxicity (Goldhaber, 2003). Provisional Tolerable Weekly Intake (PTWI) was established by JECFA and generally refers to the safety factor approach for establishing acceptable or tolerable intakes of substances that demonstrate thresholds of toxicity, and is used by international scientific committees such as JECFA and national regulatory agencies (Herrman and Younes, 1999).

Table 1. Estimated weekly intake (EWI) of elements for ‘Meeker’ fruits
 Tabela 1. Procenjeni nedeljni unos (PNU) elemenata za plod maline Miker

	Al	Cu	Mn	Ni	Pb	Zn
EWI*	0.320	0.016	0.532	0.033	0.008	0.100
PTWI**	2	0.5	1 [§]	0.035	0.025	0.42

EWI* / PTWI* (mg kg⁻¹ BW) –mg per kg of body weight; 1[§] – no PTWI data for Mn

EWI was calculated for Al, Cu, Mn, Ni, Pb and Zn, based on average daily consumption of fruits in Serbia (0.172 kg) and compared to PTWI for these elements, Table 1. Estimated weekly intakes of Al, Cu, Ni, Pb and Zn through consumption of ‘Meeker’ fruits were within the acceptable PTWI values set by JECFA. It was worth noticing that the weekly intake for Ni was on the upper limit value for this element.

Conclusion

Among twenty-two studied elements As, Bi, Cd, Co, Cr, Li, Mo, Sb and Tl were below the limit of detection. The obtained results indicated that ‘Meeker’ fruits were a good source of essential elements (K>Ca>Mg>Fe>Na). The estimated weekly intake for Ni was on the upper limit of acceptable PTWI value. So, monitoring and the evaluation of exposure to toxic elements through consumption of raspberries are advisable.

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SADRŽAJ ESENCIJALNIH I TOKSIČNIH ELEMENATA U PLODU MALINE SORTE MIKER

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Izvod

Maline su jedan od najvažnijih izvoznih proizvoda iz Srbije. U ovom radu analiziran je sadržaj esencijalnih i toksičnih elemenata primenom induktivno spregnute plazme sa optičkom emisionom spektrometrijom (eng. *ICP-OES*), kako bi se procenio kvalitet plodova maline sorte Meeker. Najzastupljeniji esencijalni elementi u plodu bili su K, Ca i Mg (2019,86, 310,28 i 275,37 mg kg⁻¹, respektivno). Da bi se procenila dijetetska bezbednost unosa elemenata konzumiranjem maline Meeker, procenjen je nedeljni unos (PNU) za Al, Cu, Mn, Ni, Pb i Zn i upoređen je sa tolerantnim nedeljnim unosom (TNU). Procenjeni nedeljni unos (PNU) za Ni (0,033) bio je na gornjoj graničnoj vrednosti.

Ključne reči: plod maline, Miker, esencijalni elementi, toksični elementi, ICP-OES analiza

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