# Comparison of Element Contents in Eggplants Grown under Organic and Conventional Farming Regimes for Human Nutrition and Health

# Organik ve Geleneksel Tarım Rejimine Göre Yetiştirilmiş Patlıcan Numunelerinin Elementer İçeriklerinin İnsan Beslenmesi ve Sağlığı Açısından Karşılaştırılması

Research Article

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## ABSTRACT

A comparative study on elemental composition of various eggplant (*Solanum melongena* L.) samples (n=10) were conducted by using a sensitive method, wavelength dispersive X-ray fluorescence (WDXRF). 28 elements were determined in eggplant samples grown under organic and conventional farming regimes. It was observed that the concentration of Ca, Fe, Mn, P, Mg, Zn, Cl, Na and Cu elements were higher in the eggplant samples grown under organic farming regime. Likewise, Al, Cr, Rb, Br, Si and Sr levels were found in higher levels in the samples grown under conventional farming regime. Our findings clearly revealed that organic eggplants are likely to have higher nutritional mineral content. And the eggplant samples grown under conventional farming regime could contain harmful metals like Al, Cr and Sr that might damage the various systems and/or organs of humans and animals.

**Key Words**
Elemental analysis, Eggplant, Organic farming, Conventional farming

## ÖZET

Bu çalışmada, organik ve geleneksel tarım rejimine göre yetiştirilmiş patlıcan numunelerinin (n=10) elementel içeriklerini incelemek için hassas bir metot olan dalga boyu ayırımlı x-ray spektroskopisi (WDXRF) kullanılarak karşılaştırmalı bir inceleme yapılmıştır. Organik ve geleneksel tarım rejimine göre yetiştirilmiş patlıcan numunelerinde 28 element tespit edilmiştir. Ca, Fe, Mn, P, Mg, Zn, Cl, Na ve Cu elementlerinin organik tarım rejimine göre yetiştirilmiş patlıcan numunelerinde daha yüksek olduğu gözlemlenmiştir. Ayrıca Al, Cr, Rb, Br, Si ve Sr elementleri ise geleneksel tarım rejimine göre yetiştirilmiş olan patlıcan numunelerinde daha yüksek oranda bulunmuştur. Bulgularımız organik tarım rejimine göre yetiştirilmiş patlıcanların daha yüksek besin değerine sahip olduklarını göstermektedir. Ayrıca geleneksel tarım rejimine göre yetiştirilmiş olan patlıcan numuneleri insan ve hayvan sağlığı için zararlı olabilecek Al, Cr ve Sr gibi metaller içermektedir.

**Anahtar kelimeler**
Elemental analiz, Patlıcan, Organik tarım, Geleneksel tarım.

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## INTRODUCTION

The intensification and expansion of modern agriculture is amongst the greatest current threats to worldwide biodiversity [1]. It is suggested that organic farming usually increases species richness, having on average 30% higher species richness than conventional farming systems. And the efficiency of agricultural subsidy programs for preserving biodiversity and improving the environment has been questioned in recent years. Organic farming operates without pesticides, herbicides and inorganic fertilizers, and usually with a more diverse crop rotation [2]. The prevalence of birth defects is increased in the regions that pesticides, fungicides, and herbicides are extensively used [3]. The pesticides used heavily in industrial agriculture are also associated with elevated cancer risks for workers and consumers and are coming under greater scrutiny for their links to endocrine disruption and reproductive dysfunction [4]. Thereby organic farming is considered as very important for sustainable agriculture, food quality, soil and environmental health. It was observed that conventional farming reduces organic soil content and decreases biological activity in soil; on the contrary, organic farming increases microbiological activity in soil [5]. Soil quality has been investigated chemically and biologically in soils receiving long-term conventional and organic farming activities and as a result, soils receiving organic farming were observed to have much better nutritional status [6]. At this point, consumers are looking for variety in their diets and are aware of the health benefits of fruits and vegetables. Of special interest are food sources rich in elemental nutrients. In fact, the intakes of these nutrient elements are associated with reduced risk of cardiovascular disease, stroke, and cancers of the mouth, pharynx, esophagus, lungs, stomach, and colon [7]. On the contrary, ingestion of metals especially heavy metals through fruits, vegetables and legumes can cause accumulation in organisms, producing serious health hazards such as injury to the kidney, symptoms of chronic toxicity, renal failure and liver damage [8].

