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Cadmium and lead in organically produced foodstuffs from the Greek market

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Abstract

Determinations of cadmium and lead content in a wide variety of organically produced foodstuffs available in the Greek market were carried out in the present study. The mean values detected ranged from non detectable to 53.4 ng g^{-1} and 65.0 ng g^{-1} for cadmium and lead, respectively. The highest cadmium concentrations were observed in the food categories of cereals (21.7 ng g^{-1}), followed by leafy vegetables (15.4 ng g^{-1}), whereas for lead the highest concentrations were found in leafy vegetables (33.4 ng g^{-1}), followed by pulses (21.4 ng g^{-1}) and alcoholic beverages (20.0 ng g^{-1}). The comparison of the two metals' content in certified organically grown foodstuffs to that of conventional ones from the Greek market demonstrates that cadmium and lead concentrations are higher in conventional foodstuffs in a percentage equal to 64% and 61% of the products compared, respectively. The results also show that "uncertified" organic products contained far larger concentrations of cadmium and lead than either the certified organic or conventional foodstuffs. These results demonstrate that although the majority of certified organic products may have lower metal content, organic agriculture as such does not necessarily reduce the cadmium and lead content of organically cultivated products, unless additional provisions are observed.

Keywords: Cadmium; Lead; Organic foodstuffs; Greece

1. Introduction

Food safety problems observed recently in Europe such as dioxins in poultry and milk and bovine spongiform encephalopathy, combined with public awareness of the impact of environmental pollution on nutrition and with environmental issues in general provoked a major dietary conversion of a sizeable part of the population towards organically produced food, in the hope of a healthier and environmentally friendly alternative (Fischer, 1999; Malmauret, Parent-Massin, Hardy, & Verger, 2002; Morgan & Murdoch, 2000; Saba & Messina, 2003 and references cited therein; Chryssohoidis & Krystallis, 2005; Pussemier, Larondelle, Van Peteghem, & Huyghebaert, 2006; Siderer, Maquet, & Anklam, 2005). Consequently, the market of the so-called organically produced agricultural and animal products is constantly expanding and developing (FAO, 2000; Hermansen, 2003), encouraged politically by the European Union's Common Agricultural Policy, which provides financial support to environmentally sound agricultural practices (Cederberg & Mattsson, 2000; Siderer et al., 2005). The expansion in Europe and North America of organic registration schemes is also supported by the close relationship between organic agriculture/farming and sustainability (Hermansen, 2003; Rigby & Cáceres, 2001).

The current situation in Greece is characterized as "transitional" since a number of organically produced foodstuffs are not certified either because they do not fulfill yet the necessary conditions or because they are produced in very small farms which have no interest to apply for

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certification. Organically cultivated land at the end of the year 2002 was ~289 km^2, accounting for 0.9% of the total agricultural land with a tendency to augment in the future, whereas the corresponding values for the European Union countries (EU 15) range from 0.7% for Ireland to 12% for Austria (personal communication with the Hellenic Ministry of Rural Development and Food). Approximately half (53.5%) of the total organically cultivated land in Greece is dedicated to the cultivation of olive trees, whereas viniculture for wine production represents 7.9%, followed by the cultivation of wheat (4.8%), barley (3.8%) and citrus trees (3.7%) (ICAP, 2002). Crop is traditionally distinguished from livestock production in Greece. Animals, mostly sheep and goats graze on harvested fields and public land and during winter grazing is supplemented by animal feed produced by the same farmer or purchased in the region around the farm. There are, however, big animal farms similar to those found in western and central Europe producing eggs, milk and meat for high volume consumption, exclusively from purchased animal feed (van der Smissen, 2002). The sector of organic livestock production is recently expanding with sheep and goat production representing the dominant section and cattle breeding demonstrating an increasing tendency (personal communication with the Hellenic Ministry of Rural Development and Food). Aquaculture, which represents a particularly powerful sector, is not included yet in the Council Regulation for organic farming (EC, 1999).

