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COMPARISON OF ELEMENT CONTENTS IN HARICOT BEANS GROWN UNDER ORGANIC AND CONVENTIONAL FARMING REGIMES FOR HUMAN NUTRITION AND HEALTH

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Abstract. Today, sustainable agriculture and food content is a very important issue in the world. Organic farming practices are very important in this respect.This study was made to observe the impact of organic agricultural regime on the products in case of haricot beans (*Phaseolus vulgaris* L.). A comparative study on elemental composition of various haricot beans (*Phaseolus vulgaris* L.) samples was conducted by using a sensitive method, wavelength dispersive X-ray fluorescence (WDXRF). 26 elements such as Al, Ca, Cu, Fe, As, Hg, Pb, Cd, Bi, Mn, Ni, P, S, Sr, Zn, Zr, La, Ti, Sn, Cl, K, Mg, Na, Ba, Rb and Si were determined in haricot beans samples (n=10) grown under organic and conventional farming regimes. The obtained results from each group were analyzed statistically by using SPSS statistic program. It was observed that the concentration and peak intensity values of Ca, Fe, Mn, P, Zn, Cl, K, Na, Mg and Si elements were higher in the haricot beans samples grown under organic farming regime. Likewise, Al and Sr levels were found in higher levels in the samples grown under conventional farming regime. Our findings clearly revealed that organic haricot beans are likely to have higher nutritional mineral content. And the haricot beans samples grown under conventional farming regime could contain harmful metals like Al and Sr that might damage the various systems and/or organs of humans and animals.

Key words: Elemental analysis, *Phaseolus vulgaris* L., haricot beans, organic farming, conventional farming, WDXRF

INTRODUCTION

The intensification and expansion of modern agriculture is amongst the greatest current threats to worldwide biodiversity [Hole et al. 2005]. It is suggested that organic

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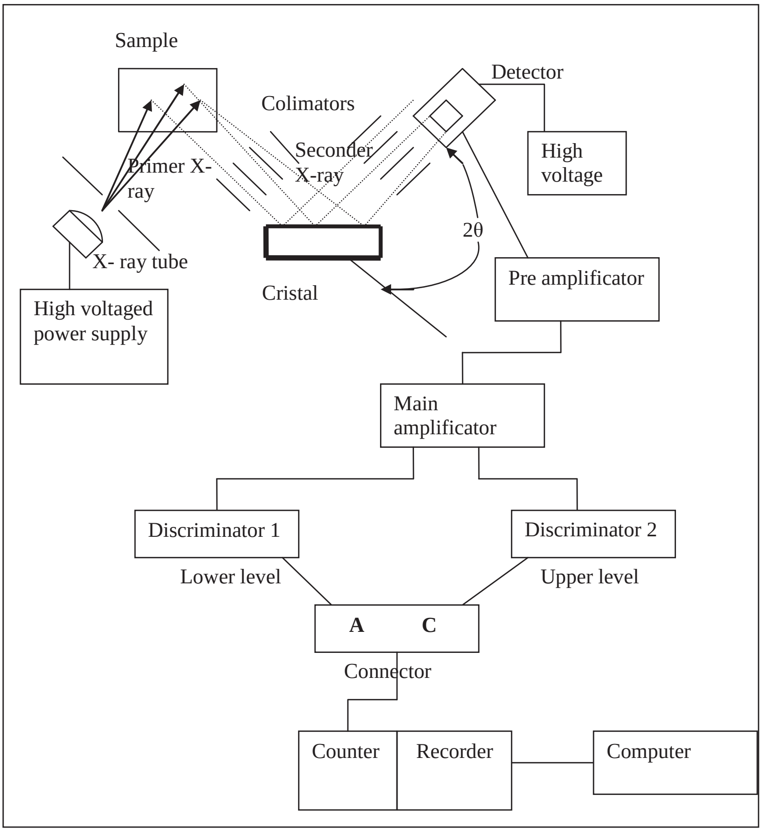
farming usually increases species richness, having on average 30% higher species richness than conventional farming systems. The efficiency of agricultural subsidy programs for preserving biodiversity and improving the environment has been questioned in recent years as well. Organic farming operates without pesticides, herbicides and inorganic fertilizers, and usually with a more diverse crop rotation [Bengtsson et al. 2005]. The prevalence of birth defects is increased in the regions that pesticides, fungicides, and herbicides are extensively used [Garry et al. 1996]. 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 [Horrigan et al. 2002]. 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 [Melero et al. 2002]. 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 [Marinari et al. 2006]. 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 [Aberoumand and Deokule 2010]. On the contrary, ingestion of metals especially heavy metals through fruits or vegetables can cause accumulation in organisms, producing serious health hazards such as injury to the kidney, symptoms of chronic toxicity, renal failure and liver damage [Zahir et al. 2009].