Eggplant is well regarded among the vegetables increasingly sought by consumers, whose demand for food with potential health promoting effects, such as disease prevention, is escalating. It is reported that eggplants associate good nutritional value and therapeutic properties. The rising consumption of eggplants, both in natura and as dry extract capsules, offers a positive scenario for the expansion of the crop [9]. To our best knowledge, there is no report on the element contents of eggplants which were grown under organic and conventional farming regimes in the literature. In the present study, the Al, Ca, Cu, Fe, Mn, Ni, Ti, Zr, P, S, Sr, Cd, Pb, As, Bi, Hg, Zn, Cl, Sn, K, Mg, Na, Ba, Rb, Si, Br, Cr and La element contents of the eggplants grown under organic and conventional farming regimes are determined by Wavelength-Dispersive X-Ray Fluorescence Spectrometry (WDXRF) method for the first time since the advantages of X-ray fluorescence spectrometry are increasingly relevant in applications to the analysis of clinical and biological materials as demand increases for non-destructive and/or spatially resolved determinations [10].

## MATERIALS AND METHODS

### WDXRF system

WDXRF system consists of detector, amplifier, discriminator, counter and printer units. The detector converts the falling X-rays to measurable pulse. X-ray detector used in the following three spectrometers: proportional, gas flow and scintillation detectors. Discriminator filters pulses that coming from detector, and allows them to pass through of certain height pulses. These pulses are saved in a recorder. If required, the number of pulses (of violence) against the wavelength and the angle of reflection spectrum is obtained by drawing the figure. The Figure 1 shows the used WDXRF system and its units.

### The Use of the WDXRF System in Elemental Analysis of Plant Samples

This study used the WDXRF system. In this study an agate mortar; a digital scale (Ohaus TS 120, USA); a hydraulic press (Spex Pmax=3.5×107 kg/m2); a WDXRF spectrometer (ZSX-100e with Rhodium target X-ray controlled by a software ZSX computer) are used. Both eggplantsamples were purchased from a local certificated company from Aydın City, Turkey. They were picked up from closer regions and in the same harvest period. Only the applied farming regimes

