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Determination of Aflatoxin and Heavy Metal Levels in Some Spices Sold as Unpackaged in Van Province and Health Risks Assessment of Heavy Metals

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ABSTRACT
Aim: This study aimed to determine the aflatoxin and heavy metal levels in the samples of unpackaged red pepper, black pepper and cumin sold in Van and to estimate the health risks of heavy metals. **Materials and Methods:** In 60 samples (20 of each spice sample) obtained from herbal shops and markets, aflatoxin analysis was done with HPLC device and heavy metal analysis was done with ICP-MS device. **Results:** Although AFG_1 and AFG_2 were not detected in all spice samples, AFB1 and AFB_2 were not detected in all cumin samples, AFB_1 was detected in all red pepper samples and only one black pepper samples, and AFB_2 in 18 red pepper samples. As a result of heavy metal analysis, the average concentration of Ni, Cd, Pb and Al were 5.08, 0.35, 2.47, 392.45 ppm in black pepper, 9.12, 0.20, 1.40, 514.4 ppm in cumin and 8.95, 0.06, 0.11, 33.75 ppm in red pepper, respectively. Arsenic was detected only in cumin and its average concentration was 0.06 ppm. **Conclusion:** In 90% (18 samples) of red pepper samples, AFB_1 was detected above the permisisble limit value in Turkish food codex. The Cd level in black pepper samples and Ni levels in all spice samples determined in this study were above the limit values. According to daily intake tolerance limits, although Ni, As, and Cd levels in spices do not pose any risk, Al in all spice samples and Pb levels in black pepper samples are above the daily intake tolerance limits. Spice samples do not pose risk of non-carcinogenic effects, as THQ exposure values are less than 1.
Keywords: Spice, Aflatoxin, Heavy Metal, Health Risk Assessment.

Van İlinde Ambalajsız Olarak Satılan Bazı Baharatlarda Aflatoksin ve Ağır Metal Düzeylerinin Belirlenmesi ve Ağır Metallerin Sağlık Risklerinin Değerlendirilmesi

ÖZ
Amaç: Bu çalışmanın amacı, Van ilinde ambalajsız olarak satılan kırmızıbiber, karabiber ve kimyon çeşitlerindeki aflatoksin ve ağır metal düzeylerinin belirlenmesi ve ağır metallerin sağlık risklerinin tahminlerinin yapılmasıdır. **Gereç ve Yöntem:** Aktarlardan ve marketlerden toplanan 60 adet örnekte (her baharat örneğinden 20'şer adet) aflatoksin analizi HPLC cihazı ile ağır metal analizi ise ICP-MS cihazı ile yapılmıştır. **Bulgular:** Baharat örneklerinin tümünde AFG_1 ve AFG_2, kimyon örneklerinin tümünde AFB_1 ve AFB_2 tespit edilmediği halde, kırmızıbiber örneklerinin tümünde, karabiber örneklerinin sadece 1 tanesinde AFB_1 ve kırmızıbiber örneklerinin 18 tanesinde AFB_2 belirlenmiştir. Ni, Cd, Pb ve Al'un ortalama değerleri sırasıyla karabiberde 5.08, 0.35, 2.47, 392.45 ppm, kimyonda 9.12, 0.20, 1.40, 514.4 ppm ve kırmızı biberde 8.95, 0.06, 0.11, 33.75 ppm olarak tespit edilmiştir. Arsenik ise sadece kimyonda tespit edilmiştir ve ortalama değeri 0.06 ppm'dir. **Sonuç:** Kırmızı biberlerin %90'ında (18 örnek) Türk Gıda Kodeksinde izin verilen sınır değerin üzerinde AFB_1 saptanmıştır. Karabiberde tespit edilen Cd ve tüm baharat örneklerindeki Ni düzeyi maksimum izin verilebilir sınır değerlerin üzerindedir. Günlük alım tolerans limitleri göre baharatlardaki Ni, As ve Cd düzeyleri herhangi bir risk oluşturmadığı halde tüm baharat örneklerinde Al, karabiber örneklerinde Pb düzeyi günlük alım tolerans limitlerinin üstündedir. THQ maruziyet değerleri, 1'den küçük olduğu için baharat örnekleri kanserojen olmayan etki riski taşımamaktadır.
Anahtar Kelimeler: Baharat, Aflatoksin, Ağır Metal, Sağlık Riski Değerlendirmesi.