The total retail market value of domestic organic foodstuffs in Greece was estimated at 18.5 million euros in 2002. The major distribution channels of organic products were supermarket chains (40%), followed by independent stores (30%), chains of specialist stores (20%), street markets (5%) and other channels (5%) (ICAP, 2002). However, only 18% of organically cultivated products can be labeled properly as "organic", whereas 40% are labeled as "organic – under conversion" and 42% are under inspection, being organically cultivated for less than 12 months, since the labeling term "organic" is attributed only after a two year period before the sowing of the first harvest for annual crops and after a three year conversion period for perennial crops, by one of the three recognised certification and inspection agencies existing (FAO, 1999). According to Chryssohoidis and Krystallis (2005) "self-respect" and "enjoyment of life" were found to be the main motivations of consumers behind the purchase of organic products in Greece, corresponding to the motives of healthiness and better taste of organic products. The motive of environmental protection through organic cultivation seems to be less important.

Although it is clear that the emphasis of organic production is given to the avoidance of the use of added agrochemicals and antibiotics, numerous consumers consider implicitly that their content in environmental pollutants (like metals) is lower, compared to that of conventionally produced foodstuffs (Ghidini et al., 2005; Jorhem & Slanina, 2000). Such an assumption is rather arbitrary. Moreover, the number of studies examining the metal content of organic foodstuffs is relatively limited (Ghidini et al., 2005; Jorhem & Slanina, 2000; Lecerf, 1995; Malmauret et al., 2002; Olsson, Jonsson, & Oskarsson, 2001; Procida, Pertoldi Marletta, & Ceccon, 1998; Woese, Lange, Boess, & Bögl, 1997; Worthington, 2001). The toxicity of cadmium and lead and their ability to bioaccumulate in the tissues of living organisms (Scoullos, Vonkeman, Thornton, & Makuch, 2001; Spiro & Stigliani, 1996 and references therein) have imposed the adoption of European legislation establishing maximum levels of certain metals, among which cadmium and lead, in foodstuffs (EC, 2001, 2005). The present paper provides information concerning the cadmium and lead content in a variety of certified and non-certified organic foodstuffs produced in Greece for which no data are available. The results allow the comparison of the metal content of both groups of "organic" foodstuffs with relevant conventionally grown ones, collected from the Greek market during the same period of time (Karavoltsos, Sakellari, Dimopoulos, Dasenakis, & Scoullos, 2002; Sakellari, Karavoltsos, & Scoullos, 2004).

2. Materials and methods

2.1. Sampling and sample preparation

Sampling of organic agricultural products was performed during 2000 in parallel with that of conventional ones (Karavoltsos et al., 2002). Organic foodstuffs of animal origin were collected during 2001 and 2002, since during 2000 organic livestock retailed in the Greek market was very limited. Food items selected were labeled as "organic", following certification by one of the three official Hellenic inspection agencies. Samples were purchased from the main distribution channels of organic foodstuffs such as supermarkets, specialized retail outlets of organic products, special organic foodstuffs' street markets, as well as directly from producers from Athens and some other Greek cities. Sampling was taking place for several months in order to permit selection of vegetables and fruits at the peak of their season. Foodstuffs originated randomly from all over Greece and therefore were probably representative of Greece (Bratakos, Lazos, & Bratakos, 2002; Ekholm et al., 2007).

It should be underlined that organic foodstuffs consumed by a relatively significant part of the Greek population are, as a rule, retailed directly by minor producers, without having the necessary certification by any of the three official Hellenic certification and inspection agencies for organic foodstuffs. For this purpose, the present study includes also samples of foodstuffs retailed as organic, lacking, however, the necessary labels of certification.

Sampling procedure and sample size were regulated according to the Greek Codex of Food and Beverages (1994) as well as to the Directive 22/2001/EC. Briefly, for each separate foodstuff of different origin five subsamples were collected each weighing 0.5–1 kg for vegetables, potatoes and fruit and 0.25–1 kg for cereals, pulses and eggs, whereas in cases of foodstuffs individually packed, three packages were sampled. Following transport to the laboratory, the subsamples were mixed to a sample prepared as for consumption keeping exclusively the edible parts and removing bruised or rotten parts. Items were rinsed with water (18.2 MΩ cm, Milli-Q, Millipore), placed on filter paper to eliminate excess moisture, peeled when necessary, chopped and homogenized, forming a pooled sample for analysis.

2.2. Chemical analysis and quality assurance

Glassware and laboratory equipment used was previously soaked in nitric acid 10% and rinsed with Milli-Q water. Approximately 1.0 g of wet sample accurately weighed was placed in teflon holders specially designed for airtight sealing, assured by their placement inside stainless steel pressure jackets. A volume of 8–12 mL (depending on the sample's nature) of nitric acid 65% suprapure was added, the samples were digested overnight on a hot plate at 120 °C and gently evaporated in order to be diluted with Milli-Q water to a final volume of 10 mL (Bosque, Schuhmacher, Domingo, & Llobet, 1990; EN 13805, 2002; UNEP, 1984).