Common bean (*Phaseolus vulgaris* L.) is the most important food legume of the *genus Phaseolus.* It is reported to be a good source of protein, vitamins and minerals, and an excellent source of complex carbohydrates [Saha et al. 2009]. To our best knowledge, there is no comprehensive report on the element contents of haricot beans which were grown under organic and conventional farming regimes in the literature. In the present study, the 26 element contents such as Al, Ca, Cu, Fe, As, Hg, Pb, Cd, Bi, Mn, Ni, P, S, Sr, Zn, Zr, La, Ti, Sn, Cl, K, Mg, Na, Ba, Rb and Si of the haricot beans 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 [Potts et al. 2002, Fernandez et al 2009, Perring and Blanc 2008, Queralt et al. 2005, Marguı et al. 2005, Yigit et al. 2010].

MATERIALS AND METHODS

Materials. 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, gasflowand 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.



Legend – Legenda:
Sample – próbka, Detector – wykrywacz, High voltage – wysokie napięcie, Collimators – kolimatory, Primer X ray – pierwotny promień rentgena, Seconder X-ray – wtórny promień rentgena, X-ray tube – lampa rentgenowska, Cristal – kryształ, High voltaged power supply – zasilanie wysokonapięciowe, Preamplificator – przedwzmacniacz, Main amplificator – wzmacniacz główny, Upper level – poziom wyższy, Lower level – poziom niższy, Discriminator – dyskryminator, Connector – łącznik, Counter – licznik, Recorder – rejestrator, Computer – komputer

Fig. 1. The used WDXRF system and its units
Ryc. 1. Wykorzystywany system *WDXRF i jego jednostki

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 grindingmill (from SpexIndistries Inc.); a mortar agate and an oven (Moisture Extraction Oven: tem. range 40°C to 250°C, from QED) were used.

Methods. Both haricot beans samples were purchased from a local certificated company from Aydın City, Turkey. They were picked up from closer regions and in the same harvest period. The examined samples are the sametype ofharicotbeans. Type ofdwarfbean (*Phaseolus vulgaris* L.) was grown inboththe agriculturalregime. Only the applied farming regimes were different. Under organic farming 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. 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 samples were ground in a mortar agate. After grinding in a grindingmill, samples weresubjected toa seconddigestion process. 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. Measurements were made on the amount of dry matter.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 2 g were analyzed on a sequential ZSX 100e WDXRF spectrometer 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 haricot beans 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.

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, As, Hg, Pb, Cd, Bi, Mn, Ni, P, S, Sr, Zn, Zr, La, Ti, Sn, Cl, K, Mg, Na, Ba, Rb and Si 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 (fig. 2). The statistical analysis of our findings revealed that Ca, Fe, Mn, P, Zn, Cl, K, Na, Mg and Si element contents were higher in the haricot beans samples grown under organic farming regime. And the contents of Al and Sr were found at lower concentrations in the haricot beans samples grown under organic farming regime. And, the amounts of some elements (Cu, Ni, S, Rb and Ba) did not show any alterations as compared to each other. On the other hand, As, Bi, Cd, Pb, Hg, La, Sn, Ti and Zr were not detected in both samples.

