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Change of Ba concentration by species and organ in several fruits grown in city centers

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Abstract

Heavy metals are elements that are very harmful to human and environmental health. Heavy metal concentration in the fruits grown in city centers can reach very high levels and consuming these fruits as food causes a direct intake of heavy metals, which these fruits contain, into a human body and can pose a significant health risk. All the compounds of barium (Ba), which is one of the most dangerous heavy metals, are toxic. Thus, determining the Ba concentration in plants, which are grown in areas with high pollution and consumed as food, is very important. In the present study, it was aimed to determine the change of Ba concentration by species and organ in several fruits grown in areas with high traffic density.

Within the scope of this study, Ba concentrations in leaf, branch, bark, seed, and fruits of *Prunus ceresifera, Tilia tomentosa, Prunus avium*, and *Prunus cerasus* were compared. As a result, it was determined that the change of Ba concentrations by species and the change by organ were statistically significant in all organs and in all species, respectively. In general, the lowest values were found in *Prunus cerasus* or *Prunus avium*, whereas the highest values were observed in *Tilia tomentosa*. Considering the organs, the lowest values were found in seed and the highest ones in bark and branch.

Keywords: Barium; Ba; Heavy metal; Fruit

1. Introduction

Nowadays, many of the most important problems throughout the world are those related with the increasing population [1,2]. The growing population also brings numerous problems [3,4]. Food deficiency is one of these problems and it was reported that approx. 830 million people throughout the world have chronic hunger [5]. It is estimated that the food supply, which has doubled in the last 35 years in order to meet the continuously increasing food demand, will double again in the next 15 years. With this increase, the areas allocated to herbal production and animal husbandry will gradually shrink and they will lose their quality [6].

It is tried to solve the food problem by using different methods such as determining the new areas to produce food products and usage areas, which have not been used for food production. Within this context, one of the methods coming to the forefront in recent years is the production of food products in urban areas. It is recommended to grow plants,

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which can be consumed as food, in all the urban regions that are suitable for growing plant [5]. However, previous studies showed that the pollution of air [7-9], water [10,11], and soil [12-14] in urban areas are at very high levels.

Studies revealed that heavy metal pollution, especially the traffic-related pollution, is at a very high level [15-17]. Heavy metals are the elements that can remain in nature without any degradation and do not disappear very easily and some of them can be toxic, carcinogenic, and lethal for humans even at low concentrations [18-20]. Previous studies showed that the heavy metal concentrations of the plants grown in city centers [21, 22]. Hence, determining the heavy metal concentrations in plants, which are grown in city centers and consumed as food, is of critical importance for human health.

Barium (Ba), which is one of the important heavy metals, is an element playing important role in production of many products. Barium, its isotopes, compounds, and alloys are used in production of Zn, Pb, Ag, rubber, ink, brake pad base, dye, rat poison, medication, radio vacuum tube and lamps, machine oil, optic glass, bromide paper, detergents, candle, plastic and textile products, drilling practices, glue, paper coatings, batteries, special glasses, oil color, oil industry, fireworks, and ceramic glazes. However, Ba is one of the most dangerous heavy metals and all of the barium compounds are toxic [23]. Hence, determining the Ba concentration in plants that are consumed as food is very important. In the present study, it was aimed to determine the Ba concentration in several plants, which are grown in high-traffic regions and consumed as food.

2. Material and methods

The present study was carried out on *Prunus ceresifera, Tilia tomentosa, Prunus avium*, and *Prunus cerasus*, which are widely grown in city centers and consumed as food. Within the scope of this study, branches with fruits on them were collected from the individuals, which were grown in high-traffic regions, at the end of June. Then, the branch samples were divided into organs (leaf, branch, bark, seed, and fruit) in the laboratory and then the samples were dried at room temperature for 15 days. Then, the samples were dried in drying oven at 50°C for a week. The prepared samples were ground into powder and the samples weighed at 0.5g were taken into tubes prepared for microwave. Then, the samples added with 10 mL 65% HNO_3 were combusted in a microwave under 280 PSI pressure and at 180ºC for 20 minutes. After the procedures, the tubes were taken out of the microwave and left for cooling. The cooled samples were added with deionized water up to 50 mL. The samples were filtered through filter paper and then read at the appropriate wavelength using an ICP-OES device. This method has been widely used in many studies in determining the heavy metals in plants [24-27].

