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Change of Cu Concentration in Some Edible Landscape Plants Grown in Ankara City Center

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ABSTRACT

New solutions are constantly developed to meet the need for food that is increasing due to the increase in the world population. A new proposal has been made recently: Some plants that are consumed as food should be used in landscaping works, thus both carrying out landscaping works and using plants grown in such areas as food at the same time. Plants used for this purpose have started to be called "edible landscape". However, there is a great risk in this application. The areas where these plants are grown can be areas with high levels of heavy metal pollution and heavy metals do not decompose in nature or disappear easily and most of them are very harmful to human health.

In addition to the high level of heavy metal accumulation in plants growing in areas where heavy metal pollution is high, consumption of these plants as food poses a great risk to human health. However, the extent of the danger has not been determined yet due to the insufficient number of studies on this subject.

This study aims to determine the variation of copper (Cu) concentration by plant species and organs in some plants grown in traffic-intensive areas and used as edible landscape plants.

Anahtar Kelimeler:
Yenilebilir Peyzaj,
Ağır Metal,
Cu,
Bakır,
Ankara.

ÖZ

Artan dünya nüfusuna bağlı olarak artan gıda ihtiyacının karşılanabilmesi amacıyla sürekli yeni çözüm önerileri geliştirilmeye çalışılmaktadır. Son dönemde bu önerilere bir yenisi eklenmiş, gıda olarak tüketilen bazı bitkilerin peyzaj çalışmalarında kullanılması ve böylece hem peyzaj çalışmalarının yapılması hem de bu alanlarda yetişen bitkilerin gıda amaçlı olarak kullanılması gündeme gelmiştir. Bu amaçla kullanılan bitkiler "yenilebilir peyzaj" adı ile anılmaya başlamıştır. Ancak, bu uygulamada büyük bir risk bulunmaktadır. Bu bitkilerin yetiştirildiği alanlar ağır metal kirliliğinin yüksek düzeyde olduğu alanlar olabilir ve ağır metaller doğada bozulmaz, kolay kolay yok olmazlar ve bir çoğu insan sağlığı açısından son derece zararlıdırlar.

Ağır metal kirliliğinin yüksek düzeyde olduğu alanlarda yetişen bitkilerde ağır metal birikiminin yüksek düzeyde olabilmesinin yanı sıra, bu bitkilerin gıda olarak tüketilmesi, insan sağlığı açısından büyük bir risk oluşturmaktadır. Ancak, bu konuda yapılmış çalışma sayısı yeterli düzeyde olmadığından tehlikenin boyutu belirlenebilmiş değildir.

Bu çalışmada trafiğin yoğun olduğu alanlarda yetiştirilen ve yenilebilir peyzaj bitkisi olarak kullanılan bazı bitkilerde, bakır (Cu) konsantrasyonunun bitki türü ve organı bazında değişiminin belirlenmesi amaçlanmaktadır.

1. Introduction

Today, the most important problems in the world are population growth and problems related to population growth in general. While the world population was only 717 million in 1750, it is estimated that it will exceed 8 billion in 2025 [1]. Population growth and concentration of population in city centers bring along many problems, especially environmental pollution [2-6]. One of the problems associated with population growth is lack of food. It is estimated that approximately 830 million people in the world suffer from chronic hunger and this problem will grow even more [7].

Solutions are sought to the food problem such as increasing production per unit area, determining new areas to produce food products, and using resources that have not been used for food so far as sources of food. In this context, one of the solutions proposed recently is producing food in urban areas. It is recommended to grow plants that can be consumed as food in parks, road refuges, rooftops, i.e. all areas where plants can be grown in cities. This is called "edible landscape" [8].

However, this practice has the potential to reflect the effects of environmental pollution caused by the rapid growth of the world's population and its concentration in city centers. Usually, city centers are areas where there is a high probability of presence of pollution factors due to the high population and human activities. A lot of pollutants caused by exhaust gases, car wheels, vehicles and vehicle wear appear in these areas. Among these, especially heavy metals are of great importance. That is because heavy metals neither decompose in nature nor disappear. They also tend to bioaccumulate [9-12].

Therefore, plants grown and consumed as food in areas where heavy metal pollution is high can lead to significant health problems. However, the number of studies on this subject is not sufficient. This study aims to determine the variation of Cu concentration by plant species and organs in some plants that are grown in city centers and consumed as food.

2. Material and Method

The study was conducted on samples collected from plants grown in Ankara city center. Samples taken from apple, cherry, almond and mulberry trees consumed as food in almost all parts of Turkey were used in this study. Following the maturation of the fruits, branch samples including fruits and leaves were taken from the said samples, the samples were brought to the laboratory and separated as leaf, fruit, branch, wood and bark.