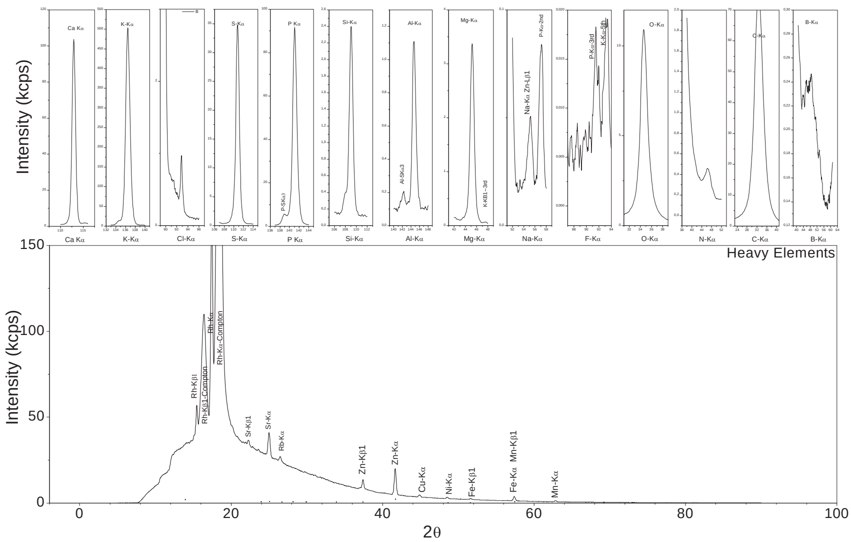
Table 1. Concentrations and peak intensities of 28 elements for haricot bean samples
Tabela 1. Stężenia i szczytowe natężenia 28 pierwiastków dla próbek fasoli szparagowej

Elements Pierwiastek	Concentratıon Stężenie (mg·100 g^{-1})		Peak ıntensıty (count per second in 100 g) Natężenie szczytowe (liczba na sekundę w 100 g)		Detectıon lımıts (ppm in 100 g) Ograniczenia wykrycia (ppm w 100 g)	
	organic uprawa organiczna	conventional uprawa konwencjonalna	organic uprawa organiczna	conventional uprawa konwencjonalna	organic uprawa organiczna	conventional uprawa konwencjonalna
Al	0.76	0.96#	52.835	68.37#	0.0075	0.0075
Ca	22.50	20.75#	5717.345	5368.365#	0.0075	0.0075
Cu	0.055	0.055	60.44	60.235	0.005	0.005
Fe	0.48	0.28#	30.095	25.56#	0.007	0.007
As	ND	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND
Bi	ND	ND	ND	ND	ND	ND
Mn	0.12	0.055#	29.725	20.5#	0.0075	0.0075
Ni	0.045	0.045	38.43	26.135	0.01	0.01
P	21.77	18.90#	4968.385	4405.315#	0.0075	0.0075
S	9.23	9.27	1679.415	16.8318	0.01	0.01
Sr	0.05	0.08#	255.03	289.015#	0.005	0.005
Zn	0.48	0.41#	699.76	564.34#	0.005	0.005
Zr	ND	ND	ND	ND	ND	ND
La	ND	ND	ND	ND	ND	ND
Ti	ND	ND	ND	ND	ND	ND
Sn	ND	ND	ND	ND	ND	ND
Cl	0.965	0.735#	33.645	25.51#	0.005	0.005
K	85.70	78.59#	24996.66	23437.86#	0.02	0.02
Mg	13.38	10.82#	167.52	154.835#	0.045	0.045
Na	0.58	0.185#	2.085	4.36#	0.075	0.075
Ba	0.275	0.275	78.8	79.22	0.05	0.05
Rb	0.03	0.03	135.5	134.31	0.005	0.005
Si	3.15	2.15#	194.52	167.52#	0.0075	0.0075

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 same element.
Wyniki analizy podano jako średnią z próbek (n = 10) z każdej grupy; ND nie wykryto; # symbol oznacza statystycznie różne od organicznego systemu uprawy na poziomie 0.01 dla tego samego pierwiastka

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 haricot beans (*Phaseolus vulgaris* L.) samples by WDXRF method since analytical performance of the method previously proposed proved to be effective and robust [Krishna et al. 2009]. There is very limited number of studies in which comprehensive elemental analyses were carried out on agricultural products. The mineral contents of several products like mulberry

[Yigit et al. 2010], tea [Ercisli et al. 2009], tobacco [Camas et al. 2007], beans [Dumlupinar et al. 2007] and hazelnuts [Akbaba et al. 2011] by using WDXRF system. But, the comparisons of haricot beans elemental contents grown under organic and conventional farming regimes have not been performed yet.