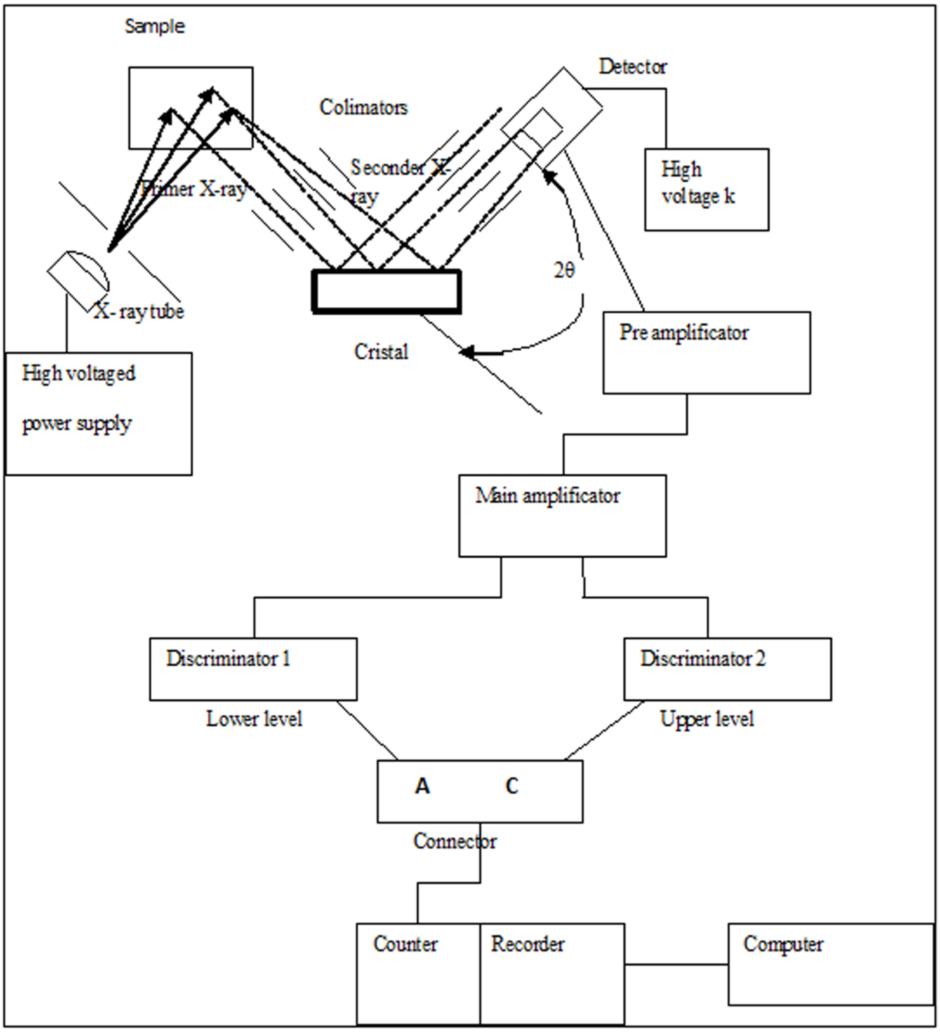


**Figure 1.** The used WDXRF system and its units

were different. Under organic farminig regime area, chemical inputs, synthetic chemical pesticides, growth regulators, synthetically compounded fertilizers, hormones, preservatives, colorings or artificial additives were not used and processing for at least seven years. In contrast to these inputs were used in conventional farming regime.

## Sample Preparation

This study used the WDXRF system. In this study a digital scale (Ohaus TS 120, USA); a WDXRF spectrometer (ZSX-100e with Rhodium target X –ray controlled by a software ZSX computer); (SPEX, Pmax = 25 tons/cm$^2$); a mortar agate and an oven are used. We have prepared our samples in laboratory conditions. All samples were prepared under controlled conditions, including the grinding method, grinding time, pelletized pressure and time. The eggplant samples were ground in a mortar agate, since the vacuum condition of the sample chamber of the system was affected by humidity; they were dried in an oven at 60°C for 35 minutes. The amount of dry matter can decrease as a result of annealing process. Annealing time was short and annealing temperature was low. Because of these reasons a serious reduction in the quantity and content was not observed. After, ground samples were pressed into uniform pellets of 20 mm diameter using a hydraulic press machine (SPEX, Pmax = 25 tons/cm$^2$) with a standing time of 60 s. Since pellets were easily formed, it was not participated any matter (eg. cellulose microcrystalline) in sample powders as a binder. 10 organic and 10 conventional samples of 770 mg were analyzed on a sequential ZSX 100e WDXRF spectrometer

**Table 1.** Concentrations and peak intensities of 28 elements for eggplant samples

| ELEMENTS | CONCENTRATION (%) | | PEAK INTENSITY (count per second) | | DETECTION LIMITS (ppm) | |
|---|---|---|---|---|---|---|
| | Organic | Conventional | Organic | Conventional | Organic | Conventional |
| Al | 0.0025 | 0.0106# | 0.1821 | 0.8041# | 0.0003 | 0.0003 |
| Ca | 0.3939 | 0.1331 | 80.8443 | 27.4654# | 0.0003 | 0.0003 |
| Cu | 0.0015 | 0.0008# | 1.1727 | 0.7411# | 0.0002 | 0.0002 |
| Fe | 0.0395 | 0.0149# | 2.4325 | 0.9997# | 0.0016 | 0.0016 |
| Mn | 0.0028 | 0.0013# | 0.5748 | 0.4172# | 0.0002 | 0.0002 |
| Ni | 0.0007 | 0.0007 | 0.4503 | 0.4500 | 0.0001 | 0.0001 |
| Ti | ND | ND | ND | ND | ND | ND |
| Zr | ND | ND | ND | ND | ND | ND |
| P | 0.4579 | 0.3728# | 106.9297 | 89.4592# | 0.0003 | 0.0003 |
| S | 0.2059 | 0.2004 | 43.7478 | 35.8622 | 0.0002 | 0.0002 |
| Sr | 0.0002 | 0.0010# | 0.9244 | 3.8998# | 0.0001 | 0.0001 |
| Cd | ND | ND | ND | ND | ND | ND |
| Pb | ND | ND | ND | ND | ND | ND |
| As | ND | ND | ND | ND | ND | ND |
| Bi | ND | ND | ND | ND | ND | ND |
| Hg | ND | ND | ND | ND | ND | ND |
| Zn | 0.0136 | 0.0080# | 14.4110 | 9.1917# | 0.0001 | 0.0001 |
| Cl | 1.2651 | 0.8017# | 43.9662# | 28.2937 | 0.0018 | 0.0021 |
| Sn | ND | ND | ND | ND | ND | ND |
| K | 3.8113 | 3.7388 | 1033.8926 | 967.1503 | 0.0007 | 0.0008 |
| Mg | 0.3804 | 0.2961# | 4.8750 | 3.7432# | 0.0010 | 0.0011 |
| Na | 0.0398 | 0.0139# | 0.1598 | 0.0638# | 0.0016 | 0.0016 |
| Ba | 0.0043 | 0.0046 | 1.1600 | 1.1992 | 0.0001 | 0.0001 |
| Rb | 0.0004 | 0.0007# | 1.8410 | 3.0327# | 0.0001 | 0.0001 |
| Si | 0.0072 | 0.0255# | 0.5692 | 2.0621# | 0.0003 | 0.0003 |
| Br | 0.0005 | 0.0024# | 2.8128 | 6.3603 | 0.0001 | 0.0001 |
| Cr | 0.0026 | 0.0057# | 0.3563 | 0.7913# | 0.0003 | 0.0004 |
| La | ND | ND | ND | ND | ND | ND |

