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**ORIGINAL PAPER**

# MACRO- AND MICROELEMENT COMPOSITION OF OSAGE ORANGE *MACLURA POMIFERA* L. (MORACEAE)*

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**Abstract**

The content of macro- and micro- as well as toxic elements in *Maclura pomifera* L. fruit has been investigated in order to estimate its potential applications in food, pharmaceutical and cosmetic products. The content of 29 elements (As, Ag, Al, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Ge, Hg, In, K, Li, Mg, Mn, Na, Ni, P, Pb, Sb, Si, Sr, Tl and Zn) has been determinated from the fruit samples which originated from the Jablanica District in Serbia. The element content was determined in the fruit core, flesh and seed. The preparation of samples for macro- and microelement analysis was done by wet digestion. Concentrations of elements after digestion were determined by Inductively Coupled Plasma–Optical Emission Spectrometry (ICP-OES). The results showed that of all the examined macroelements, potassium appeared in the highest concentration in all three sample parts (1175-3137 mg $kg^{-1}$). *Maclura pomifera* L. seed analysis showed the highest Mg, Na, P, Zn and Fe content compared to the core and flesh fruit part, which points to the highest nutritional value of seeds. Of all the toxic heavy metals, lead (2.962-16.90 mg $kg^{-1}$), arsenic (0.987-1.352 mg $kg^{-1}$) and mercury (8.229-9.465 mg $kg^{-1}$) were detected over the allowable limits set for food. However, the determined arsenic and lead concentrations, unlike mercury ones, do not exclude the possibility of using *Maclura pomifera* L. as raw material in different industries.

**Keywords:** *Maclura pomifera* L., microelements, macroelements, toxic, ICP-OES.

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## INTRODUCTION

*Maclura pomifera* L. (Moraceae) or Osage orange is a thorny dioecious plant tree that belongs to ornamental species, mostly cultivated in Texas, Oklahoma, and Arkansas. It is common in other countries too because of its ability to grow in most types of soils (Altuner et al. 2012). The tree of this species as well as its fruit and seeds have a wide range of applications. *Maclura pomifera* (MP) tree fruits are heavy, coarse-textured, yellow-green balls that measure 10-15 cm in diameter. The first use of MP trees, such as growing hedges, was proposed by Wright and his friend Turnfor in the 1850s (Smith, Perino 1981). Later investigations into this species characterized it as a plant possessing certain economically important chemical properties. Primary components of fresh fruit include pectin (46.04%), resin (16.64%), fat (5.16%) and sugar (before hydrolysis, 4.46%) (Smith, Perino 1981). Alkaloids, glucosides, titratable acids, lecitin, vitamin C and flavonoid pigments are also present (Saloua et al. 2009). Apart from being used for decorative purposes or as an insect repellent, the fruit can serve as a source of green-yellow pigment. Although MP fruit have not been considered as a food source, they can be seen as a functional food ingredient in the future because of their beneficial antioxidant and nutraceutical properties. Various parts of MP fruit are used in the treatment of sore eyes, tooth pain, uterine haemorrhage, gastric damage and in cancer treatments (Mahmoud 1981, Bourdy et al. 2004, Bozkurt et al. 2017). As well as being abundant in carbohydrates, fats, and albumins (Wehmer 1929), MP latex is rich in certain enzymes such as lipase, amylase and proteinase (Gerber, Salkind 1913, Gerber 1913). The lipolytic, amylolytic, and proteolytic latex activities observed in MP justify its potential use in the development of functional foods (Gerber, Salkind 1913, Gerber 1913, Corrons et al. 2017, Gonzales et al. 2018). Numerous studies suggest that it possesses unusual quantities of serine peptidases in the latex that can be used to hydrolyze soy protein (Bertucci et al. 2015). Lupeol, a triterpene alcohol, was isolated from the unsaponifiable fraction of the petroleum ether extract of dried MP fruit (Swift, Walter 1942). Methyl esters of the MP seed oil suggest the potential of this biomaterial for making biodiesel fuel (Moser et al. 2011, Rogers et al. 2015). As reported, MP and its components have antibacterial, antifungal, antiviral, cytotoxic, antitumor, estrogenic and antimalarial activities (Hay et al. 2004). Tsao and collaborators (2003) studied two predominant isoflavones, osajin and pomiferin, that provide an antioxidant MP activity. An antifungal agent and a nontoxic antibiotic useful as a food preservative have been extracted from the heart part of wood (Barnes, Gerber 1955). Recent studies have shown that MP seed oil could be used as broad spectrum UV protectants in cosmetic, pharmaceutical and food products (Saloua et al. 2009).