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INTRODUCTION

Spices, which consist of leaves, flowers, seeds or juices of plants, are food additives with specific odors and flavors, used to increase appetite, facilitate digestion and for preservative purposes. Spices, which are widely used in the food industry and at home, play an important role in the aroma and flavor change of foodstuffs (Uner et al., 2000). Most of the spices used in food production are contaminated to varying degrees by mold spores, yeasts and bacteria (Gecan et al., 1986). Molds, which can resist preservation and storage techniques such as heating, freezing, antibiotic and radiation application, cause mycotoxin formation in foods. Among the mycotoxins, AF is the most important. AF, which can cause acute, subacute and chronic poisoning when ingested by humans and animals, is the substance with the highest potential to cause liver cancer in humans and is evaluated as group I carcinogens by the World Cancer Research Center (IARC) (Hazir & Coksoyler, 1998). Apart from liver cancer, AF also has many important toxic effects such as suppressing the immune system and causing deterioration in protein metabolism (Williams et al., 2004).

Heavy metals are one of the most important food contaminants threatening human health in recent years. The closeness of the cultivation areas to the city, unplanned urbanization, domestic and industrial wastes, heavy metals emitted from the chimney smoke or the exhausts of motor vehicles adversely affect all living things in the ecosystem (Okcu et al., 2009). Heavy metals taken into the body by consuming a food contaminated with heavy metals, depending on the concentration and accumulation in the tissues, it can lead to important health problems in chronic dimensions (Jarup, 2003). Most of the health problems caused by heavy metals are chronic diseases or cancers that require advanced diagnosis and treatment. Toxic heavy metals that people can come into contact with frequently due to daily use and environmental pollution are arsenic, mercury, lead, cadmium, nickel and aluminum (Freedman, 1995).

Prolonged consumption of foods containing high amounts of aflatoxin and heavy metals may pose a problem for public health. For this reason, it is important to determine the levels of aflatoxin and heavy metals in spices such as red pepper, black pepper and cumin, which are consumed by constantly participating in meals, in order to raise awareness of the society and protect consumer health. This study was planned to determine the levels of aflatoxin and heavy metals in red pepper, black pepper and cumin samples used as spices to add flavor to foods in Van province and to predict the health risks of heavy metals. Thus, possible risks in terms of public health were evaluated by revealing the aflatoxin and heavy metal levels in these spice samples.

MATERIALS AND METHODS

Sample collection

A total of 60 samples of red pepper (n=20), black pepper (n=20) and cumin (n=20) were obtained from herbal shops and local markets in Van province in 2018. Samples of 50 grams, which were placed in sterile bags, were delivered to the laboratory in a short time.

Measurement of aflatoxin

Analysis of aflatoxin in the samples was performed with high performance liquid chromatography (HPLC) device (Agilent, 1100 series, U.S.A.) with fluorescent detector, after purification using an immunoaffinity column (IAK). As a method, the method of AOAC (2000) (999.07) was used.

Measurement of heavy metals

For determination of heavy metal concentrations, a wet digestion of the dried samples was done according to the method described by Allen (1986) using %65 HNO_3 and $HClO_4$ mixture. Each sample was weighed about 0.5 g and then combined with a 10 ml of 3:1 acid mixture (HNO_3 and $HClO_4$). After waiting for a while, the mixture was heated up to 70 ^{0}C until a transparent solution was obtained. The clear solution was transferred into 25 ml volumetric flask, and completed to the mark with double distilled deionized water. Blanks were also prepared according to the same digestion procedure for comparison. The metal content analysis of the samples was performed with an ICP-MS device (Thermo Scientific UK, X Series 2). The metal levels in the studied spice samples were compared with the Maximum permissible limits (MPL) in spices determined by WHO/FAO (2007). No maximum limit is specified for Al in spices.

