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Accumulation and distribution of toxic and potentially toxic elements in potato on different types of soil

Jelena Popović-Djordjević[1*], Zoran Broćić[1], Mirjana Kresović[1], Jelena Mutić[2]

[1]University of Belgrade, Faculty of Agriculture, Belgrade, Serbia
[2]University of Belgrade, Faculty of Chemistry, Belgrade, Serbia

*jelenadj@agrif.bg.ac.rs
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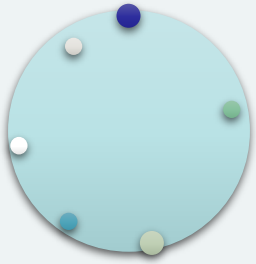


- Potato is among the most significant crop cultures in the world.
- In 2018, world production of potato was ~368 million tons, whereas in Serbia 487909 tons were produced [1].
- Potato is the most consumed vegetable in Serbia [2].

- The nutritive value of potato is mainly attributed to the chemical composition of the tuber (dry matter, total sugars, reduced sugars, proteins, vitamins and essential elements).
- The elemental composition of tubers depends on many factors, such as: genotype, developmental phase of the plant, agroecological conditions, chemical properties of soil, fertilization and irrigation.
- The same genotypes on different locations can have different concentrations of trace elements due to their interaction with the environment.
- Geochemical origin of trace elements in the soil, intensive agricultural production, use of contaminated soil and irrigation water may increase their toxic levels in tubers [3,4].
- Thus, the knowledge about trace elements in the soil–plant chain is important from different aspects such as safe environment, food safety and human health [5].

Aim of the work

- To determine the content of arsenic (As), cadmium (Cd) and lead (Pb) as toxic, and aluminium (Al), barium (Ba), nickel (Ni) and vanadium (V) as potentially toxic elements, in potato tuber (peel and core) of five varieties grown at different types of soil, and soil samples.

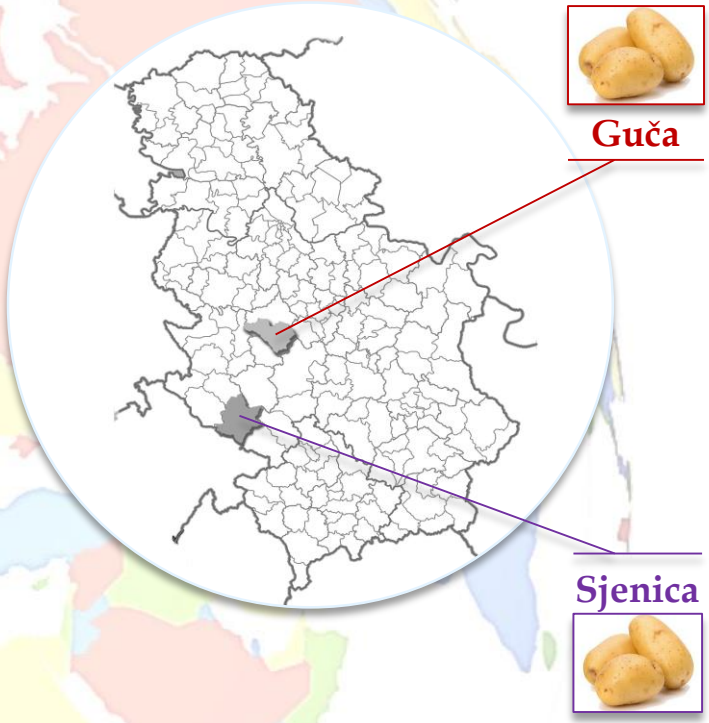
- To calculate bioaccumulation factor (BAF) of each studied element in the peel and in the core of tubers.

- To evaluate bioaccumulation potential of studied varieties on two types of soil.

Study area

- Guča, West Serbia
(43° 47′ N/20° 13′ E, ~400 m a.s.l.)
- Sjenica, South-Western Serbia
(43° 16′ N/20° 20′ E, ~1026 m a.s.l.)

• Soil properties:
Very acidic - pH 4.77 (Guča location)
Slightly acidic - pH 6.80 (Sjenica location)



Material

- Studied varieties: Agria, Aladin, Desiree, Newton and Bellarosa

- Total of 100 randomly taken tuber samples of five potato varieties from each location were collected at the end of growing season at the stage of physiological maturity.

*Study area map is self-created using map of Serbia available at:
https://bs.m.wikipedia.org/wiki/Datoteka:Map_Serbia_Blank_(without_Kosovo)

Methods

- Content of Al, As, Ba, Cd, Ni, Pb and V was determined by inductively coupled plasma–optical emission spectrometry (ICP–OES). **Instrumentation**: Inductively Coupled Atomic Emission Spectrometer, ICP-OES (Thermo Scientific, United Kingdom), model 6500 Duo, equipped with a CID86 detector.

- Prior to the analysis, fresh potato tubers were washed (by tap and then by de-ionized water), air dried and peeled. The peel and the core (inner part) were analyzed separately.

- Digestion of samples with acid mixtures was done by microwave digestion: tuber peel and core samples (65% HNO_3/30% H_2O_2 – 7:1) and soil samples (65% HNO_3 /36% HCl – 2:1). **Instrumentation**: Ethos 1, Advanced Microwave Digestion System, Milestone, Italy.