Each sample analysed in the present study was treated in triplicate and both cadmium and lead determinations were performed by graphite furnace atomic absorption spectrometry (GFAAS Varian SpectrAA 640Z with Zeeman background correction). Solutions of ammonium dihydrogen phosphate ($H_2NH_4PO_4$) 0.1% (w/v) for cadmium and 0.5% (w/v) for lead were used as matrix modifiers (Campillo, Viñas, López García, & Hernández Córdoba, 1999; Parsons & Slavin, 1999). The furnace operating conditions [temperature (°C)/ramp time (s)/hold time (s)] employed for cadmium determinations were: drying: 85 °C/5 s/0 s; 95 °C/40 s/0 s; 120 °C/10 s/0 s; pyrolysis: 800 °C/5 s/10 s; atomization: 1800 °C/0.8 s/2 s; cleaning: 2200 °C/2 s/2 s. For lead determinations the furnace operating conditions were the same, except for the temperature of atomization (1600 °C).

Reagent blank tests were performed for every batch of five samples measured. Three certified reference materials (CRMs) were employed to evaluate measurement accuracy [certified value (ng/g dry wt)/value detected (ng/g dry wt)/recovery (%)/RSD (%)]: BCR No184 (lyophilized bovine muscle): [$13.0 \pm 2.0/13.2 \pm 1.5/101/11.4$] for cadmium and [$239 \pm 11/240 \pm 17/100/7.1$] for lead; BCR No. 278R (mussel tissue): [$348 \pm 7/347 \pm 22/100/6.3$] for cadmium and [$2.00 \pm 0.04/2.0 \pm 0.1/100/5.0$] for lead and BCR No279 (sea lettuce): [$274 \pm 22/269 \pm 24/98/8.9$] for cadmium and [$13.48 \pm 0.36/13.2 \pm 0.9/98/6.8$] for lead. The limits of detection (LOD) for cadmium (1.0 ng/g dry weight) and lead (8.0 ng/g dry weight) were calculated by multiplying the standard deviation of seven replicate samples prepared at an approximate low concentration by 3.14 (USEPA, 1997).

3. Results and discussion

It is noteworthy that in none of the different kinds of certified and non-certified organic foodstuffs and beverages examined in the present study, did cadmium and lead values exceed the maximum levels established by the European legislation (EC, 2001). However, the cadmium and lead concentrations observed in the samples cover a very wide range (Table 1). The determined mean concentrations of cadmium varied from non detectable in several kinds of foodstuffs to 53.4 ng g^{-1} wet weight in wholewheat flower, followed by wheat (41.7 ng g^{-1}). Seemingly, the mean concentrations of lead ranged from non detectable to 65.0 ng g^{-1} wet weight in parsley, followed by spinach (50.1 ng g^{-1}) (Table 1). Among the various categories of organic foodstuffs analysed in the present study, the highest mean values of cadmium content were detected in the food categories of cereals (21.7 ng g^{-1}) and leafy vegetables (15.4 ng g^{-1}) (Fig. 1). In the case of conventional foodstuffs (Karavoltsos et al., 2002) the mean cadmium content of cereals (16.3 ng g^{-1}) is lower than that of organic ones and leafy vegetables are as well among the food categories with the highest mean cadmium content (28.3 ng g^{-1}). Regarding lead concentrations, the highest mean values are detected in leafy vegetables (33.4 ng g^{-1}), followed by pulses (21.4 ng g^{-1}) and alcoholic beverages (20.0 ng g^{-1}) (Fig. 2). This sequence is somewhat different in the case of conventional foodstuffs (Sakellari et al., 2004), where leafy vegetables (88.4 ng g^{-1}) are followed by cereals (43.6 ng g^{-1}) and other vegetables (41.2 ng g^{-1}). The natural conclusion of these results is that the metal content is mostly affected by overall environmental conditions and legacy or long term history of the cropland and it is not always directly and obviously linked with the attempts to cultivate organic products.