Legend – Legenda: Intensity – natężenie, Heavy elements – pierwiastki ciężkie

Fig. 2. The intensities of some elements versus diffraction angle obtained from the haricot bean sample grown under organic farming regime.

Ryc. 2. Natężenie niektórych pierwiastków a kąt dyfrakcji otrzymany z próbek fasoli szparagowej, hodowanej zgodnie z systemem organicznym

Recently, the results of a unique study in the literature for determining the elemental contents of dried haricot beans, by using a low-power reactor as the neutron source without any distinction of applied farming regime, indicated that this fruit is an ample source of Ca, Fe, Mg and Mn elements [Waheed and Siddique 2009]. In this investigation, we found statistically important alterations in the element contents of the haricot beans grown under organic and conventional farming regimes. The WDXRF analysis of this study indicated that Ca, Fe, Mn, P, Zn, Cl, K, Na, Mg and Si element contents were higher in the haricot beans samples grown under organic farming regime. In accordance with our findings, it was reported that there exist some large differences in the elemental balances of vegetal products between organic and conventional dairy farming [Beyhan et al. 2010, Hasegawa et al. 2005, Bengtsson et al. 2003, Gustafson et al. 2006]. This is also consistent with analyses by Worthington [2001] who also found that organic crops contained significantly more Fe and P than conventional crops. Again, Gundersen et al. [2000] 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. Adotey et al. [2009] 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 Mg, Ca, P, Na, Cl and K) and some minor elements or trace elements (such as Fe, Mn, Si and Zn) in the haricot beans grown under organic farming regime.

On the other hand, 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 [Mannan et al. 1992]. In our study, the contents of Al and Sr were found at higher concentrations in the haricot beans samples grown under conventional farming regime. In accordance with our finding, Santos et al. [2010] 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 [Seaborn and Nielsen 1994, Geyikoglu et al. 2005]. Similarly, Gjorgieva et al. (2010) reported that Sr was toxic metals to living organisms.

CONCLUSIONS

The determined weight percent concentrations of Ca, Fe, Mn, P, Zn, Cl, K, Na, Mg and Si elements (which are essential for human health) were higher, and the amounts of toxic metals (Al and Sr) were lower in the haricot beans samples grown under organic farming regime. Thus, we could suggest that this farming regime is crucial for nutritional value of haricot beans.

REFERENCES

Aberoumand A., Deokule S.S., 2010. Elements evaluation of some edible vegetables and fruits of Iran and India. Asian J. Agric. Sci., 2, 35–37.

Adotey D.K., Serfor-Armah Y., Fianko J.R., Yeboah P.O., 2009. Essential elements content in core vegetables grown and consumed in Ghana by instrumental neutron activation analysis. African J. Food Sci., 3, 243–249.

Akbaba U., Sahin Y., Turkez H., 2011. Comparison of element contents in hazelnuts grown under organic and conventional farming regimes for human nutrition and health. Fresenius Environ. Bull. (in press).

Beyhan O., Elmastas M., Genc N., 2010. Trace elements in some hazelnut varieties near industrial area and far from industrial area in Turkey.Asian J. Chem., 22, 4040–4044.

Bengtsson J., Ahnström J., Weibull A.C., 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. J. Appl. Ecol., 42, 261–269.

Bengtsson H., Oborn I., Jonsson S., 2003. Field balances of some mineral nutrients and trace elements in organic and conventional dairy farming – a case study at Ojebyn, Sweden. Eur. J. Agronom., 20, 101–116.

