Original articles

Is there any potential health risk of heavy metals through dietary intake of olive oil that produced in Morphou, Cyprus

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Summary. *Background and Objective:* The purpose of this study was to assess concentrations of heavy metals in olive oils, and to assess the potential health risks using the Daily Intake of Metal (DIM) and the Health Risk Index (HRI) of these metals via dietary intake of olive oil. *Methods and Study Design:* A total of 500 adults aged 30-49 years were included in the study to investigate the average dietary intake of olive oil, and the average body weight of the study population. In addition, a total of 27 natural olive oil samples were analyzed for heavy metals using Inductively Coupled Plasma-Mass Spectrometer with three replications. Concentrations of heavy metals were determined in olive oils produced in Morphou and Lefka. Furthermore, potential health risks of heavy metals via dietary intake of olive oil were calculated. *Results:* The results showed that the mean levels of ^{52}Cr, ^{59}Co, ^{60}Ni, ^{75}As, ^{111}Cd, ^{208}Pb, ^{57}Fe, ^{65}Cu, and ^{66}Zn in the olive oil samples were 123.83±44.70 ng/ml, 0.81±2.20 ng/ml, 30.18±9.77 ng/ml, 0.87±1.46 ng/ml, 1.53±2.02 ng/ml, 27.72±28.77 ng/ml, 875.06±806.85 ng/ml, 7.85±13.54 ng/ml, and 469.36±312.86 ng/ml, respectively. Also, HRI was calculated as less than 1 for all heavy metals. *Conclusions:* According to the results of the current study, although health risk assessment showed no potential risk for the local population through the consumption of olive oil, it is very important to assess the health risks of ingesting heavy metals with dietary intake of other frequently consumed foods in the studied region.

Keywords: Olive oil consumption, potential health risk, public health nutrition, local population, heavy metals

Introduction

Dietary intake of olive and olive oil is an important feature of the traditional Mediterranean diet (1). Olive oil contains mainly oleic acid and some biologically active phenolic compounds that protect the human health from chronic diseases (2). Besides this, it was stated that heavy metals could pass into and contaminate the olive oils. The presence of heavy metals in olive oils depend mainly on contamination of the soil and the environment. Moreover, heavy metals could pass through to olive oils from fertilisers, metal containing pesticides, and metal processing equipments (3-8).

Living organisms require varying amounts of essential heavy metals, namely iron (Fe), cobalt (Co), copper (Cu), manganese (Mn), and zinc (Zn) are required for biochemical processes (9), but excessive concentrations can prevent normal vital functions of an organism and can be harmful to human health (10). Heavy metals such as mercury (Hg), cadmium (Cd), arsenic (As) and lead (Pb) are considered to be the most toxic metals for humans. Toxic heavy metals can cause modification of biological molecules and oxidative stress, and can lead to cell damage or death (11, 12). According to these effects, some heavy metals are known as carcinogenic, mutagenic, teratogenic, and endocrine disruptors, while others cause neurological and behavioral disorders (11). Furthermore, exposure of heavy metals may lead to intrauterine growth retardation, psycho-social behavioral disorders, immune functions failure, and upper gastro-intestinal system cancers (13, 14). Furthermore, contamination of foods with heavy metals impairs the absorption of some essential nutrients (15).

Heavy metals are normal compartments of the ecosystem and are present in soil, water, and air. Heavy metals enter the human body via respiration and dermal contact, and via contaminated food and drinking water (16). Heavy metals accumulate in the environment and subsequently contaminate the food chain. This contamination poses a risk to the environment and human health (11). Food chain contamination is one of the important pathways for human exposure to these toxic elements (17, 18). For this reason, it is important to evaluate the heavy metal concentrations, avarage daily intakes, and potential human health risks in commonly consumed foods, especially in developing countries (19-26).