Heavy metal health risk assessment

Estimated Daily Intake (EDI) and target hazard quotient (THQ) calculations were made to determine possible consumer risks from spice consumption. In calculations, average adult body weight was considered to be 60 kg for adult and life expectancy is 70 years (USEPA, 2000). An average daily consumption of 0.01 kg of spices was assumed in this study. This method was adapted because spices are widely consumed as a major part of the diet (Asomugha et al., 2016).

Calculation of the daily heavy metal intake:

$EDI = (C_{metal} \times D_{food\ intake}) / BW_{average}$

Where:

EDI: Estimated daily intake (mg/kg/day)

C - the metal concentration in spices in mg/kg,

D - the daily intake of food in kg person^{-1} (0.01 kg)

BW - average body weight in kg person^{-1} (60 kg)

Calculated EDI values were compared with estimated daily intake limits reported by WHO/FAO (2011) and JEFCA (2011). While the instrumental analysis results were used directly for all the metals examined during the calculations, but a different conversion factor was applied for As. Since a significant part of the As in the tissues is in organic form, they do not show as much toxic effects as inorganic forms (Castro-Gonzalez & Mendez-Armenta, 2008). Therefore, when calculating the possible risk of As level for the consumer, 3% of the total As concentration was used as in previous studies (Traina et al., 2019).

The ratio between the reference dose (RfD) of metals and the exposure to metals represents the Target Hazard Ratio (THQ). THQ; It also expresses the risks of non-carcinogenic effects of the concentrations of metals taken into the body for consumers. THQ calculations were made according to the formula reported by the USEPA (2019).

$THQ= [(EF \cdot ED \cdot FIR \cdot C)/(RfD \cdot BW \cdot AT)] \cdot 10^{-3}$

Where:

Efr - exposure frequency in 365 days/year

ED - exposure duration in 70 years (equivalent to an average lifetime)

FIR - average daily consumption in kg/person/day

C - concentration of metal in food sample in mg/kg

RfD - reference dose in mg/kg/day (for Al, As, Cd, Ni ve Pb respectively; 1.00, 0.0003, 0.001, 0.02 ve 0,004) (EPA, 2016)

BW - average body weight in kg person^{-1} (60 kg)

ATn - average exposure time for non – carcinogens in days *(365 day/year x ED).*

A total THQ value greater than 1 indicates that there are non-carcinogenic health risks for the consumer (USEPA, 2019).

The HI has been developed to estimate the overall non-carcinogenic risk to human health through exposure of more than one pollutant. HI is the total of the hazard quotients all heavy metals in spices.

HI = THQ(Ni) + THQ(As) + THQ(Cd) + THQ(Pb) + THQ(Al)

If the values of THQ/HI $\geq$ 1 indicates that the population will pose potential adverse health effects, while if THQ/HI < 1, the population is unlikely to experience obvious adverse effect (Mohammadi et al., 2019).

Statistical analysis

Data were analyzed with IBM SPSS V23. One-way analysis of variance (ANOVA) was used to analyze data with normal distribution. Tukey HSD test was used in multiple comparisons. The Kruskal Wallis test was used to compare data that were not normally distributed. Analysis results are presented as mean ± standard deviation. The significance level was taken as $p<0.05$.

Ethical considerations

Ethics committee approval is not required as this study does not fall under the scope of "research that requires ethics committee approval".

RESULTS

The data obtained as a result of aflatoxin analysis in this study were shown in Table 1.As a result of the HPLC analysis, AFB1, AFB2, AFG1 and AFG2 were not detected in cumin.

Table 1. Aflatoxins levels of red pepper samples.