A number of foodstuffs advertised or promoted as organic, mainly in street markets, lack any proper control and informative labels securing certification by any of the accredited certification agencies. In Table 2, data regarding cadmium and lead concentrations in such unlabelled "organic" foodstuffs are presented. It is noteworthy that significantly higher concentrations in comparison with the corresponding labeled organic foodstuffs for both cadmium (e.g., in potatoes and celery) and lead (in celery, lettuce, fresh small onions, leek, broccoli and apples) were detected. The most readily available explanation for such a differentiation is the transitional character of the used cropland which in most cases was previously treated with high quantities of phosphates. Another explanation is that uncontrolled organic vegetables are frequently produced in very small plots of land in the immediate hinterlands and suburbs of big cities next to big industries, motorways or railroads where pollution is high. Taking the previous observations into consideration, foodstuffs classified as "organic" but lacking the appropriate labeling were regarded as questionable and therefore they were considered separately and not

Table 1
Cadmium and lead content in certified organic foodstuffs from the Greek market

Sample	n[a]	Mean (ng Cd g^{-1} wet wt ± SD)	Median (ng Cd g^{-1})	90th Percentile (ng Cd g^{-1})	Mean (ng Pb g^{-1} wet wt ± SD)	Median (ng Pb g^{-1})	90th Percentile (ng Pb g^{-1})
Cereals							
Rice	5	9.7 ± 5.1	12.5	13.9	19.9 ± 12.6	25.3	30.9
Frumenty[b]	3	26.9 ± 9.6	26.5	34.7	22.6 ± 5.3	22.2	26.9
Wheat	5	41.7 ± 10.9	39.5	52.5	12.7 ± 7.4	10.8	20.0
Pasta	4	20.1 ± 8.2	19.7	26.7	15.8 ± 14.4	9.0	27.7
Greek pasta (hilopites)[c]	2	20.7 ± 3.0	20.7	22.4	10.4 ± 8.4	10.4	15.2
Biscuits	3	15.8 ± 3.6	15.8	18.7	24.8 ± 10.1	19.3	33.1
White flower	6	16.9 ± 5.2	16.5	21.5	21.0 ± 10.6	19.3	33.1
Whole-wheat flower	2	53.4 ± 11.8	53.4	60.1	29.2 ± 34.8	29.2	48.9
White bread	5	14.4 ± 6.0	14.4	20.3	8.8 ± 2.9	8.4	11.8
Whole-wheat bread	4	18.2 ± 9.1	15.1	27.2	11.3 ± 3.6	11.5	14.5
Meat							
Beef	3	<1.0	–	–	<8.0	–	–
Pork	4	<1.0	–	–	<8.0	–	–
Turkey	3	1.2 ± 0.1	1.2	1.3	<8.0	–	–
Salami	3	<1.0	–	–	<8.0	–	–
Eggs							
Eggs	4	<1.0	–	–	<8.0	–	–
Dairy products							
Yogurt	3	<1.0	–	–	<8.0	–	–
Greek feta	4	<1.0	–	–	<8.0	–	–
Oils							
Olive oil	6	<1.0	–	–	19.2 ± 5.5	15.4	25.3
Potatoes							
Potatoes	7	8.6 ± 2.7	7.6	11.6	11.8 ± 2.8	11.9	14.6
Leafy vegetables							
Parsley	4	5.9 ± 2.3	5.8	8.0	65.0 ± 19.8	69.6	81.0
Spinach	5	37.0 ± 10.5	36.6	46.4	50.1 ± 17.4	52.8	65.0
Celery	4	5.3 ± 1.8	5.1	6.8	9.6 ± 1.9	8.8	11.1
Amarantus blitum	2	21.7 ± 6.7	21.1	27.1	32.2 ± 6.1	34.8	36.2
Lettuce	5	7.3 ± 4.2	6.5	11.4	10.3 ± 2.7	9.5	13.2
Other vegetables							
Dry onion[d]	3	2.1 ± 0.3	2.0	2.4	<8.0	–	–
Fresh small onions	4	2.9 ± 1.0	2.4	3.7	<8.0	–	–
Leek	3	1.8 ± 0.6	1.9	2.2	<8.0	–	–
Fresh garlic	3	5.1 ± 2.1	4.8	6.9	26.6 ± 7.6	23.2	32.9
Cucumber	4	<1.0	–	–	<8.0	–	–
Beet	3	3.3 ± 1.4	3.1	4.5	29.4 ± 6.5	32.1	33.7
Cabbage	6	6.5 ± 6.9	2.9	14.9	11.2 ± 4.2	8.8	16.6
Cauliflower	4	5.9 ± 5.0	4.8	10.8	15.1 ± 4.0	15.8	18.4
Broccoli	3	4.5 ± 0.6	4.6	4.9	10.8 ± 3.1	9.8	13.3
Green pepper	4	12.1 ± 9.7	9.6	21.6	<8.0	–	–
Carrot	4	4.9 ± 2.1	5.2	6.6	27.9 ± 10.3	29.0	37.8
Aubergine	4	5.0 ± 3.5	5.2	8.0	33.0 ± 8.8	34.3	40.4
Fresh green beans	3	2.4 ± 1.5	1.9	3.7	10.5 ± 2.1	10.8	12.1
Artichoke	3	15.5 ± 8.7	15.4	22.4	36.1 ± 11.4	30.6	45.6
Tomatoes	8	3.2 ± 1.0	3.0	4.4	<8.0	–	–
Pulses							
Broad	3	2.7 ± 0.8	2.4	3.4	<8.0	–	–
Beans	4	8.7 ± 4.0	8.6	12.2	19.3 ± 6.5	20.2	24.9
Lentils	3	1.2 ± 0.2	1.2	1.4	31.3 ± 5.4	33.6	34.8
Chick peas	3	1.1 ± 0.1	1.0	1.2	40.6 ± 20.7	29.0	57.4
Broad beans	3	1.3 ± 0.3	1.2	1.5	<8.0	–	–