Although there are extensive studies on the morphological, physical and chemical MP composition (Smith, Perino 1981, Delle Monache et al. 1984,

Schnabel et al. 1991, Tsao et al. 2003, Saloua et al. 2009, Teixeira et al. 2009), there are no data about the MP mineral composition. Macro- and micro-elemental food composition is of great importance, as much as the presence of those micro-elements that have toxic effects because of the prolonged use of cosmetics, food or medicines containing toxic elements that may affect human health and cause damage to the environment. In short, MP has a wide range of applications in different technologies (cosmetics, pharmaceuticals, etc.) as raw material, and therefore the main goal of this work has been to determine precisely the content of minerals present in MP fruit. Another objective has been to assess whether MP could be used as food in human diet. Considering the above, the results presented in this manuscript could be useful for students and academics as well as for those engaged in the production, processing and marketing of *Maclura pomifera* L. fruit.

## MATERIAL AND METHODS

In order to estimate the content of macro-, micro- and toxic elements, calibration standards were prepared. Multistandard, a standard solution (Merck) which contained Ag, Al, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, K, Li, In, Mg, Mn, Na, Ni, Pb, Tl and Zn at a concentration of 1000 ppm, was used for the preparation of calibration solutions. The elements As, Ge, Hg, P, Sb, Si and Sr were determined using the specific calibration standards (1000 ppm), respectively. Distilled water, purified by Fisher Chemical (HPLC grade), was used for all sample dilutions. The carrier gas was Argon 5.0 (99.99% purity). The preparation of standard solutions was performed by diluting the multistandard, so that the concentrations of standards for the calibration were in the range of expected concentrations of the analysed elements. Table 1 shows the wavelength detection of each element in the samples, correlation coefficient ($R^2$), limit of detection (LOD), as well as the range of linearity.

### Sampling and sample preparation

Osage orange *Maclura pomifera* L. (Moraceae) was collected from the territory of Jablanica District in Serbia. Before any further analysis, each fresh MP sample (total mass = 615.4 g) was divided into three parts: seed, core and flesh. The preparation of analytical samples was carried out according to the published wet digestion method (Havlin, Soltanpour 1980). An amount of 0.30 g of a sample was treated with 10 ml of nitric acid (65 ww%, p.a, Merck) and heated to complete mineralization. Before ICP-OES analysis, all samples were diluted with distilled water purified by Fisher Chemical (HPLC grade) to the 100 ml volume and then filtered (0.45 μm).

Table 1

Calibration parameters: λ (nm), $R^2$, LD (μg $L^{-1}$) and the range of linearity (μg $L^{-1}$)