Camas N., Karabulut B., Karabulut A., 2007. Elemental analysis of some important tobacco varieties (*Nicotianatabacum* L.) by WDXRF spectroscopy. Asian J. Chem., 19, 3971–3978.
Dumlupinar R., Demir F., Bostan H., 2007. Determination of chilling temperature effects on inorganic element composition and distribution in beans using WDXRF-spectroscopic technique. Fresenius Environ. Bull., 16, 548–554.
Ercisli S., Demir F., Budak G., 2009. Determination of elemental variations in tea leaves (*Camellia sinensis* L.) in different harvest time by WDXRF spectrometry. Asian J. Chem., 21, 1313–1317.
Fernandez O.G., Margui E., Queralt, I., 2009.Multielemental analysis of dried residue from metal-bearing waters by wavelength dispersive X-ray fluorescence spectrometry. Spectrochım. Acta. B., 64, 184–190.
Garry V.F., Schreinemachers D., Harkins M.E., Griffith J., 1996. Pesticide appliers, biocides and birth defects in rular Minnesota. Environ. Health Persp., 104, 394–399.
Geyikoglu F., Turkez H., Keles S.M., 2005. The role of fruit juices in the prevention of aluminum sulphate toxicity in human blood in vitro. Fresenius Environ. Bull., 14, 878–883.
Gjorgieva D., Kadifkova P. T., Bačeva K., 2010. Some toxic and essential metals in medicinal plants growing in R. Macedonia. American-Eurasian J. Toxicol. Sci. 2, 1, 57–61.
Gundersen V., Bechmann I. E., Behrens A., Sturup S., 2000. Comparative investigation of concentrations of major and trace elements in organic and conventional Danish agricultural crops. 1. Onions (*Allium cepa Hysam*) and Peas (*Pisumsativum Ping Pong*). J. Agric. Food Chem., 48, 6094–6102.
Gustafson G.A., Salomon E., Jonsson S., 2006. Barn balance calculations of Ca, Cu, K, Mg, Mn, N, P, S and Zn in a conventional and organic dairy farm in Sweden Agric. Ecosyst. Environ., 119, 160–170.
Hasegawa H., Furukawa Y., Kimura S.D., 2005. On-farm assessment of organic amendments effects on nutrient status and nutrient use efficiency of organic rice fields in Northeastern Japan. Agr. Ecosyst. Environ., 108, 350–362.
Hole D.G., Perkins A.J., Wilson J.D., Alexander I.H., Grice P.V., Evans A.D., 2005. Does organic farming benefit biodiversity? Biol. Conserv., 122(1), 113–130.
Horrigan L., Lawrence R.S., Walker P., 2002. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environ. Health Persp., 110 (5), 445–456.
Krishna A.K., Mohan K.R., Dasaram B.A., 2009. Qualitative application in quantitative determination of major and trace elements in plant species using wavelength dispersive x-ray fluorescence spectrometry. Atom. Spec., 30, 208–217.
Mannan A., Waheed S., Ahmad S., Qureshı I.A., 1992. Dietary evaluation of toxic elements through integrated diet. J. Rad. Nucl. Chem., 162, 111–123.
Margui, E., Hidalgo, M., Queralt, I., 2005.Multielemental fast analysis of vegetation samples by wavelength dispersive X-ray fluorescence spectrometry. Spectrochim. Acta. B., 60, 1363–1372.
Melero S., Porras J.C., Herencia J.F., Madejon E., 2006. Chemical and biochemical properties in a silty loam soil under conventional and organic management. Soil Till. Res., 90, 162–170.
Marinari S., Mancinelli R., Campiglia E., Grego S., 2006. Chemical and biological indicators of soil quality in organic and conventional farming systems in Central Italy. Ecol. Indic., 6, 701–711.
Perring L., BlancJ., 2008. Faster Measurement of Minerals in Milk Powders: Comparison of a High Power Wavelength Dispersive XRF System with ICP-AES and Potentiometers Reference Methods. Food Anal. Method., 1, 205–213.
Potts P.J., Ellis A.T., Kregsamer P., Marshall J., Streli C., Weste M., Wobrauschekc P., 2002. Atomic spectrometry update. X-ray fluorescence spectrometry. J. Anal. At. Spectrom., 17, 1439–1455.
Queralt I., Ovejero M., Carvalho M.L., Marques A.F., Llabre´s J.M., 2005. Quantitative determination of essential and trace element content of medicinal plants and their infusions by XRF and ICP techniques. X-Ray Spectrom., 34, 213–217.