The collected samples were first kept in the laboratory for two months to become dry and then dried for 48 hours at 40 °C in an oven. 2 gr dried samples were soaked in 50 ml NO_3 concentration and kept at room temperature for 1 day. Then 50 ml ultra pure water was added to the samples which were kept in the heater for 1 hour at 80 °C. The samples were prepared by filtering them with a 0.45-micron porous filter paper. The samples were sent to Kastamonu University Central Research Laboratory Application and Research Center after the preliminary preparations and copper (Cu) concentrations were determined with ICP analysis. The results were evaluated and interpreted through variance analysis and Duncan test by means of the SPSS 17.0 package program.

3. Findings

Table 1 shows the results of the variance analysis performed to determine the variation of Cu concentration by species and organs.

Table 1. Mean Values by Species and Organs and Duncan Test Results

	Apple	**Cherry**	**Almond**	**Berry**
Leaf	15015 ^{d}	12707 ^{d}	14594 ^{d}	14093 ^{e}
Branch	17927 ^{e}	4577 ^{a}	29594 ^{e}	6683 ^{b}
Bark	13338 ^{c}	9470 ^{b}	7422 ^{a}	8129 ^{c}
Wood	4317 ^{a}	25035 ^{e}	8067 ^{b}	5177 ^{a}
Fruit	7126 ^{b}	10390 ^{c}	8380 ^{c}	9248 ^{d}
F Value	26940***	27663***	28756***	14766***

The results in the table reveal that the Cu concentration variation by organs in all fruits included in the study was statistically significant ($p<0.001$). The mean values indicate that the highest Cu concentration was in the branches and leaves of the apples while the lowest Cu concentration was observed in the wood and fruit parts.

The lowest concentrations were obtained in the branches and barks of the cherries while the highest concentrations were obtained in the wood and leaf parts. There is a difference of more than five times between the Cu concentration in the branches (4577 ppb) and the woods (25035 ppb) of the cherries. The lowest concentrations were observed in the barks, woods and fruits of the almonds while it stands out that the values are very close. The Cu concentration in the branches where the highest value was obtained is more than 3 times these values.

The results observed in the mulberries are quite remarkable. The highest value in the mulberries was obtained in the leaves and the second highest value was obtained in the fruits. The lowest value in the mulberries was obtained in the woods. Graphic 1 shows the variations in the Cu concentration by species and organs.

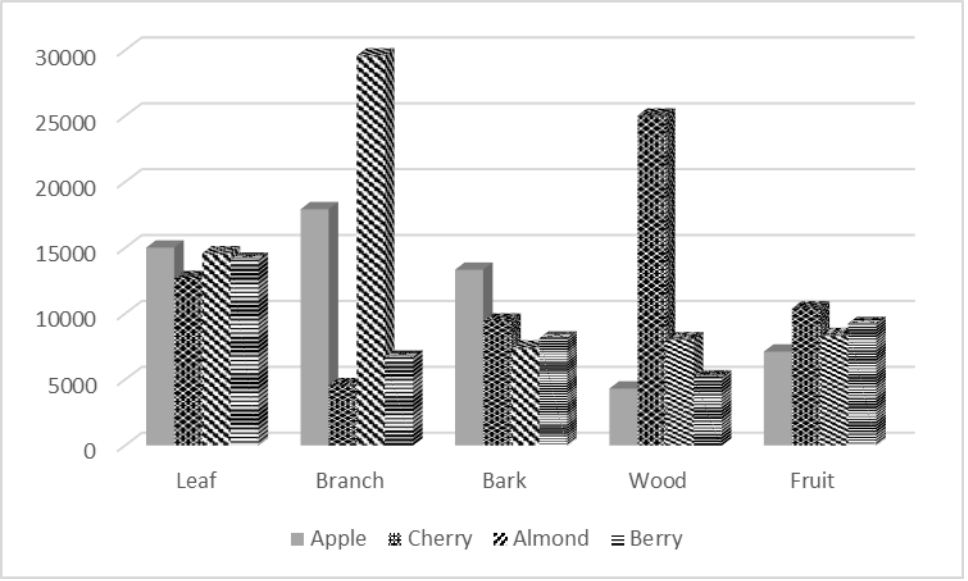

Figure 1. Variations in the Cu concentration by species and organs

4. Result and Discussion

The data obtained from the study revealed highly dreadful results. Heavy metal concentrations determined especially in leaves have been examined and it has been stated that these values are quite high in areas where traffic is intense in studies conducted so far. The results of this study show that the concentrations determined in many species of fruit are quite high.