The aim of this study was to investigate the concentrations of Chromium (Cr), Fe, Co, Ni, Cu, Zn, As, Cd, and Pb in olive oils, and secondly assess the potential health risks using the Daily Intake of Metal (DIM) and the Health Risk Index (HRI) of these metals via dietary intake of olive oil produced in Morphou and Lefka, Northern part of Cyprus.

Methods

Study Population

This study was conducted in Morphou and Lefka districts. Total population at that area is 30,037 and 7974 of the them are between the ages of 30-49 years (27). A total of 500 adults (42.2% men, 57.8% women) between the ages of 30-49 were included in the study to investigate the average olive oil consumption and average body weight.

Concentrations of Cr, Fe, Co, Ni, Cu, Zn, As, Cd ve Pb were determined in olive oils produced in Morphou and Lefka districts. Furthermore, potential health risks of ingesting heavy metals via dietary intake of olive oil were calculated.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Ethics Committee at the Hacettepe University (date:17.04.2014, decision no:431-1391). Written informed consent was obtained from all subjects/patients.

Dietary Intake of Olive Oil

A food frequency questionnaire (FFQ) was used to quantize the participants' dietary intake of olive oil. The FFQ was performed face to face. Daily avarage dietary intake of olive oil was assessed by examinining the consumption frequency and consumption amount of olive oil (28).

Body Weight

Body weights were taken with a TANITA BC420 MA body composition analyzer. All of the participants' body weights were taken after a minimum of 3 hours fasting period, without footware, and with thin clothes (28). Body composition measurements were also taken with the TANITA BC420 MA body composition analyzer, but the data obtained was not included in this study.

Heavy Metal Analysis of Olive Oils

A total of 27 olive oil samples were taken to determine the heavy metal concentrations of olive oils produced in Morphou and Lefka districts. All samples were from the same harvest time. ^{52}Cr, ^{57}Fe, ^{59}Co, ^{60}Ni, ^{65}Cu, ^{66}Zn, ^{75}As, ^{111}Cd, and ^{208}Pb analysis of olive oils were conducted with Inductively Coupled Plasma – Mass Spectrometer (Thermo Scientific X Series II ICP-MS).

Prior to analysis by ICP-MS, the samples were digested using the closed CEM Mars 5 microwave digestion system [Operation Parameters as follows; Power 1200W, Ramping temperature (15:00 min.), Pressure (800 psi), Temperature (200°C), Holding time (15:00 min.)]. In order to validate the microwave method for accuracy and precision, a certified reference material (CRM) for oil (109469 Multi-element Standard II Oil Dissolved) was analyzed for the corresponding elements.

For the quantitative analysis of oils, calibration curves were built on six different concentrations. Standard solutions were prepared by diluting a multi-element solution containing As, Cd, Cr, Co, Cu, Fe, Pb, Ni, and Zn. The working concentration range for

As, Cd, Cr, Co, Cu, Ni, Pb, and Zn was 0.1-100 ng/ml, whereas it was 5-200 ng/ml for Fe.

All of the measurements were carried out using the full quantitative mode analysis. Each analysis was performed three times.

Health Risk Assessment

In order to evaluate the potential health risks of consumption of olive oil the DIM and HRI were calculated using following formulas:

$$DIM = (C_{metal} \times D_{food\ intake}) / Bw$$

C_{metal}= concentration of metal in the olive oil (μg/g)

$D_{food\ intake}$= daily intake of olive oil (kg/day)

Bw= human body weight (kg)

$$HRI = DIM / RfD$$

RfD: Reference oral dose for the metal (mg/kg of Bw/day)

DIM shows the amount of heavy metal intake to the human body through consumed food. Reference oral dose (RfD) is an estimation of a daily oral exposure for the human population which does not cause deleterious effects during one's lifetime; generally used in EPA's non-cancer health assessments (29). Human health risks caused by the intake of metal-contaminated foods were evaluated using HRI. HRI is the ratio between DIM and the RfD. If the HRI is lower than 1, then there is no potential health risks for the human (30).