Saha S., Singh G., Mahajan V., Gupta H.S., 2009. Variability of Nutritional and Cooking Quality in Bean (*Phaseolus vulgaris* L.) as a Function of Genotype. Plant Foods Hum. Nutr., 64, (2), 174–180.

Santos J.S., Santos M.L.P., Conti M.M., 2010. Comparative study of metal contents in Brazilian coffees cultivated by conventional and organic agriculture applying principal component analysis. J. Braz. Chem. Soc., 21, doi: 10.1590/S0103-50532010000800009.

Seaborn C.D., Nielsen F.H., 1994. High dietary aluminum affects the response of rats to silicon deprivation. Biol. Trace Elem. Res., 41, 295–304.

Waheed S., Siddique N., 2009. Evaluation of dietary status with respect to trace element intake from dry fruits consumed in Pakistan: a study using instrumental neutron activation analysis.Int. J. Food Sci. Nutr., 60, 333–343.

Worthington V., 2001. Nutritional quality of organic versus conventional fruits, vegetables, and grains. J. Altern. Compl. Med., 7, 161–173.

Yigit D., Akar F., Baydas, E., 2010. Elemental composition of various mulberry species. Asian J. Chem., 22, 3554–3560.

Yigit D., Baydas E., Guleryuz M., 2009. Elemental Analysis of Various Cherry Fruits by Wavelength Dispersive X-Ray Fluorescence Spectrometry. Asian J. Chem., 21, 2935–2942.

Zahir E., Naqvi I.I., Udin S.M., 2009. Market basket survey of selected metals in fruits from Karachi City (Pakistan). J. Basic. Appl. Sci., 5, 47–52.

PORÓWNANIE ZAWARTOŚCI PIERWIASTKÓW W ROŚLINACH FASOLI SZPARAGOWEJ UPRAWIANYCH W SYSTEMIE ORGANICZNYM I KONWENCJONALNYM W CELACH SPOŻYWCZYCH I LECZNICZYCH

Streszczenie. Obecnie rolnictwo nienaruszające równowagi ekologicznej oraz wartość żywności stanowią sprawę istotną dla całego świata. Praktyki uprawy ekologicznej mają w tej kwestii duże znaczenie. Celem niniejszej pracy jest obserwacja wpływu systemu rolnictwa organicznego na produkty, na przykładzie fasoli szparagowej (*Phaseolus vulgaris* L.). Przeprowadzono badanie porównawcze składu pierwiastkowego (chemicznego) różnych próbek fasoli szparagowej (*Phaseolus vulgaris* L.) czułą metodą fluorescencji rozpraszającej długość fali promieniami Roentgena (WDXRF). 26 pierwiastków, takich jak: Al, Ca, Cu, Fe, As, Hg, Pb, Cd, Bi, Mn, Ni, P, S, Sr, Zn, Zr, La, Ti, Sn, Cl, K, Mg, Na, Ba, Rb oraz Si oznaczono w próbkach fasoli szparagowej (n = 10) uprawianej systemem organicznym i tradycyjnym. Otrzymane wyniki z każdej grupy poddano analizie statystycznej z wykorzystaniem programu statystycznego SPSS. Zaobserwowano, że wartości stężenia I szczytowej intensywności pierwiastków Ca, Fe, Mn, P, Zn, Cl, K, Na, Mg oraz Si były wyższe w próbkach fasoli szparagowej uprawianej systemem organicznym. Stwierdzono także wyższy poziom Al i Sr w próbkach uprawianych zgodnie z systemem konwencjonalnym. Nasze wyniki wyraźnie wykazały, że uprawiana organicznie fasola szparagowa prawdopodobnie zawiera więcej mineralnych składników odżywczych, zaś uprawiana zgodnie z systemem konwencjonalnym może zawierać szkodliwe metale, takie jak Al i Sr, mogące uszkadzać różne narządy i/lub układy w organizmach ludzi i zwierząt.

Słowa kluczowe: analiza pierwiastkowa, fasola zwykła, uprawa organiczna, uprawa konwencjonalna, WDXRF

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