The data were analyzed using variance analysis in SPSS package program and the factors with a statistically significant difference at the minimum confidence level of 95% were subjected to Duncan's test. The data obtained were interpreted by simplifying and tabularizing.

3. Results

Duncan test results, mean values, error ratio, and F values obtained from the variance analysis of the changes of Ba concentrations in organs by species are presented in Table 1.

Table 1 Change of Ba (ppb) concentration by species

Organ	*Prunus ceresifera*	*Prunus cerasus*	*Prunus avium*	*Tilia tomentosa*	F Value
Leaf	16.64 b	8.41 a	8.02 a	15.66 b	96.354***
Branch	15.57 b	11.41 a	20.15 c	24.67 d	3661.598***
Bark	16.91 c	13.02 b	12.78 a	18.13 d	2730.543***
Seed	3.92 c	2.50 b	2.32 a	8.26 d	3403.911***
Wood	5.14 c	22.80 d	4.10 b	3.42 a	128599***
Fruit	4.67 b	3.00 a	4.58 b	-	980.259***

***; p<0,001

As seen in Table 1, the change of Ba concentration by species was statistically significant for all organs (p<0.001). Given the mean values and Duncan's test results, it can be seen that the data gathered in two groups for leaf and fruit, whereas

they constitute a separate group for the other organs. The lowest value in wood was found in *Tilia tomentosa*, whereas the lowest values in other organs were found in *Prunus cerasus* or *Prunus avium*. The highest values in organs other than wood were generally found in *Tilia tomentosa*.

Duncan test results, mean values, error ratio, and F values obtained from the variance analysis of the changes of Ba concentrations in species by organs are presented in Table 2.

Table 2 Change of Ba (ppb) concentrations by organs

Organ	***Prunus ceresifera***	***Prunus cerasus***	***Prunus avium***	***Tilia tomentosa***
Leaf	16.64 e	8.41 c	8.02 d	15.66 c
Branch	15.57 d	11.41 d	20.15 f	24.67 e
Bark	16.91 f	13.02 e	12.78 e	18.13 d
Seed	3.92 a	2.50 a	2.32 a	8.26 b
Wood	5.14 c	22.80 f	4.10 b	3.42 a
Fruit	4.67 b	3.00 b	4.58 c	-
F Value	10141.309***	43402.503***	2026.897***	450.298***

***; p<0,001

Examining Table 2, it can be seen that the change of Ba concentration by organs was statistically significant for all the species examined in the present study ($p<0.001$). Given the mean values and Duncan's test results, the lowest value of *Tilia tomentosa* was found in wood, whereas the lowest values were found in seed in all other species. The highest values were found in bark in *Prunus ceresifera*, in wood in *Prunus cerasus*, and in branch in *Prunus avium* and *Tilia tomentosa*.

4. Discussion

Within the scope of this study, it was determined that the change of Ba concentration by species was statistically significant in all the organs. In many studies carried out before, it was revealed that the concentration changes of many elements by species were statistically significant [28,29]. and the most important factor influencing the element concentration in plants by organ was the plant species [30].

The accumulation of elements in organs within the plant organism is shaped by the mutual interaction between many factors [31]. One of the most important factors is the habitus and development of plant [32-34]. Plant development is affected by the mutual interaction between genetic structure [35-38] and environmental conditions [39-42]. Since the genetic structure of plants significantly varies between the species, it is usual for the accumulation of heavy metal in the same organs of different species grown in the same environment to be different and it was reported in many studies [15, 16].

Another factor influencing the heavy metal accumulation in plants is the habitus of plant [27]. Besides the plant's genetic structure, plant habitus is affected by the climatic factors such as temperature, precipitation, and humidity [43-47] and edaphic factors such as soil texture, structure, nutrient content, and pH [48-52]. Hence, habitus and genetic structure of plants are affected by many factors that are in mutual interaction with each other [53]. Thus, it is usual for the heavy metal accumulation in the same organs of different species to be at different levels.