Spice	No	AFB_1 (ppb)	AFB_2 (ppb)
Red Pepper	1	8.01	0.80
Red Pepper	2	9.47	0.76
Red Pepper	3	13.51	0.83
Red Pepper	4	12.43	0.81
Red Pepper	5	9.41	0.77
Red Pepper	6	0.29	0
Red Pepper	7	0.47	0
Red Pepper	8	13.66	0.93
Red Pepper	9	11.22	0.82
Red Pepper	10	11.28	0.88
Red Pepper	11	8.07	0.79
Red Pepper	12	8.13	0.76
Red Pepper	13	20.11	0.89
Red Pepper	14	15.21	0.87
Red Pepper	15	19.96	0.99
Red Pepper	16	20.14	1.00
Red Pepper	17	14.32	0.92
Red Pepper	18	11.53	0.86
Red Pepper	19	31.60	1.23
Red Pepper	20	37.49	1.35
Average Concentration		13.81±8.9	0.81±0.32

While AFB_2, AFG_1, AFG_2 were not detected in black pepper, low levels of AFB_1 were detected in only one sample. However, although AFG_1 and AFG_2 were not detected in red pepper, high levels of AFB_1 were detected in all samples and AFB_2 was detected in 18 samples. The amount of AFB_1 in red pepper samples was found to be between 0.286-37.491 ppb (mean 14.2±8.4).

Table 2. Comparison of heavy metal levels in spices (Mean±SD).

Spices	n	Ni (ppm)	As (ppm)	Cd (ppm)	Pb (ppm)	Al (ppm)
Black pepper	20	5.08±1.28^{a}	---	0.35±0.48^{a}	2.47±3.51^{a}	392.45±247.4^{a}
Cumin	20	9.12±6.01^{b}	0.06±0.05	0.20±0.26^{ab}	1.40±1.86^{ab}	514.4±537.9^{a}
Red Pepper	20	8.95±4.51^{b}	---	0.06±0.01^{b}	0.11±0.05^{b}	33.75±10.01^{b}
MPL (WHO/FAO)		1.63	1.0	0.2	5.0	-

a,b: There is no difference between groups with the same letter on the same line for each parameter.
WHO/FAO - World Health Organization/ Food and Agricultural Organization (2007).
MPL; Maximum permissible limit (ppm)

As a result of heavy metal analysis, the mean level of Ni in black pepper samples was determined to be lower than in other spice samples. Arsenic was detected only in cumin samples. The mean value of Cd, Pb and Al were lower in red pepper samples compared to the other spice samples (Table 2).

Table 3. Calculated daily intake level of each spices for various metals (mg/kg/day), on assumed 0.01 kg consumed by 60 kg body weight.

Spices	Ni	As	Cd	Pb	Al
Black pepper	$8x10^{-4}$	---	$5x10^{-5}$	$4x10^{-4}$	$65x10^{-3}$
Cumin	$15x10^{-4}$	$3x10^{-7}$	$3x10^{-5}$	$2x10^{-4}$	$85x10^{-3}$
Red Pepper	$15x10^{-4}$	---	$1x10^{-5}$	$2x10^{-5}$	$6x10^{-3}$
PTDI	$50x10^{-4}$ (WHO, 2011)	$2X10^{-3}$ Anonymous (2022).	$20x10^{-5}$ (WHO, 2011)	$2x10^{-4}$ (WHO, 2011)	$14x10^{-4}$ JECFA (2011)

PTDI: Provisional Tolerable Daily Intake

Table 4. Effect of Daily intake of heavy metal (mg/kg/day) on the consumption of 0.01 kg of spices, effect based on 60 kg of human body weight.

Spices	Ni	As	Cd	Pb	Al
Black pepper	NO EFFECT	NO EFFECT	NO EFFECT	ACUTE	ACUTE
Cumin	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	ACUTE
Red Pepper	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	ACUTE

According to Table 3, Al in all spice samples and Pb level in black pepper samples are above the daily intake tolerance limits. Therefore, all spice samples have the risk of acute toxicity in terms of Al and black pepper samples in terms of Pb levels if they are consumed continuously.