*Results of the analysis were given as average of samples (n=10) from each groups; ND: Not detected; # symbol means statistically different from organic farming regime at the level of 0.01 for the same element*

equipped with a Rh X-ray tube. Matrix-correction process is made automatically by this system. The measurement room temperature is on the average 20-21 degrees and relatively dry environment. The elementary differences were investigated between the eggplants grown under organic and conventional farming regimes. The obtained spectra were drawn using Origin 7.0 software. 10 samples from each of the two groups were prepared for good counting statistics.

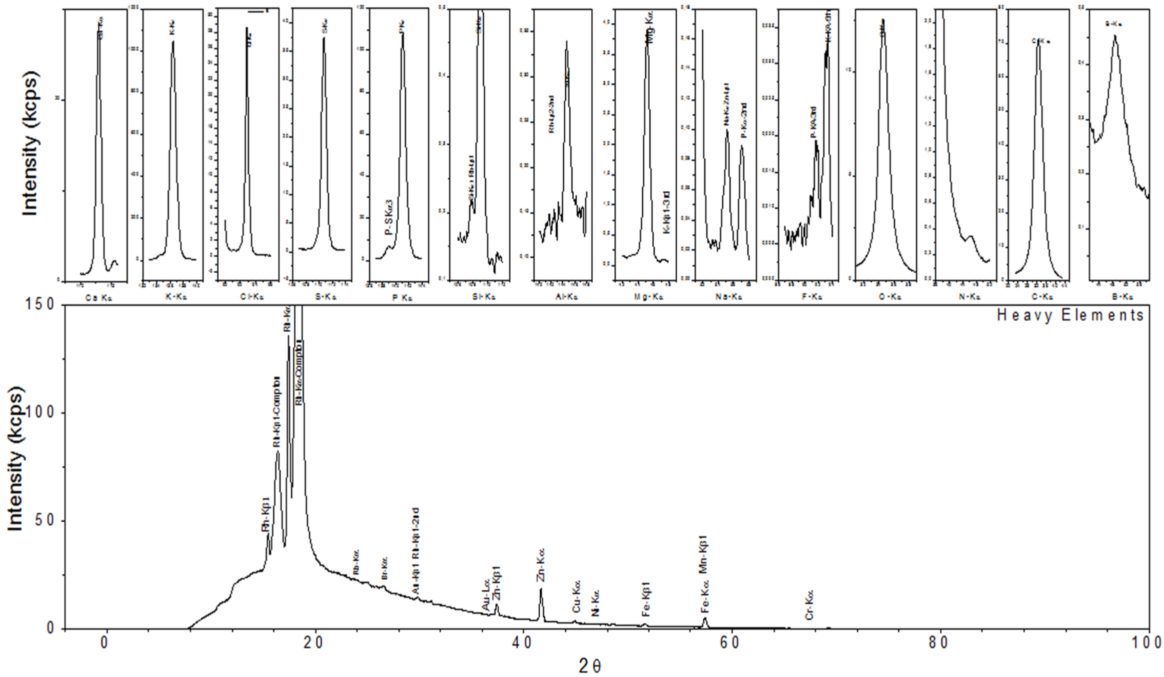


**Figure 2.** The intensities of some elements versus diffraction angle obtained from the eggplants sample grown under organic farming regime.