Participants' body weight and olive oil consumption measurements were taken by the researchers for this study. Individual body weight and olive oil consumption measurements were used for calculating DIM, RfD and HRI. Heavy metal concentrations of olive oils were also used for calculating DIM.

RfD of Cd (0.001 mg/kg Bw/day), Ni (0.02 mg/kg Bw/day), Cr (1.5 mg/kg Bw/day), and As (0.003 mg/kg Bw/day) were taken from Integrated Risk Information System (US-EPA), and RfD of Fe (0.8 mg/kg Bw/day), Cu (0.5 mg/kg Bw/day), Zn (0.3 mg/kg Bw/day), and Pb (old value-0.025 mg/kg Bw/day) were taken from Evaluations of the Joint FAO/WHO Expert Committee on Food Additives (JECFA). There is no consensus for the RfD of Co, and the National Institute of Public Health and the Environment references used for Co and Tolerable Daily Intake (TDI) of Co were estimated as 0.0014 mg/kg Bw/day (31-33).

Statistical analysis

The results are expressed as mean ± SD (minimum-maximum). Data analysis and the significance of differences were determined with independent samples' *T*-tests. Statistical significance was set at $p<0.05$. SPSS 20.0 packet program was used for all statistical analysis.

Results

Dietary Intake of Olive Oil

Average dietary intake of olive oil was found to be 27.59±15.93 g/day for all participants, and 32.35±17.49 g/day for men, and 25.33±14.63 g/day for women respectively. The average body weight of men was 86.9±16.48 kg, and that of women was 67.7±13.51 kg (Table 1).

Heavy Metal Concentrations of Olive Oils

The concentrations of Cr, Co, Ni, As, Cd, Pb, Fe, Cu, and Zn of olive oils are given in Table 2. The mean concentrations of heavy metals in olive oils of ^{52}Cr, ^{59}Co, ^{60}Ni, ^{75}As, ^{111}Cd, ^{208}Pb, ^{57}Fe, ^{65}Cu, and ^{66}Zn were 123.83±44.70 ng/ml, 0.81±2.20 ng/ml, 30.18±9.77 ng/ml, 0.87±1.46 ng/ml, 1.53±2.02 ng/ml, 27.72±28.77

Table 1. Daily dietary intake of olive oil and average body weight of participants

	Men (n=211)	**Women (n=289)**	**Total (n=500)**
	$\bar{\chi}$± SD (min-max)	$\bar{\chi}$± SD (min-max)	$\bar{\chi}$± SD (min-max)
Olive Oil Consumption (g/day)	32.35±17.49 (3.2-80.0)	25.33±14.63 (2.0-90.0)	27.59±15.93 (2.0-90.0)
Olive Oil Consumption (kg/year)	11.80±6.38 (1.16-29.20)	9.24±5.34 (0.7-32.85)	10.07±5.81 (0.7-32.85)
Body weight (kg)	86.9±16.48 (54,7-165.0)	67.7±13.51 (41.0-128.9)	73.8±17.06 (41.0-165.0)
Olive oil consumption per kg (Olive oil/body weight)	0.38±0.21 (0.03-1.06)	0.38±0.23 (0.02-1.45)	0.38±0.22 (0.02-1.45)

Table 2. Mean concentrations of heavy metals in olive oils

Heavy metals	*Heavy Metal Concentrations*			
	$\bar{\chi}$	SD	min	max
^{52}Cr (ng/ml)	123.83	44.70	50.81	217.96
^{59}Co (ng/ml)	0.81	2.20	nd	12.17
^{60}Ni (ng/ml)	30.18	9.77	11.87	53.84
^{75}As (ng/ml)	0.87	1.46	nd	7.39
^{111}Cd (ng/ml)	1.53	2.02	nd	6.98
^{208}Pb (ng/ml)	27.72	28.77	nd	126.32
^{57}Fe (ng/ml)	875.06	806.85	74.90	4248.76
^{65}Cu (ng/ml)	7.85	13.54	nd	49.14
^{66}Zn (ng/ml)	469.36	312.86	nd	1131.89

ng/ml, 875.06±806.85 ng/ml, 7.85±13.54 ng/ml, and 469.36±312.86 ng/ml respectively.