| Element | Detection wavelength (nm) | Correlation coefficient ($R^2$) | Limit of detection (μg $L^{-1}$) | Linearity range (mg $L^{-1}$) |
|---|---|---|---|---|
| As | 197.2 | 0.999 | 2.55 | 0.002-3.60 |
| Ag | 224.6<br>328.1 | 0.999<br>0.999 | 0.39 | 0.014-12.00<br>$3 \cdot 10^{-4}$-12.00 |
| Al | 167.1<br>394.4 | 0.999<br>0.999 | $7.6 \cdot 10^{-2}$ | $7.6 \cdot 10^{-5}$-2.40<br>0.002-12.00 |
| B | 182.6<br>249.7 | 0.999<br>0.999 | 6.43 | 0.007-12.00<br>0.006-12.00 |
| Ba | 233.5 | 0.995 | 0.183 | $1.83 \cdot 10^{-4}$-12.00 |
| Bi | 190.2<br>223. 1 | 0.999<br>0.999 | 3.53 | 0.003-12.00<br>0.004-12.00 |
| Ca | 183.8<br>396.8 | 0.999<br>0.999 | 2.14 | 1.6-480.00<br>0.0024-2.41 |
| Cd | 214.4 | 0.999 | 0.127 | $1.27 \cdot 10^{-4}$-12.00 |
| Co | 228.6 | 0.999 | 0.327 | $3.27 \cdot 10^{-4}$-12.00 |
| Cr | 283.5 | 0.999 | 0.435 | $4.35 \cdot 10^{-4}$-12.00 |
| Cu | 224.7<br>324.7 | 0.999<br>0.999 | 0.259 | $9.07 \cdot 10^{-4}$-12.00<br>$2.59 \cdot 10^{-4}$-12.00 |
| Fe | 259.9 | 0.999 | 0.118 | $1.18 \cdot 10^{-4}$-12.00 |
| Ga | 417.2 | 0.999 | 1.7 | 0.002-12.00 |
| Ge | 265.1 | 0.999 | 1 | 0.001-12.00 |
| Hg | 184.9 | 0.999 | 0. 192 | $1.92 \cdot 10^{-4}$-12.00 |
| In | 325.6 | 1.000 | 4 | 0.004-12.00 |
| K | 404.7<br>766.4 | 0.999<br>0.999 | 0.378 | 0.798-300.0<br>$3.78 \cdot 10^{-4}$-1.20 |
| Li | 323.2<br>670.7 | 1.000<br>0.999 | $5.75 \cdot 10^{-2}$ | 0.079-12.00<br>$5.75 \cdot 10^{-5}$-1.20 |
| Mg | 279.5<br>285.2 | 0.999<br>0.999 | 0.115 | $1.15 \cdot 10^{-4}$-6.04<br>4.03-120.0 |
| Mn | 257.6 | 0.999 | $3.57 \cdot 10^{-2}$ | $3.57 \cdot 10^{-5}$-12.00 |
| Na | 330.2<br>598.5 | 0.999<br>0.999 | 4.75 | 7.98-480.0<br>0.005-12.00 |
| Ni | 231.6 | 0.999 | 0.474 | $4.74 \cdot 10^{-4}$-12.00 |
| P | 214.9 | 1 | 1.59 | 0.002-120.0 |
| Pb | 220.3 | 0.999 | 1.78 | 0.002-12.00 |
| Sb | 187.1 | 0.999 | 2.44 | 0.002-12.00 |
| Si | 251.6 | 0.999 | 1.6 | 0.002-60.00 |
| Sr | 407.7 | 0.999 | $6.23 \cdot 10^{-3}$ | $6.23 \cdot 10^{-6}$-2.41 |
| Tl | 190.8 | 0.999 | 1.72 | 0.002-12.00 |
| Zn | 213.8 | 0.999 | $8.2 \cdot 10^{-2}$ | $8.2 \cdot 10^{-5}$-12.00 |

**Analysis of samples**

The quantitative analysis of all samples was performed on ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry, ARCOS FHE12, SPECTRO, Germany), according to the manufacturer's instructions. The instrument settings are presented in Table 2.

Table 2

Operating conditions for ICP-OES (W)

| Plasma Power (W) | 1400 |
|---|---|
| Gas flow (L $min^{-1}$)<br>- coolant<br>- auxiliary | <br>13<br>0.80 |
| Nebulizer type | cross flow |
| Nebulizer flow rate (L $min^{-1}$) | 0.95 |
| Pump speed | 30 |
| Stabilization time (s) | 0 |
| Number of probes for each measuring | 3 |
| Plasma observation | axial |

## RESULTS AND DISCUSSION

In order to obtain a more complete picture of the presence of minerals in MP fruit, the fruit was devided to seed, flesh and core, after which the content of 29 minerals was examined. The results fell into three groups (the content of macro-, micro- and toxic elements) and presented in Figures 1, 2 and 3, respectively.