### Statistics

The obtained results were statistically examined using SPSS statistical software and t-test. By this statistical examination, it was investigated whether the differences observed between the element concentration and peak intensity in each group were statistically significant.

## RESULTS AND DISCUSSION

Concentrations and peak intensities of Al, Ca, Cu, Fe, Mn, Ni, Ti, Zr, P, S, Sr, Cd, Pb, As, Bi, Hg, Zn, Cl, Sn, K, Mg, Na, Ba, Rb, Si, Br, Cr and La were measured for each sample. The results of the measurements are given in Table. The intensities are plotted as the function of diffraction angle for some elements in the organic samples (Figure 2). The statistical analysis of our findings revealed that Ca, Fe, Mn, P, Mg, Zn, Cl, Na and Cu element contents were higher in the eggplantsamples grown under organic farming regime. And the contents of Al, Cr, Rb, Br, Si and Sr were found at lower concentrations in the eggplant samples grown under organic farming regime. However, the amounts of some elements (Ni, S, K and Ba) did not show any alterations as compared to each other. On the other hand, As, Bi, Cd, Hg, Pb, Ti, Sn, La and Zr were not detected in both samples.

Elemental analysis of plant samples is essential in monitoring plants' development, determine their nutritional value and nutrient insufficiency, and to check for diseases.

In the present study we determined the element contents of the eggplant samples by WDXRF method since analytical performance of the method previously proposed proved to be effective and robust [11]. There are very limited number of studies in which elemental analyses were carried out on agricultural products. The mineral contents of several products like mulberry [12], tea [13] and tobacco [14] but not eggplants were examined by using WDXRF system. Moreover, the comparisons of chickpea elemental contents grown under organic and conventional farming regimes have not been performed yet.

The WDXRF analysis of this study indicated that Ca, Fe, Mn, P, Mg, Zn, Cl, Na and Cu element contents were higher in the eggplant samples grown under organic farming regime. This is consistent with analyses by [15] who also found that organic crops contained significantly more Fe, Mg and P than conventional crops. Again, [16] compared the Ca and Mg contents of onions (Allium cepa) from conventionally and organically cultivated sites and determined significantly different levels between the organically and conventionally grown onions. [17] indicated that the concentration of essential elements in foodstuffs of one region might vary from the other since food supplies are affected by various agricultural practices, type of soil, type of fertilizer and chemicals used type of pesticides and herbicides sprayed. Therefore, the differences of the applied practices could cause the determined increases of major elements (such as Na, Mg, P, Cl and Ca) and some minor elements (Mn, Fe and Zn) in the eggplants frown under organic farming regime.

The present findings also indicated that the contents of Al, Cr, Rb, Br, Si and Sr were found at higher concentrations (but in the level of permitted) in the eggplant samples grown under conventional farming regime. As a matter of fact, food due to the introduction of mechanized farming, ever increasing use of chemicals, sprays, preservatives, food processing, canning etc., are likely to be further contaminated with the toxic elements [18]. In accordance with our finding, [19] reported that chemicals used in the traditional and technological coffee farms might cause increases of toxic metals concentrations in the crops and crop soil, were taken up by plants, and passed on in the food chain. Previous reports indicated that Al was accepted as toxic to plants, fish, and higher animals [20-22]. reported that Cr and Sr were toxic metals to living organisms. In general Br was reported to be non toxic and normally the levels of Br in soils were very low so that Br toxicity did not occur naturally [23]. In opposition to, Br was reported to be toxic and caused burns and blisters on the skin [24]. On the other hand, Si protected plants from multiple abiotic and biotic stresses [25]. And, physiological experiments indicated exchangeability of Rb for potassium in blood, plasma, and tissue. Medical and toxicological literature generally indicated a very low degree of Rb toxicity [26]. Again, Rb did not seem to produce any severe side effects in the dose administered, but it has a long biological half-life and caution was still required [27].

## CONCLUSION

The determined weight percent concentrations of Ca, Fe, Mn, P, Mg, Zn, Cl, Na and Cu elements (which are also essential for human health) were higher, and the amounts of toxic metals (Al, Cr and Sr) were lower in the eggplant samples grown under organic farming regime. Thus, we could suggest that this farming regime is crucial for nutritional value of eggplant. In addition, as seen from the results obtained from present study, the usage of WDXRF analysis is an efficient and useful technique for food science which deserves attention for interdisciplinary studies.

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