Potential health risk index for population

Potential risk to human health from the intake of metal contaminated olive oils was calculated using DIM and HRI. Values of DIM and HRI calculated for the study population are presented in Table 3.

Daily intake amounts of Cr, Co, Ni, As, Cd, Pb, Fe, Cu and Zn were 4.77 X 10^{-5}, 3.14 X 10^{-7}, 1.17 X 10^{-4}, 3.37 X 10^{-6}, 5.93 X 10^{-6}, 1.07 X 10^{-4} , 3.39 X 10^{-3}, 3.04 X 10^{-5}, and 1.82 X 10^{-3} respectively. The dietary intake amounts of Cr, Co, Ni, As, Cd, Pb, Fe, Cu, and Zn were found to be lower than the recommended values. Health Risk Index for Cr, Co, Ni, As, Cd, Pb, Fe, Cu, and Zn were 2.26 X 10^{-2}, 2.24 X 10^{-3}, 5.58 X 10^{-3}, 1.12 X 10^{-3}, 5.93 X 10^{-3}, 3.07 X 10^{-2}, 4.24 X 10^{-3}, 6.08 X 10^{-5}, and 6.06 X 10^{-3} respectively. If the ratio is less than 1, there are not any obvious risks (30). HRI was calculated as less than 1 for all heavy metals.

Discussion

There are studies concerning the heavy metal contamination in vegetable oils (34-39), however, to our knowledge, there are few studies about the health risk assessment (40). The main objective of this study was to determine the concentrations of heavy metals in olive oils consumed in Morphou and estimate the potential human health risk factors from individual consumption.

Table 3. Daily Intake of Metal (DIM) and Health Risk Index (HRI) of heavy metals via dietary intake of olive oil produced in Morphou and Lefka

	DIM	HRI
Men		
Cr	4.74 X 10^{-5}	2.66 X 10^{-2}
Co	3.12 X 10^{-7}	2.23 X 10^{-3}
Ni	1.16 X 10^{-4}	5.81 X 10^{-3}
As	3.35 X 10^{-6}	1.11 X 10^{-3}
Cd	5.90 X 10^{-6}	5.89 X 10^{-3}
Pb	1.06 X 10^{-4}	3.05 X 10^{-2}
Fe	3.37 X 10^{-3}	4.21 X 10^{-3}
Cu	3.02 X 10^{-5}	6.05 X 10^{-5}
Zn	1.80 X 10^{-3}	6.03 X 10^{-3}
Women		
Cr	4.78 X 10^{-5}	2.08 X 10^{-2}
Co	3.15 X 10^{-7}	2.25 X 10^{-3}
Ni	1.17 X 10^{-4}	5.86 X 10^{-3}
As	3.38 X 10^{-6}	1.12 X 10^{-3}
Cd	5.95 X 10^{-6}	5.95 X 10^{-3}
Pb	1.07 X 10^{-4}	3.08 X 10^{-2}
Fe	3.40 X 10^{-3}	4.25 X 10^{-3}
Cu	3.05 X 10^{-5}	6.10 X 10^{-5}
Zn	1.82 X 10^{-3}	6.08 X 10^{-3}
Total		
Cr	4.77 X 10^{-5}	2.26 X 10^{-2}
Co	3.14 X 10^{-7}	2.24 X 10^{-3}
Ni	1.17 X 10^{-4}	5.58 X 10^{-3}
As	3.37 X 10^{-6}	1.12 X 10^{-3}
Cd	5.93 X 10^{-6}	5.93 X 10^{-3}
Pb	1.07 X 10^{-4}	3.07 X 10^{-2}
Fe	3.39 X 10^{-3}	4.24 X 10^{-3}
Cu	3.04 X 10^{-5}	6.08 X 10^{-5}
Zn	1.82 X 10^{-3}	6.06 X 10^{-3}