Table 1 (*continued*)

Sample	n[a]	Mean (ng Cd g^{-1} wet wt ± SD)	Median (ng Cd g^{-1})	90th Percentile (ng Cd g^{-1})	Mean (ng Pb g^{-1} wet wt ± SD)	Median (ng Pb g^{-1})	90th Percentile (ng Pb g^{-1})
Fruits							
Apple	5	<1.0	–	–	12.9 ± 2.8	12.8	15.7
Kiwi	3	<1.0	–	–	12.7 ± 2.7	13.7	14.6
Orange	6	<1.0	–	–	27.2 ± 5.5	26.8	33.2
Mandarin	3	<1.0	–	–	9.0 ± 1.1	8.4	9.8
Apricot	3	<1.0	–	–	13.8 ± 3.7	15.5	16.1
Peach	4	<1.0	–	–	<8.0	–	–
Alcoholic beverages							
White Wine	4	<1.0	–	–	21.6 ± 5.3	20.6	26.7
Red wine	5	<1.0	–	–	17.5 ± 5.8	17.1	23.4

[a] Number of different samples analysed.
[b] Traditional wheat product prepared with the addition of milk.
[c] Type of traditional Greek pasta.
[d] The adjective 'dry' is part of the traditional name of that specific vegetable and does not imply any dehydration during the experimental procedure.