According to Table 5, THQ and HI values were lower than 1 in all spice samples in this study.

Table 5. THQ and HI values of heavy metals in spices.

Spices	THQ					HI (TTHQ)
	Ni	As	Cd	Pb	Al	
Black pepper	0.042	---	0.058	0.003	0.065	0.168
Cumin	0.076	0.000001	0.033	0.006	0.085	0.200
Red Pepper	0.075	---	0.010	0.005	0.006	0.096

TTHQ (Total Target Hazard Quotient)

DISCUSSION

It is known that aflatoxin, which is commonly found in herbal products, also poses a great risk for spices. The main reasons for this are that spices are mostly produced in tropical climates with high temperature and humidity, have traditional processing technologies, and are stored under inappropriate conditions (Salari et al., 2012).

In the Turkish Food Codex Contaminants Regulation prepared in accordance with the European Union Commission Regulation on Determination of the Maximum Limits of Certain Contaminants in Foods numbered 1881/2006/EC, red pepper (Capsicum spp.) (including their dried fruits, whole and ground forms) and black pepper (Piper spp.) (including their fruits, white pepper and black pepper), the maximum AFB_1 limit is 5 µg/kg, and the AFB_1+B_2+G_1+G_2 limit is 10 µg/kg (Anonymous, 2011).

In this study, the amount of AFB_1 above the permissible limit value in the Turkish Food Codex (5 ppb) was detected in 90% (18 samples) of the red pepper samples. In this study, the fact that the red pepper samples contain aflatoxin B_1 can be accepted as an indication that the production, harvest, drying and storage conditions are not made in accordance with hygienic rules or that the spice offered for sale openly and kept in inappropriate storage conditions is contaminated with mold spores. In a similar study, it was determined that all of the samples of red pepper samples sold without packages in Van were contaminated with AFB_1 at different levels (1.10-44.00 ppb). The amount of AFB_1 was found to be above the limit value (5 ppb) in 57.5% (23 samples) and at the limit value in 7.5% (3 samples) of the red pepper samples, (Agaoglu, 1999).

Among the spices, there are many studies showing that red pepper is the most sensitive product to aflatoxin. In studies conducted in different regions of Turkey, results were obtained confirming the risk of aflatoxin in red peppers. In a study, it was determined that all 30 red pepper samples and 90% of 15 chili pepper samples were contaminated with aflatoxin, 27% of red peppers and 63% of chili peppers exceeded the permissible limit of 10 ppb total aflatoxin (Bircan, 2005). Aflatoxin analysis was performed in 50 red pepper samples collected from the market in Kayseri and AFB_1 was detected between 1.48-70.05 ppb in all of them, 6% of which was above 5 ppb (Kanbur et al., 2006). It was determined that 68 of 100 red pepper samples collected from retail outlets in Istanbul were contaminated with AFB_1 at the level of 0.025-40.9 ppb (Aydin et al., 2007). According to the results of aflatoxin analysis performed by TLC in 49 red pepper samples collected from different cities of Turkey, AFB_1 at the level of 3.5-80 ppb in 24.5%, AFB_2 at the level of 3-60 ppb in 22%, and AFG_1 in the level of 8-40 ppb in 10% were detected in red peppers. 20 ppb of AFG_2 was found in only one sample (Demircioglu & Filazi, 2010). Ozbey and Kabak (2012) examined a total of 105 spice samples, consisting of chili pepper, red pepper, black pepper, cumin and cinnamon, obtained from the market in Ankara and Çorum, in terms of aflatoxin. At the end of the study, AFB_1 was detected between 0.20-35.77 ppb in 63.9% of 22 red pepper samples. Golge et al. (2013) detected aflatoxin in 150 (82.4%) of 182 red pepper samples collected from the market in Adana and Osmaniye provinces in Turkey. While AFB_1 between 0.24-165 ppb was detected in 150 of 150 aflatoxin positive samples, AFB_2 between 0.15-11.3 ppb in 84, AFG_1 between 0.15-3.88 ppb in 32 samples, AFG_2 was not found in any sample.