Dietary Intake of Olive Oil

Olive oil is a common component of the Mediterranean Diet. Olive oil has important effects on serum lipoprotein levels, atherosclerosis, hypertension, cardiovascular diseases, and thrombotic risk, oxidative stress, obesity, type 2 diabetes, inflammation, and cancer (1). Dietary intakes of olive oil in Spain, Italy and Greece were found to be 33 g/day for men and 27 g/day for women, 20.7 g/day for men and 15.2 g/day for women, 40.6 g/day for men and 29.4 g/day for women respectively (41). Dietary intakes of olive oil were found to be 32.35±17.49 g/day for men and 25.33±14.63 g/day for women in this study. Cyprus is an island in the Mediterranean region and the main dietary source of oil is olive oil like the other Mediterranean populations. For that reason, it was thought that the average olive oil consumption is found as much high as other Mediterranean countries like Spain and Greece.

Heavy Metal Concentrations of Olive Oils

Heavy metals can pass through to olive oils from the contaminated soil and environment. Soil's composition, contaminated water, metal based pesticides and fertilizers, industrial emissions, harvesting processes, storage and transportation are the main factors that affect the heavy metal concentrations in olive oil. The concentrations of the metals that are present in small amounts differ according to the olive oils' origin and growing conditions (3-8).

The high level of copper (Cu) in olive oil causes peroxidation of fatty acids. Also, copper adversely affects the quality of olive oil, especially its organoleptic properties (42). It is stated that there is copper in the archaeological structure of Cyprus. Cu and mining operations were carried out by the Cyprus Mining Corporation (CMC) in the Lefka region of the Northern Cyprus between 1913 and 1974. Iron and copper containing sulfur compounds in mining areas cause heavy metal contamination in drinking water and irrigation water (43). It is recommended that the concentration of copper found in the food should not exceed 0.1 mg/kg (44). Despite all, in this study the concentration of copper in olive oil was found to be 7.85±13.54 ng/ml, whichis similar to other studies (34-38).

High iron concentration affects the taste and the oxidative stability of the oils. The increase in Fe peroxide levels accelerate the oxidation of the oil (45). The area where the olive tree is grown, the origin of the olive, the processing methods, and the contamination occurring during storage can affect the iron content in the olive oils (3-8). The mean concentration of ^{57}Fe is 875.06±806.85 ng/ml in this study. Iron concentration of olive oil samples in some of the other studies was <40-550 ng/g. Iron concentration of olive oil samples in this study is higher than those studies (35-38). It is thought that this may be due to the iron, pyrite, and copper sulfide mineralization of the Trodos Mountain deposits in Northern Cyprus (43). Also, it has been determined that the type and quality of the olive oil may affect the olive oil heavy metal content (38). A report published in the USA in 2010 stated that the Fe concentrations of olive oils should be ≤3.0 mg/kg (46). In this study, the Fe concentrations of natural olive oils was found to be below 3 mg/kg.

Zinc concentration of Sicilian olive oils was found to be 157.00-385.22 ng/g (4). Zinc concentration of virgin olive oils produced in Sicily and Apulia was found to be 161.9-335.0 ng/g (42). Zinc concentration of natural olive oils in Turkey was found to be 292.69-341.32 ng/ml (34). The mean concentrations of heavy metals in natural olive oils for ^{66}Zn was 469.36±312.86 ng/ml in this study. Zinc concentration was found to be higher in this study. Zinc concentration of olive oils vary according to the water, air and soil contamination, metal based pesticides and fertilizers, and industrial emissions (3-8).