The concentration macro-elements as well as the balance and ratios of some elements are of great importance in many aspects. Once an individual's mineral ratios are known and fully understood, it is possible to determine the efficiency of major organs. For example, calcium and potassium ratios, so called the thyroid ratio, regulate the thyroid gland so that calcium slows down the thyroid and potassium speeds it up. In order for the gland to operate at its maximum capacity, there has to be just the right balance between these two minerals (Ca/K = 1/4) (Olagbemide et al. 2016). The adrenal gland act properly only at certain values of sodium to magnesium that have to be less than 3.2. When the sodium level drops under an adequate level the person's adrenal medulla will start to slow down, which results in diminished levels of energy (Gross, Underhill 1922). The significance of macro-elemental composition is important for the functioning of human and animal organisms as well as for the normal growth of vegetables and herbs. The results of

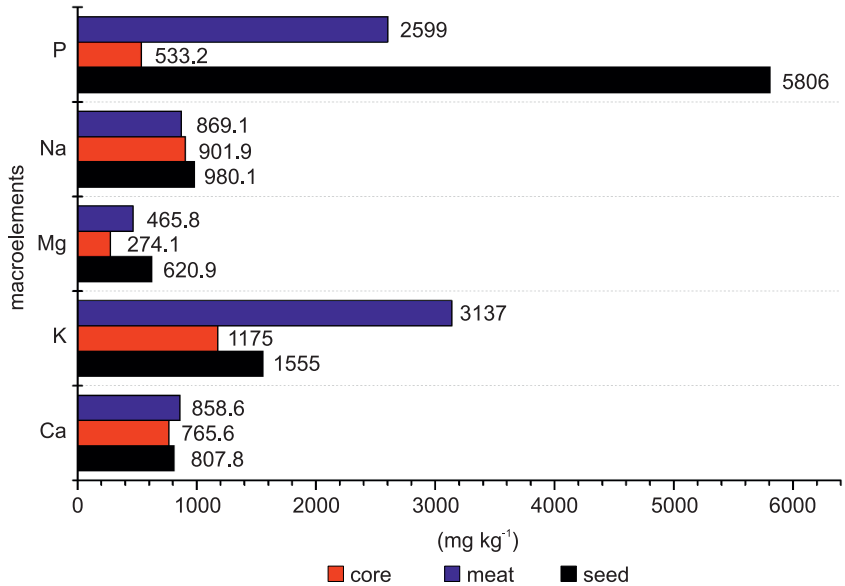


Fig. 1. Macro-elements in *Maclura pomifera* L. (mg kg$^{-1}$)