Cu is a trace element that is essential for human and animal metabolism. Cu is an indispensable part of red blood cells and many oxidation and reduction processes in animals and humans. However, Cu is quite harmful when taken too much. The main symptoms of acute Cu poisoning are abdominal pain, nausea, vomiting, and diarrhea [13]. Low-level copper ions can cause hepatic cirrhosis, Wilson's disease, systematic rheumatism diseases, and kidney diseases while high-level copper ions can cause leukemia [14]. Therefore, it is very dangerous to consume plants grown in regions with Cu pollution as food.

Cu is an element that has been the subject of many studies so far. Mossi [15] found the lowest values in areas without traffic in unwashed Bo leaves (371.3 ppb) while the highest values were in washed leaves (19482 ppb) of Mh. In traffic-intensive areas, the lowest values were obtained in washed Ej leaves (357.4 ppb) while the highest values were obtained in washed Bt branches (11917.2 ppb). Türkyılmaz et al. [16] state that Cu concentration varies depending

on traffic density, and the Cu concentration that is 69,615 ppb in non-traffic areas increases to 71,096 ppb in less traffic-intensive areas and 110,441 ppb in traffic-intensive areas.

Suzuki et al. [17], Demirayak et al. [18], Li et al. [19], and Sawidis et al. [20], determined the variations of Cu concentration in *Rhododendron pulchrum*, *M. grandiflora*, *Sophora japonica*, and *Platanus orientalis* respectively. When the values obtained within the scope of the study were examined, it was determined that there were significant differences in the same organs on the basis of species. It has been determined in studies conducted so far that the most significant differences in the variation of heavy metal concentrations usually occur on the basis of species. It has been determined in a lot of studies that different heavy metals are held more densely by different plants [21-24].

Another result obtained in the study was that Cu concentration in organs varied significantly. There are also numerous studies on how it is kept more densely in different organs of same plants [15,25]. Studies have even shown that there are differences among same plants' organs with varying ages [26-28].

Heavy metal accumulation potentials of plants are closely related to anatomical structures and therefore species of plants. Studies conducted so far have shown that diffusion of heavy metals in the atmosphere and their entry into plant structures are a very complex mechanism [29-31]. The heavy metal accumulation potential of plants growing in the same environment varies depending on factors such as organelle structure, physical and chemical properties of metals, organelle morphology, plant habitus, time of exposure to heavy metal and amount of particulate matter in addition to plant species and plant organ [30-32].

Besides these factors, it is also stated that heavy metal concentrations may be at different levels in subspecies, forms, varieties and origins of the plant [33-36]. Studies show that many phenological, morphological and anatomical structures change depending on these characteristics. It is inevitable that plant metabolism will also change, and this will affect heavy metal absorption [15]. It is stated that many factors affecting the plant metabolism such as the stress level of the plant [37-39], environmental conditions such as climate [40-42], soil [43-44] and genetic structure [45-46] can affect heavy metal absorption and therefore heavy metal concentration in plants.

Besides the toxic effects of metals on plants, food safety has attracted a lot of attention worldwide in recent years. Many studies have been conducted recently on the health risks associated with ingestion of contaminated vegetables. It is reported that metal content in edible parts of plants can cause serious public health conditions by exceeding the maximum permitted limits (MPL). This is because some heavy metals can be quite harmful to humans even at low exposure levels. This is caused by the fact that heavy metals do not have an effective tolerance or excretion mechanism. Consumption of plants contaminated with heavy metals is specified to be highly or slightly harmful to human health [8,47]

5. Suggestion

The variations of the Cu element, which is a heavy metal highly important for human health, in five organs of four plant species were examined in this study. Heavy metals are extremely hazardous to human health. Some of them are particularly toxic, even at low concentrations. Therefore, it is very important to determine the concentrations of these elements in organelles which are consumed as food and thus can be taken directly into the human body.

As a result of the study, Cu concentrations determined in the fruits of some species, especially Mulberry, were found to be quite high. Consumption of food contaminated with heavy metals is extremely dangerous for human health. Therefore, consumption of plants grown in city centers with high levels of traffic and pollution is extremely risky for health and authorities and citizens should be informed about the risks of consuming these plants as food.

Four plant species were evaluated within the scope of this study. However, a large number of vegetables and fruits are grown in city centers and areas where industrial pollution is high, and they can be consumed as food. This situation can lead to very serious health problems. On the other hand, the number of studies on this subject is not sufficient. Therefore, it is recommended that studies related to this subject be continued by increasing and diversifying them.

Competing Interest / Conflict of Interest

"The authors declare that they have no conflict of interests"

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