Chromium can pass from the metal equipment and materials that are used in olive oil production. Also, other factors like water, air and soil contamination affect the olive oil's chromium content (3-8). The mean concentrations of heavy metals in olive oils for ^{52}Cr was 123.83±44.70 ng/ml. Chromium concentration of olive oil samples in some of the other studies was about 18-261.3 ng/g (34-38).

Nickel and cobalt concentrations can change according to the regional differences (11). Nickel concentration of natural olive oils was 71.3-75.8 ng/ml in Turkey (34), nickel concentration of virgin olive oils was 0-46.9 ng/g in Italy (35), and nickel concentration of extra virgin olive oils was 19.49 μg/kg in Spain (37). Nickel concentration of natural olive oils in this study was found to be 30.18 ng/ml. Cobalt concentrations of Italian virgin and extra virgin olive oils was found to be 0.003-0.006 μg/kg (39) and 0.023-0.413 ng/g (35) respectively. Cobalt concentration of olive oils were <1.5 ng/g in Spain (36), 2.30-2.43 ng/ml in Turkey (34), 0.92 μg/g in Croatia (6) and 0.81±2.20 ng/ml in this study. Analysis of the metals in different categories of olive and olive-pomace oils showed that the type and quality of the olive oil may affect the olive oil heavy metal concentrations (38).

Pb, As, Cu, Cr, and Cd are important toxic heavy metals and have been identified as health risks by

World Health Organization (33). People are exposed to Pb, As, Cu and Cd mainly through food and drinking water (17, 18). Toxic heavy metals like cadmium, arsenic, and lead can cause oxidative stress and can lead to cell damage and can interact with cellular molecules. Cadmium accumulates principally in vital organs, especially in kidneys and liver (11, 12). It was found that Cd concentrations of olive oils in Sicily were <1.2 ng/g (4, 5). Cadmium concentrations of Italian virgin olive oils was found to be 0.088-0.366 ng/g (35). Cadmium concentration of natural olive oils were <1.5 ng/g in Spain (36).

Lead can be present in olive oils because of enviromental contamination. The local exposure should be estimated considering the transmission of metallic pollutants due to the industry and chemicals used in the olive tree growing methods. In addition, lead content of olive oil can be affected by whether the area where the olive tree is growing is close to traffic (3-8). It has been found that the Pb content of olive oils (4-6, 34, 36) are considerably below the maximum residue limit (0.01 μg/g) (44). Content of olive oils in different studies (34, 35, 38) and in this study were below the maximum residue limit (44).

Potential health risks of heavy metal intake with dietary intake of olive oil

Food chain contamination is one of the important pathways for human exposure to toxic elements (17, 18). For this reason, it is important to evaluate the heavy metal concentrations, avarage daily intakes, and potential human health risks in commonly consumed foods, especially in developing countries (19-26, 47, 48). The human health risks of heavy metals that enter the body by foods are assessed by various formulas (4, 5, 49-51).

DIM and HRI of heavy metals via dietary intake of olive oil produced in Morphou and Lefka were evaluated in this study (table 3). It is the first study where the individuals' own body weight measurements and their daily average dietary intakes of olive oil were taken by a food consumption survey and were used to calculate DIM and HRI.

HRI value >1 indicates a risk for human health and HRI <1 means the exposed population is assumed to be safe (30). All HRI values were determined as <1 in this study. Accoring to this, dietary olive oil intake was shown not to pose any potential health risks for the adult population in Morphou and Lefka. We did not find any studies that evaluates the potential health risks of heavy metals with dietary intake of olive oil by HRI formula. For this reason, the HRIs arising from the intake of heavy metals with commonly consumed foods in different countries have been discussed.