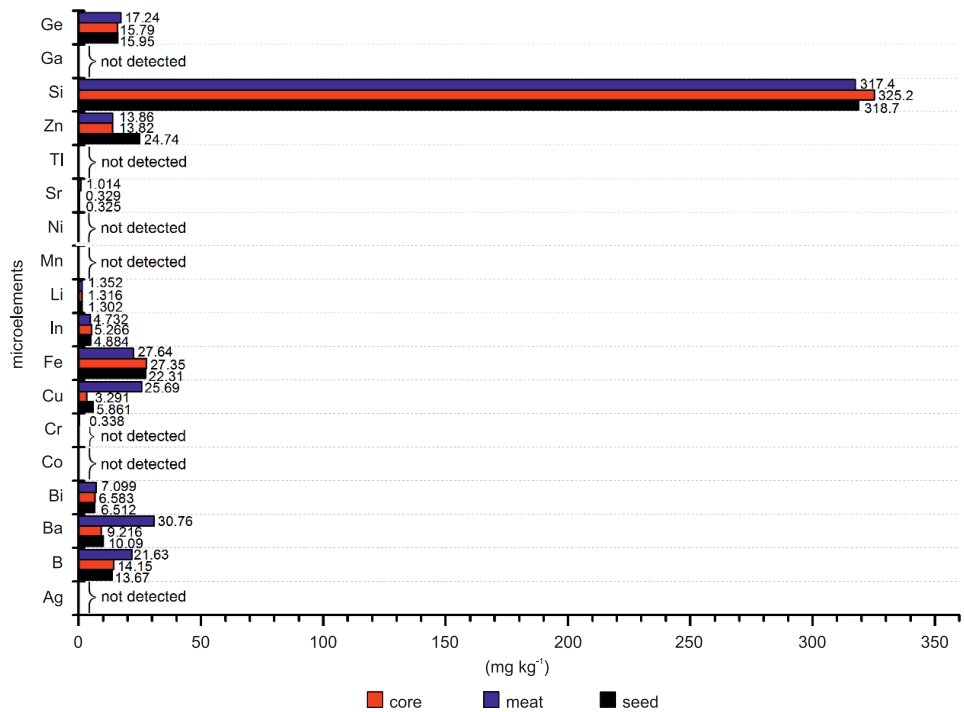


Fig. 2. Micro- and trace elements in *Maclura pomifera* L. (mg kg$^{-1}$)

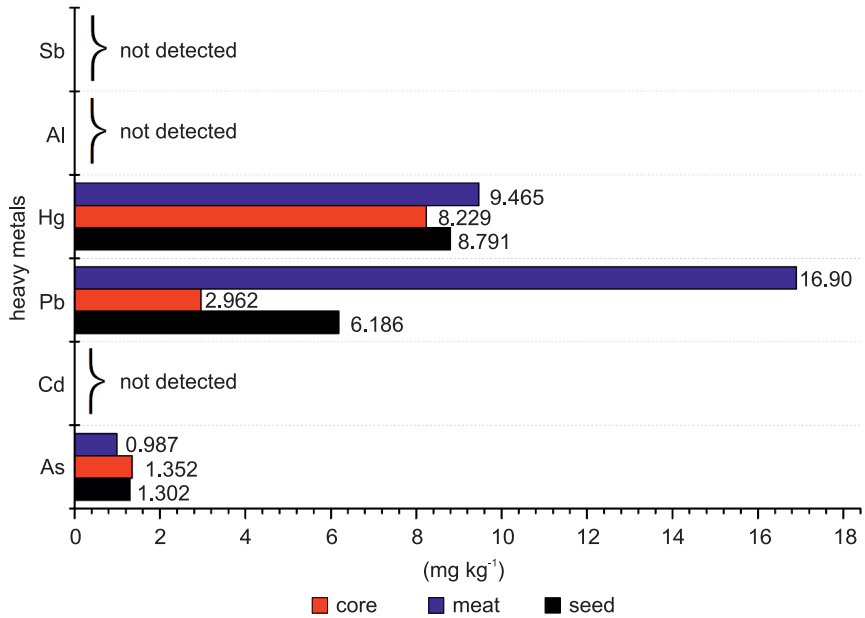


Fig. 3. Toxic elements in *Maclura pomifera* L. (mg kg$^{-1}$)

a study into the presence of macro-elements in MP are shown in Figure 1. Based on these data, it can be concluded that among the investigated macro-elements (K, Ca, Mg, Na and P), potassium reached the highest content was in flesh, seed and MP core: 1175, 1555 and 3137 mg kg$^{-1}$, respectively. That could have been expected since potassium is naturally present in all fruits in the form of its salt of tartaric acid (Tormen et al. 2011). Potassium has already been detected as a major MP seed oil nutrient in an amount of 421.6 mg/100 g (Saloua et al. 2009). Among other macro-elements, a high phosphorus content was observed in MP seeds (5806 mg kg$^{-1}$), which was is 2.23 and 10.89 times higher compared to the P content in MP flesh and core, which was predictable as well since the main sources of phoshopous are grains, beans, nuts and seeds (Calvo et al. 2014). Second to calcium, phosphorus corresponds to 1% of human body weight. Because of the widespread presence of phosphorus in every living organism, its content in food is important.