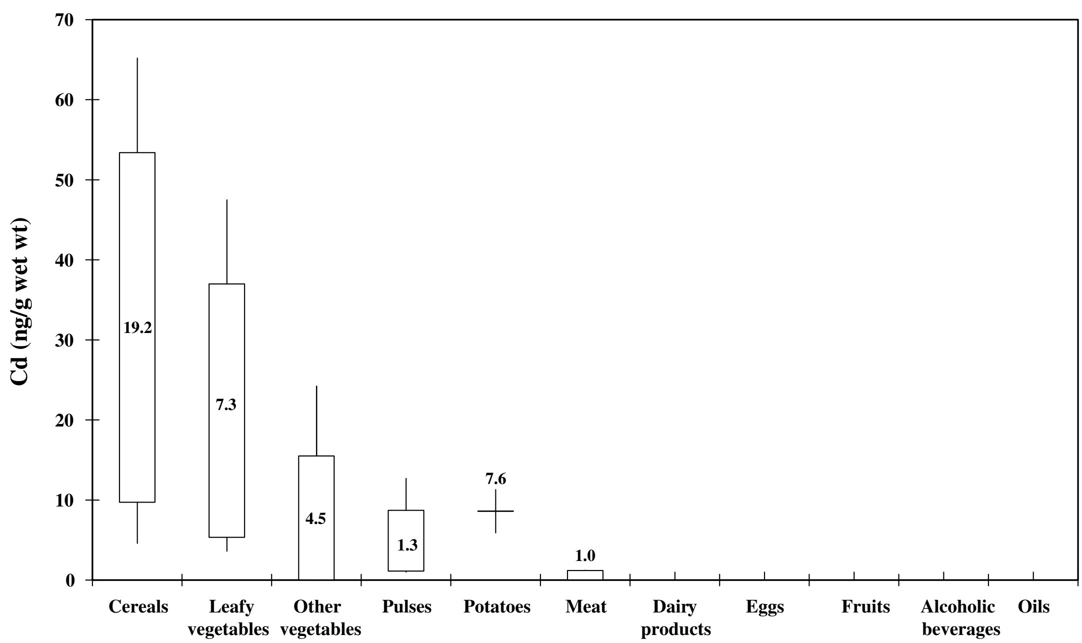

Fig. 1. Cadmium content in food categories of certified organic foodstuffs available in the Greek market. The box represents the range of mean values of different foodstuffs of each category with the median value inside, whereas the line the outlier values.

included in the following calculations, based exclusively on certified organic products.

Figs. 3 and 4 present a comparison of cadmium and lead, respectively, between organic and conventional foodstuffs. The coordinates (x, y) of each point in the diagram represent the metal content of a certified organic foodstuff (x) and of the corresponding conventional one (y). Cadmium and lead concentrations in conventional foodstuffs are found in Karavoltsos et al. (2002) and Sakellari et al. (2004), respectively. Black dots indicate the case according to which conventional foodstuffs have higher metal content than organically produced ones and open dots the case according to which organic foodstuffs have higher or equal metal content than the conventional ones. The diagonal line represents the case in which the metal concentration is identical in the organic and corresponding conventional foodstuff. In 64% of the foodstuffs examined the mean cadmium content was found to be lower in the labeled organic foodstuffs compared to the conventional ones (Fig. 3), while for the case of lead the percentage was found equal to 61% (Fig. 4). It is noteworthy that all high metal values (particularly of lead) were found in the measured conventional foodstuffs. These results are compatible with those deriving from the limited number of works available on this issue (Lecerf, 1995; Woese et al., 1997; Jorhem & Slanina, 2000; Worthington, 2001; Malmauret et al., 2002; Ghidini et al., 2005), pointing out that proper organic agriculture may help avoiding extremely high metal content

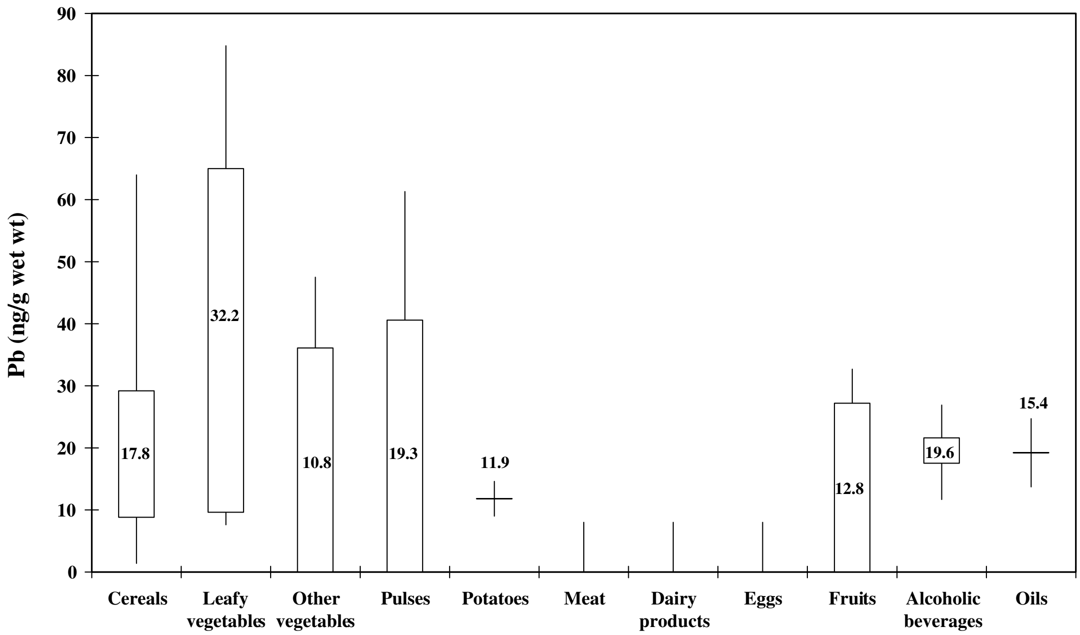

Fig. 2. Lead content in food categories of certified organic foodstuffs available in the Greek market. The box represents the range of mean values of different foodstuffs of each category with the median values inside, whereas the line the outlier values.