F. Zhu et al. (40) determined the health risk assessment of heavy metal (Cu, Zn, Fe, Mn, Cd, Ni, Pb, As) concentrations in edible vegetable oils consumed in China. It was found that the dietary intakes of these heavy metals from a weekly consumption of 175g of edible vegetable oils, or a daily consumption 25g of edible vegetable oils for a 70kg individual should pose no risk to human health. In this study, it was also determined that consumption of olive oil in similar quantities and dietary heavy metal intakes were not within the limits that could pose a risk for human health.

Khan et al. (52) conducted a study to investigate the concentrations of heavy metals (Cd, Cu, Ni, Pb and Zn) in vegetables, and the human health risks caused by ingestion of contaminated vegetables in northern Pakistan. As a result, HRI values were found to be within the safe limit (<1) except for Pb. In another study, it was determined that Cd and Cu contamination posed a risk (HRI >1), but Zn intake did not pose any risks (HRI<1) to local population through vegetable consumption in India (19). Additionally, HRIs of the studied metals (Cd, Cr, Cu, Ni Pb, and Zn) were <1, indicating that there is a relative absence of health risks associated with the ingestion of contaminated vegetables in China (53). In a study that aimed to investigate the concentrations of Cd, Ni, Pb, Co, and Cr in the most frequently consumed vegetables in Brazil, risk to human health by the intake of metal-contaminated vegetables was characterized using the hazard quotient (HQ) which is similar to HRI. Consequently, dietary intake of these vegetables can be considered safe and without any risks to human health (54). Huang at al (17) analyzed 343 vegetables for the concentrations of As, Cd, Hg, and Pb, and evaluated the health risks by calculating the health hazard index (HI). At the mean exposure level, all HIs were less than the threshold of 1. This indicates that for the general population there is low health risks of ingesting As, Cd, Hg, and Pb via the vegetable intake in China. Singh et al (55) conducted a study to assess the risks to human health caused by heavy metals (Cd, Cu, Pb, Zn, Ni, and Cr) through the intake of locally grown vegetables and cereal crops in India. Rice and wheat grains contained less heavy metals compared to the vegetables, but HRI of rice and wheat grains were greater than that of the vegetables due to higher consumption of cereals in the diet.

Since rice is one of the most important foods, a total of 70 rice seed samples were collected from paddy fields in five regions of Southwest Iran. It was found that, long term dietary intake of the local rice may bear a high risk of heavy metal exposure to the humans in the study region (20). Conversely, Shirani et al showed that for the general population there are no health risks to Pb, As, and Cd ingested via rice intake in Iran (48). In a systematic review, estimated weekly intakes for Cd, Pb, As, Cu, Zn, Cr, Ni, and Co did not exceed the provisional tolerable weekly intake values. Accordingly, the rice types consumed in Iran have no health hazards for the population (56).

Orisakwe et al. (57) assessed lead, cadmium, and nickel levels in commonly consumed food crops and fruits in Nigeria. Daily intake rates (g $person^{-1}day^{-1}$) of heavy metals through consumption of contaminated food crops and fruits were calculated. It was stated that local food crops commonly available in South Eastern Nigeria villages may contribute to the excessive accumulation of heavy metals in the body. In an another study, it was found that consumption of vegetables in Nigeria could be one of the contributory factors to the heavy metal accumulation among the population due to their frequent consumption (22).

Conclusion

Heavy metals have been known to be a major environmental problem. They can enter into the human body via food, water and air. Heavy metals can be toxic, even in relatively low concentrations and therefore pose adverse health risks to humans. In this regard, it was the first time in Northern part of Cyprus, that a study was conducted to determine metal concentrations of heavy metals in olive oils, and assess the potential health risks through the these metals via dietary intake of olive oil. It therefore appears that they are not any potential health risks of exposure from olive oil consumption in Morphou and Lefka. Beside this, the olive oil heavy metal concentrations can vary from region to region. This study provides some baseline information for further studies in this field. It is important to determine the health risks of heavy metals with dietary intake of other frequently consumed foods because intakes of these heavy metals will increase with dietary intake of other foods such as vegetables and cereals.

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