The calcium content in MP seed, core and flesh was 807.8, 765.6 and 858.6 mg kg$^{-1}$, respectively. The content of Ca in almonds, hazelnuts and Brazil nuts ranges from 1338 to 1506 mg kg$^{-1}$. The average amount of calcium in the fruit is 339-2348 mg kg$^{-1}$, compared with 97.1 to 4970 mg kg$^{-1}$ in food (Mehari et al. 2015), which is also detected in the case of MP. After calcium, the sodium MP content is also considerable. Sodium, like potassium, is one of most abundant cations in the body that participate in water metabolism, contraction of muscles, transfer of carbon-dioxide to the lungs, etc.

(Marschner 1995, Barker, Pilbeam 2015). Its high concentrations are required for many functions. In MP seed, core and flesh, its concentration is significant: 980.1, 901.9 and 869.1 mg $kg^{-1}$, recpectively. The presence of magnesium is detected in lower amounts compared to other macro-elements. The Mg avarage concentration in fruits is 191.7 and in veritables and herbs 191 mg $kg^{-1}$ (Mehari et al. 2015). The higest Mg concentration is detected in MP seeds (620.9 mg $kg^{-1}$). Magnesium regulates protein synthesis, muscle and nerve function and blood pressure (Marschner 1995, Barker, Pilbeam 2015). Participates in the active transport of calcium and potassium ions across the cell membrane, which is an important process for conducting nerve impulses and normal heart rhythm. The recommended daily intake of Mg for men and women is about 400 mg (Guerrera et al. 2009).

Micro and trace elements MP content is presneted in Figure 2. Of all investigated micro and trace elements, the presence of Ag, Co, Mn, Ni, Tl and Ga were not detected. *Silicon* is detected in the highest concentration compared to the other investigated micro elemets. The detected Si content was higher in MP meat (325.2 mg $kg^{-1}$), compared to seed and core (318.7 and 317.4 mg $kg^{-1}$, recpectively). The recommended daily intake of Si is 21-200 mg, and is considered as probably essential micro-element in trace amount. Si is important for skin and cardiovascular health as well as for bones (McNaughton et al. 2005). After Si the significant presence of *iron*, *copper* and *zinc* were detected in all three sample parts. Zinc is very important as one of the trace element and is required for normal growth. According to WHO, the recommended daily allowance of zinc is 12 - 15 mg (WHO, 1989). Copper, along with vitamin C and zinc, helps in the maintenance of the elasticity of fibers, providing better skin structure support. According to WHO, the recommended daily dosage of copper is 1 mg (WHO, 1989). The invession of a diet that is deficient in a particular essential elements as Zn, Fe and Cu can enhance the accumulation of some toxic metals as Cd or Pb (WHO, 1996), which can influance trace element metabolism (Alonso et al. 2004).

Iron is used for the activity of some enzymes that generate energy. In processed foods, Fe is present in the highest concentrations (averege 106 mg $kg^{-1}$), compared to the Zn (27 mg $kg^{-1}$) and Cu (3.4 mg $kg^{-1}$), (Mehari et al. 2015). In fresh herbs and fruits the averege content of Fe is 60 and 13 mg $kg^{-1}$ respectively, that is higher compared to the Zn (25 and 15 mg $kg^{-1}$) and Cu (6.8 and 6.2 mg $kg^{-1}$). Examined MP parts demonstrated the highest Cu content in the core (25.69 mg $kg^{-1}$) that is 10 times higher compared to the seed and meat part. MP seed was the richest in zinc and iron content compared to the other parts. The average data of Cu, Fe and Zn content in fruits and herbs (Papa et al. 2009, Mehari et al. 2015), shown overlapping with obtained MP data (Figure 2). The Saloua and collaborators (2009) also demonstrated that besides potassium, calcium, magnesium, sodium and phosphorus as prevalent minerals, iron, zinc and copper were detected in highest amounts in seed as well seed oil.