Table 2
Cadmium and lead content in non-certified foodstuffs sold or advertised as "organic" in the Greek market

Sample	n[a]	Mean (ng Cd g^{-1} wet wt ± SD)	Median (ng Cd g^{-1})	90th Percentile (ng Cd g^{-1})	Mean (ng Pb g^{-1} wet wt ± SD)	Median (ng Pb g^{-1})	90th Percentile (ng Pb g^{-1})
Potatoes							
Potatoes	4	60.5 ± 19.8	60.0	78.1	15.6 ± 2.7	15.8	18.1
Leafy vegetables							
Spinach	3	38.1 ± 9.6	39.2	45.6	54.1 ± 8.9	54.6	61.1
Celery	3	15.9 ± 9.7	15.9	23.7	74.7 ± 56.7	80.5	118.7
Amarantus blitum	3	23.8 ± 14.0	22.2	35.3	35.9 ± 15.8	36.6	48.4
Lettuce	5	9.5 ± 5.8	9.9	15.4	22.9 ± 12.3	25.8	34.7
Other vegetables							
Fresh small onions	3	5.5 ± 0.9	5.8	6.1	15.1 ± 6.2	16.5	19.7
Leek	3	2.6 ± 1.0	2.8	3.3	16.6 ± 5.8	16.8	21.1
Fresh garlic	1	5.9	–	–	29.2	–	–
Beet	2	3.2 ± 0.4	3.2	3.4	33.5 ± 33.8	33.5	52.6
Broccoli	2	4.8 ± 0.8	4.8	5.3	30.1 ± 15.8	30.1	39.1
Carrot	4	4.8 ± 0.9	4.6	5.7	29.3 ± 5.9	31.0	33.7
Tomatoes	4	3.8 ± 0.8	4.0	4.3	<8.0	–	–
Pulses							
Broad beans	4	1.0 ± 0.5	0.9	1.5	<8.0	–	–
Fruits							
Apple	4	<1.0	–	–	28.6 ± 4.0	28.6	32.3
Kiwi	3	<1.0	–	–	16.7 ± 7.2	15.8	22.6
Orange	6	<1.0	–	–	32.0 ± 6.5	32.7	38.2
Mandarin	5	<1.0	–	–	10.2 ± 3.3	9.2	13.7

[a] Number of different samples analysed.

in its products but does not automatically or necessarily reduce the heavy metal content of all organic products (Pussemier et al., 2006).

Apparently, other factors beyond those controlled by the applied organic cultivation practices could significantly affect the cadmium and lead content of the produced food-

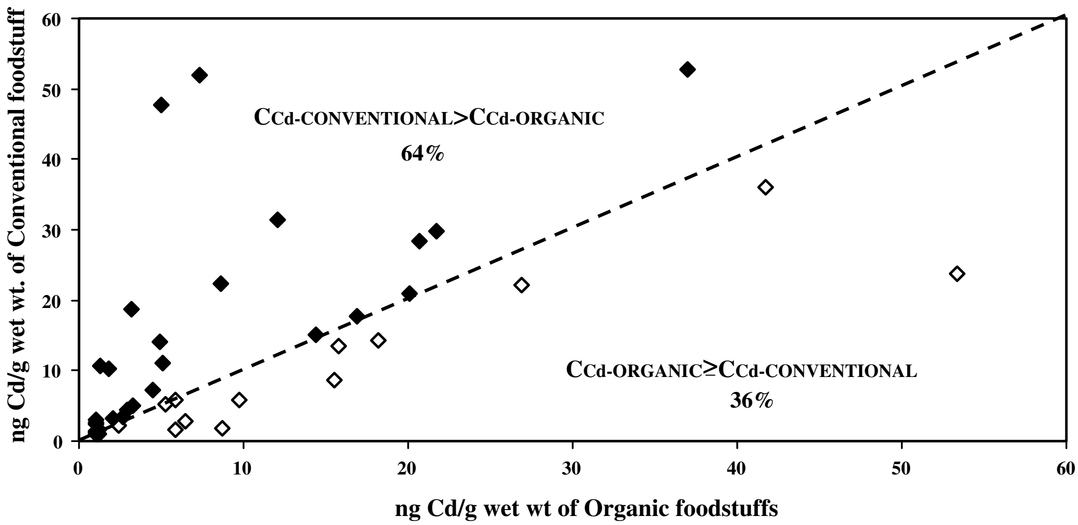

Fig. 3. Comparison of cadmium content between certified organic and conventional foodstuffs.