- Bioaccumulation factor (BAF) of each studied element, as the ratio between its content in the peel and in the core of the tuber and the soil, was calculated [6], using the equation:

$$BAF = Ct/Cs$$

- Ct and Cs - concentration of element in the tuber (peel or core) and in the soil, respectively.

Results

- In all studied varieties tuber peel had the highest content of Al, Ba, Cd, and Ni, compared to the relevant core, regardless the soil type.
- At very acidic soil (pH 4.77) As and V were below the limit of quantification in the core of varieties Aladin and Bellarosa, respectively. In addition, content of As was higher in the core than in the peel of Newton variety.
- At slightly acidic soil (pH 6.80) content of As was higher in the core compared to the peel in varieties Agria, Desiree and Newton.
- The highest/lowest content (in fresh weight of samples) was measured for Al (57.2 mg/kg in the peel of Desiree variety grown at Sjenica location, and for V (0.01 mg/kg) in the core of varieties Desiree and Bellarosa grown at Guča and Sjenica location, respectively.
- In the core of all studied varieties content of Cd was within the safe limit for these elements (0.1mg/kg), whereas the content of Pb surpassed the safe limit value (0.1mg/kg), according to national and European Union regulations [7, 8].

- Content of As in the core of studied varieties was below the maximum allowable concentration (0.3 mg/kg) set by national regulation [7].
- The highest/lowest BAF values were calculated for Cd (0.339) in the peel of Bellarosa variety grown at highly acidic soil, and Al (0.0002) in the core of most studied varieties grown on both soil types, respectively.
- In the core of Newton and Bellarosa varieties higher BAF values for Cd and Pb were observed in tubers obtained from very acidic soil (Guča location), compared to the samples obtained from slightly acidic soil.
- In the core of Desiree tubers grown on slightly acidic soil (Sjenica location) higher BAFs for Cd and Pb were found.
- BAF values for As in core were higher for tubers of all studied varieties grown at less acidic soil (pH 6.8).
- Trend of accumulation of toxic elements (Cd>Pb>As) in studied tubers (both core and peel) was in agreement with literature [5].

✘ Content of quantified elements in the soil samples, with the exception of Ni, was within the allowable limits set by national regulation [9].

✘ The highest/lowest concentration in the soil was measured for Al at Sjenica location (16493 mg/kg), and Cd at Guča location (0.56 mg/kg), respectively.

✘ Higher values of BAF were observed for the peel in comparison to the core of all tuber varieties (Figure 1).

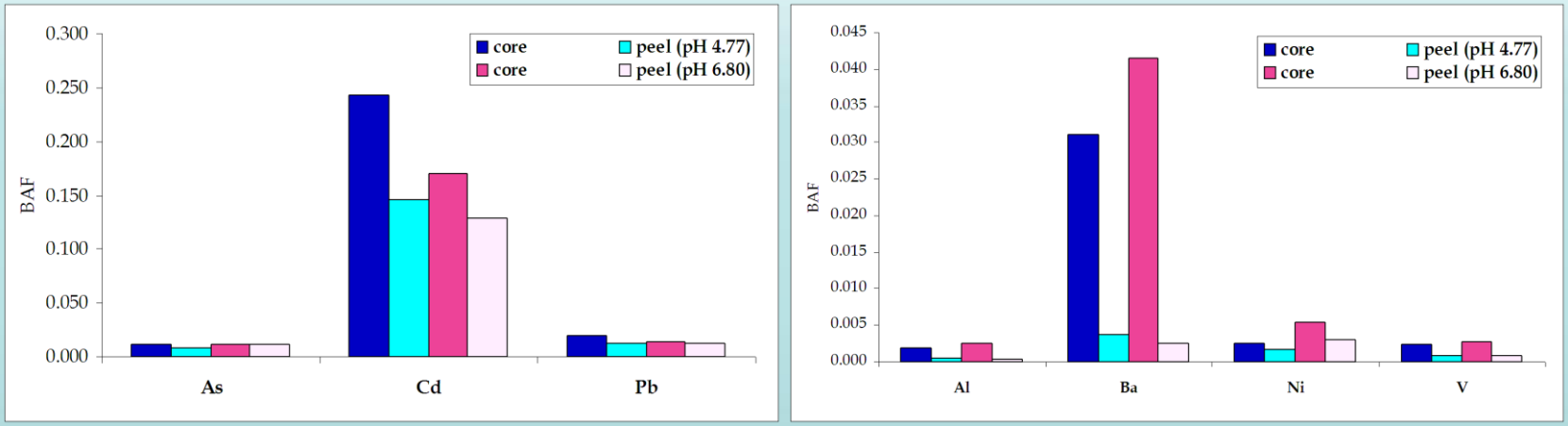


Figure 1. The average values of bioaccumulation factor (BAF) for toxic elements (A) and potentially toxic elements (B) in the peel and the core of tubers grown on different types of soil

Conclusions

- The elevated content of Pb in both the peel and the core of all studied varieties was noticed
- In the core, average BAF values of toxic elements were higher than those of potentially toxic elements
- In the peel of studied varities, average BAF values were in the same order at both soil pH values (Cd>Ba>Pb>As>Ni>Al=V)
- In the core, average BAFs for toxic elements were as follows: Cd>Pb>As, whilst for Al, Ba, Ni and V depended on soil pH

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