Detected elements that are considered non-essential are lithium, strontium, bismuth, and germanium. Cereals and cereal-based products contain very little lithium (1 mg $kg^{-1}$ ), but most vegetables (dry weight) contain >1 mg $kg^{-1}$ (Haddadin et al. 2002); fruits as apples or lemons are cited as having around 1.4 mg $kg^{-1}$ of lithium. The detected Li amount in MP is 1.3 mg $kg^{-1}$ (in all three parts) that considers it equivalent to the amount detected in most fruits (Haddadin et al. 2002). Strontium usually occurs in association with the large Ca amount. Sr content in fruits varies: 0.16-6.34 mg $kg^{-1}$ (Altundag, Tuzen 2011). The obtained analysis results (Figure 2) were in agreement and shown that Sr content was the highest in the core, 1.014 mg $kg^{-1}$ compared to the meat and seed, 0.329 and 0.325 mg $kg^{-1}$, respectively.

Barium is present in all foods, in concentration ranges from 0.21 to 11 mg $kg^{-1}$, but tends to remain below 2 mg $kg^{-1}$ whereas *bismuth* levels in foods are usually low (González-Weller et al. 2013). Ba content in MP sample was higher that reported (González-Weller et al. 2013), especially in MP core part in concentration of 30.76 mg $kg^{-1}$. This value must be taken into account because short term exposure can cause vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness until large amounts of barium intake can cause, high blood pressure, changes in heart rhythm or paralysis and possibly death (Martin, Griswold 2009).

Bismuth is present in many cosmetic and pharmaceutical products, and due to less toxicity compared to lead, is oftenly used as replacement. In vegitables and fruits is present in very low amonts. The identified Bi concentration in MP was in the range of 6.512-7.099 mg $kg^{-1}$. Although the half-life of bismuth is generally short for most of tissues, Bi consumption may concider as toxic after prolonged therapeutic application, leading predominantly to kidney failure or mental disorders (Michalke et al. 2008).

Germanium is an important element and has essential effects on human health. Foods found to contain germanium were potato, garlics and carrots, having 1.85, 2.79 and 0.60 mg $kg^{-1}$ (McMahon et al. 2006). Food that contains the highest concentration of germanium was Soya mince having 9.39 mg $kg^{-1}$ (McMahon et al. 2006). Detected germanium amount in MP was higher than reported- 17.24 mg $kg^{-1}$ in MP core, until amount in seed and meat was slightly lower – 15.95 and 15.79 mg $kg^{-1}$. Daily intake of germanium from food in adults ranges only from 0.367 to 1.5 mg, which is not toxic to humans (Chen, Lin 2011).

Indium in MP seed, meat and core was detected in significant amount of 4.884, 5.266 and 4.732 mg $kg^{-1}$. Once absorbed they tend to be stored temporarily in the muscles, skin, and bones before being excreted. It has no metabolic role in any organism and can be toxic, too.

Boron contributes to the functioning and the absorption of calcium, magnesium and phosphorus. Its deficiency can cause bone demineralization.

The boron content in the MP is in the range from 13.67-21.63 mg $kg^{-1}$. The recommended daily intake of B is not precisely defined, but the maximum allowable daily intake ranges from 6 to 20 mg (Devirian, Volpe 2003).

Chromium is an essential trace element, that is not often detected in food. It affects the metabolism of carbohydrates, fats and proteins. The presence of this element in the feed is conditioned by the temperature of processing foodstuffs and geographical origin of the same. The presence of Cr was detected to a greater amount in the cortex than fruit meat, tomatoes and peaches – 11.3 and 2.07 mg $kg^{-1}$ of dry weight (Papa et al. 2009). Cr in MP was detected only in MP core, 0.338 mg $kg^{-1}$.