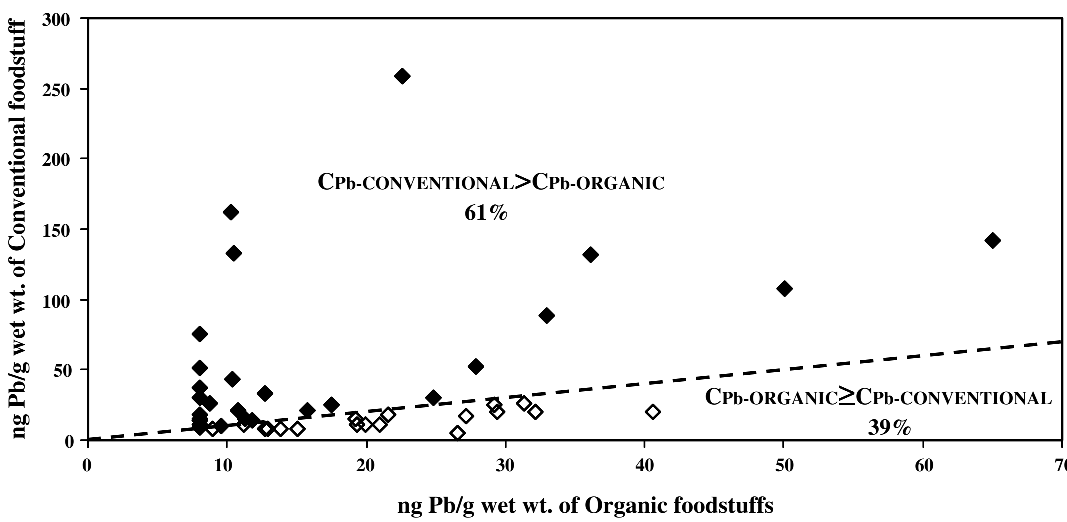

Fig. 4. Comparison of lead content between certified organic and conventional foodstuffs.

stuffs. Some of the possible reasons include sporadic contamination from nearby sources of pollution (e.g., industries, motorways, etc.) mostly via dry or wet atmospheric deposition and precipitation mainly during the growing seasons (Woese et al., 1997; Jorhem & Slanina, 2000; Scoullos et al., 2001; Karavoltsos et al., 2002; Malmauret et al., 2002), as well as the impact of the soil either due to changes in the pH or to accumulation of metals through the application of fertilizers for many decades (Magkos, Arvaniti, & Zampelas, 2003). Greek farmers apply commercial phosphate fertilizers, a part of which were produced by phosphorite ores imported mainly from African countries rich in cadmium (Scoullos et al., 2001). As a result, the two or three year conversion period in farms demanded by official regulations in order to be certified as suitable for organic farming, appears to be inadequate for the passive remediation of most of the agricultural lands regarding metals, a view which is also supported by the Organic Trade Association (Fischer, 1999). Furthermore, through the use of manure, usually applied in traditional agricultural systems, significant amounts of metals, particularly cadmium, may also be deposited to the soil. The situation becomes even more complicated, taking into consideration that increased metal levels in different soils, under different organic content conditions, result in different metal accumulation by the various different plants cultivated there and thus the final metal content in the foodstuffs produced by these plants may vary considerably from very low to high (Moolenar & Lexmond, 1999).

4. Conclusions

Careful examination of the results of the present work based on the analysis of 52 different kinds of organic foodstuffs and beverages from the Greek market indicates that in the majority (more than 60%) of the products examined the certified organic products have lower cadmium and lead content than the relevant conventional ones. In some samples of the non-certified organic products examined some of the highest cadmium and lead concentrations were detected.

These observations demonstrate that properly observed practices for organic agriculture could eventually lead to production of foodstuffs with lower metal content although organic agriculture as such is not able to secure low metal contents in its products unless additional provisions are observed. Obviously the metal content is influenced by a variety of environmental factors irrelevant or marginally connected to agricultural practices such as high background levels in the soil (due to different mineralogy) or high overall metal pollution in the soil, in the atmosphere and in irrigation waters. The legacy of long term use of rich in cadmium phosphorous fertilizers, etc., in cultivations under transition should be also taken into account.

A new legislation was presented recently in Greece geared towards addressing such problems in an attempt to systematize the control and certification processes of organic products.

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