As a result of this study, it was determined that the change of Ba concentration by organs was statistically significant for all species; in general, the lowest values were found in seeds and the highest ones in barks and branches. It was reported in many studies that the heavy metal accumulations in different organs were at different levels. The accumulation of heavy metals in organs is influenced by the mutual interaction between many factors and the organ structure is among the most important factors [24,25].

Heavy metals can enter the plant body through soil or air. Especially in the intakes from air, the duration of interaction with air is very important. The seeds, in which the lowest concentrations were found in the present study, are within the fruit and they have no contact with air. However, bark and wood are always in contact with air. Furthermore, in the regions with high pollution levels, the heavy metals in the air adhere to the particles and contaminate them with heavy

metal. Because of the rough structure of bark, the particles contaminated with heavy metal can easily retain on the bark surface and the heavy metal concentration in bark increases [21]. Especially in previous studies comparing the heavy metal concentrations in outer bark and wood, it was determined that the heavy metal concentrations in outer bark were much higher than in the wood [26,27].

Heavy metal accumulation in various organs of plants is closely related with the plant metabolism. For this reason, various factors significantly affecting the plant metabolism such as stress level [54-56], hormone treatments [57-59], and cultivation practices such as pruning and shading [60] also affect the heavy metal accumulation within the plants. Moreover, the environment and soil structure changing with the human effect in urban areas and also the micro-ecological factors emerging as a result of human effects [61-65] can influence the change of elements in plant organs.

As a result of this study, it was determined that Ba concentration can be at very high levels in fruits of several species grown in urban areas. Similar results were reported in some of the studies carried out on this subject. For instance, in a study carried out on plum, the highest Ni concentration was obtained from the fruits [5]. Besides the toxic effects of metals on plants, the food security also drew interest throughout the world in recent years. Many studies have been carried out on the health risks related with the consumption of contaminated vegetables in the last 20-30 years and it was reported that heavy metal contents in the edible plants grown in polluted regions can cause severe public health problems by exceeding the maximum acceptable limit [5,66]. Hence, consumption of various organs of plants, which are grown in high-traffic regions, as food may cause severe health problems.

5. Suggestions

Within the scope of this study, the changes of Ba, which is one of the heavy metals that are very toxic and can pose significant risk for human health despite they are widely used, in the organs of four plant species widely grown in city centers were examined. Heavy metals are very dangerous elements for human health and some of them may have a toxic effect even at very low concentrations. Hence, determining the concentrations of these elements in organs, which are consumed as food and thus directly taken into the human body, is very important for human health.

Consumption of foods contaminated by heavy metals is very dangerous for human health. For this reason, consumption of plants grown in highly polluted areas such as mining facilities, industrial facilities, and high traffic density is very risky for health and citizens and authorized bodies should be informed about the risks of consuming these plants as food.

Within the scope of this study, four plant species were examined. However, many vegetables and fruits are grown in regions with high levels of heavy metal pollution and they are sometimes consumed as food. Furthermore, agricultural activities are conducted in large areas nearby several industrial facilities. It is very important to examine these plants and to reveal the potential threats in further studies. Hence, it is recommended to carry out similar studies by increasing the diversity.

6. Conclusion

Air pollution is one of the most important problems threatening the organic life and ecosystem throughout the world. Among the components of air pollution, the most important ones are the heavy metals that can be toxic and carcinogenic even at low concentrations and even the nutrient elements can be harmful when at high concentrations. However, edible landscaping poses a considerable risk. Heavy metal accumulation in plants grown in urban centers can reach to high levels, and consuming these plants will allow these heavy metals a direct access into the human body and wreak havoc to the public health. But since this subject has not been sufficiently studied yet, the extent of such a risk is not accurately determined yet. This study aims to determine the changes of Ba concentrations in the leaves, branches, barks, seeds, fruits and woods of *Prunus ceresifera, Tilia tomentosa, Prunus avium*, and *Prunus cerasus*. The results showed that the concentrations of Ba element increased in many organs and that the heavy metal concentrations in fruits could be very high. This situation indicates that fruit and vegetables grown in urban centers, where heavy metal pollution may be high, can be harmful to the public health if consumed as crops. Although a large number of plant species have been the subject of studies to date, these studies are not at a sufficient level yet. Therefore, it can be recommended to continue and diversify similar studies.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they no conflict of interest. The none of the authors have any competing interests in the manuscript.

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