Heavy metals are classified as the most dangerous inorganic environmental pollutant elements because they are non-biodegradable, with a tendency towards bioaccumulation and expression of the toxic effects even at very low concentrations. Some heavy metals such as copper, zinc, manganese, selenium, molybdenum and iron are among the group of trace microelements because even though they are toxic in higher concentrations, at lower amounts they c are necessary for the growth and development of plants and other living organisms. The accumulation of heavy metals in plants depends not only on the total content in the soil, but also on the kind of affinity, as well as individual and interactive effects of different soil properties. Metals in cosmetic products derived from crude oil such as mineral oils, paraffin, silicones, aliphatic hydrocarbons or as UV filters in face and body care products and pigments in coloured cosmetics may also be harmles after absorption into the skin (Borowska, Brzóska 2015). The possible occurrence of Sb, Al, Hg, Pb, Cd and As was examined in MP samples, but only Hg, Pb and As was detected (Figure 3). Lead is considered to be a very toxic element. Lead poisoning affects the brain function and nervous system, reduces the level of intelligence, perception and memory mode and in most severe cases can cause death (Petrović et al. 2015). Comparing the levels of lead per location, greater concentrations are detected in locations close to heavy road traffic (Fang et al. 2014), which might be the reason why lead was detected in the analysed MP samples (Figure 3). In vegetables and herbs, the lead concentration is usually 9-27 mg $kg^{-1}$ and in fruit 4.1-13 mg $kg^{-1}$ (Mehari et al. 2015). Lead in the MP samples we analysed was found to accumulate mostly in the core (16.90 mg $kg^{-1}$), with 2.73- and 5.7-fold lower concentrations in flesh and seed, respectively. The content of lead detected in the MP core may be considered as higher than allowed for food (Regulation, 1992), but the value is still in accordance with the data published previously (Borowska, Brzóska 2015, Mehari et al. 2015) and allowed by the regulation (US Government 2008), thus indicating that MP could be used in some cosmetic and pharmaceutical products.

Arsenic is one of the most toxic and carcinogenic element of the second group of *p* elements, which occurs in inorganic and organic form. Arsenic and manganese in the soil often co-occur with iron, mainly pyrite and arsenopyrite. They can also be found in the form of different arsenic sulfide minerals.

These minerals are unstable, and under certain weather conditions reactions arise that cause potential "leaking" of arsenic into groundwater. Because of the serious threat it poses to the heart, lungs, stomach, liver and kidneys, the maximum limit of As should be represent 0.42 µg/day. Overall, the contamination of MP samples with As limits – its use as food (WHO, 1989), but not in the cosmetic industry, where the As concentrations allowed are up to 3 mg $kg^{-1}$ (US Government 2008, Eltegani et al. 2013, Borowska, Brzóska 2015) of pharmaceutical products (Abernethy et al. 2010).

Mercury is found in small amounts in rocks, air and water from industrial waste. Fish but also other food can contain mercury. It has toxic effects on humans, especially babies and children. In drinking water, the permissible mercury concentration is 0.002 mg $L^{-1}$, while in foor it can reach 1.5 mg $kg^{-1}$ (Regulation 1992). In cosmetic products, the allowed mercury concertation is 1 mg $kg^{-1}$ (USFDA, 2000, US Government 2008), except in eye area cosmetics, where mercury can be used as as a preservative in an amount of up to 65 mg $kg^{-1}$ (US Government 2008). Since the detected mercury concentration in MP was in a range of 8.229-9.465 mg $kg^{-1}$, MP may pose a health hazard.

## CONCLUSIONS

The macro-element analysis performed in this study showed the highest potassium presence in all three sample parts (1175-3137 mg $kg^{-1}$). MP seed analysis showed the highest Mg, Na, P, Zn and Fe content compared to the fruit core and flesh part, which points to the highest seed nutritional value. Of all the examined toxic heavy metals, lead, arsenic and mercury were detected. Because of the detected metals in MP whose content exceeded the allowable limits, it can be conclude that MP fruit cannot be used as a food. The determined arsenic (0.987-1.352 mg $kg^{-1}$) and lead concentrations (2.962-16.90 mg $kg^{-1}$) are in compliance with the pharmaceutical and cosmetic regulations, which indicate that MP can be used as raw material in these industries. The rsults presented in this work, regarding the presence of some toxic elements in all MP fruit parts, recommend caution before its use. These data apply only to the MP fruit harvested in Jablanica District because the content of minerals and heavy metals may depend on a site place of plant growth and on the environment's state.

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