In addition, studies conducted abroad have revealed the importance of mold contamination and aflatoxin problem in both spices and red peppers. It was determined that 67% of the 86 samples obtained from the market in Sri Lanka and 31% of the samples obtained from the market in Belgium contained AFB_1 over 5 ppb (Yogendrarajah et al., 2014). It has been determined that 95% of the red pepper samples obtained from the market in different regions of Morocco contain AFB_1 between 1.1-15.4 ppb (El Mahgubi et al., 2013). Aflatoxin was detected in 56% of powdered red peppers, 59% of red peppers collected from markets, 58% of powdered red peppers and 54% of red peppers collected from restaurants in Pakistan. The amount of AFB_1 was over 10 ppb in approximately 38% of the powdered red pepper samples and in approximately 30% of the red pepper samples (Iqbal et al., 2013).

In other studies (Agaoglu, 1999; Aydın et al., 2007; Ozbey ve Kabak, 2012), the amount of AFB_1 in red pepper samples are similar to the values obtained in this study. However, the level of AFB_1 reported by Bircan (2005), Demircioglu & Filazi (2010) and Golge et al. (2013) is much higher than the value in this study. Also, the results of AFB_1 obtained by Kanbur et al. (2006), El Mahgubi et al. (2013) is much lower than our results. AFB_2 levels determined in this study is much lower than determined by Demircioglu & Filazi (2010) and Golge et al. (2013). The differences in the results are thought to be because of climatic and regional factors besides the red pepper type and manufactural processing.

In most of the health problems caused by heavy metals, treatment options are limited and sequelae or death can be observed frequently. This suggests that primary prevention measures may be more successful than secondary and tertiary treatment services. The main purpose in primary prevention is to prevent the contact of living things with heavy metal, which is risky for their lives. In this study, red pepper with the highest aflatoxin contamination was determined as the spice with the lowest heavy metal load in terms of Cd, Pb and Al, excluding Ni (Table 2). On the other hand, cumin is the spices with the highest value in terms of Ni, As and Al, and black pepper in terms of Cd and Pb. The Cd level in black pepper samples and Ni levels in all spice samples determined in this study were above the limit values according to the Maximum permissible limit determined by WHO/FAO (2007). Nickel is emitted into the atmosphere by the combustion of nickel fuels, mining and refining processes, and ashing of urban wastes. In addition, sewage sludge is found in mixed soil and cigarettes (Unal, 2019). So, the reason for the high Ni level in all spices in this study may be the increase in Ni level in the soil due to industrialization, waste and sewage sludge. Cd element, which has a very high rate of transfer from soil to plant and is quite mobile in the soil, can be easily taken up by plants even at very low concentrations, especially in zinc deficiency, and accumulate in the edible parts of the plant. Cadmium, which passes into soil and water through industrial waste and residues, phosphorus fertilizers, pesticides, pollutes water and soil. Cadmium accumulates in the roots of some vegetables and fruits because the roots take heavy metals from the soil (Kahvecioğlu et al., 2008). Therefore, high cadmium levels may have been detected in black pepper samples.

Nkansah and Amoako (2010) determined the lead level as 0.1153-0.0973 g/kg and the Ni level as 0.0735-0.0593 g/kg in some spice samples collected in the city of Kumasi. In some samples, especially ginger, black pepper and cinnamon, the lead level was found to be higher than the limits determined by WHO/FAO. Dogan et al. (2014) determined the Ni level was 0.77-15.6 ppm, the Cd level was 0.001-0.24 ppm, the As level was 0.005-0.12 ppm, the Pb level was 0-0.68 ppm in the samples they took from 11 different factories producing red pepper flakes in Turkey. Soliman (2015) examined arsenic levels in 8 different spice samples collected from local markets in Egypt and determined the arsenic level as 0.02-0.11 ppm. Inam et al. (2013) investigated the Pb, Cd, As and Ni contents of five of the most widely used spices in Nagpur and found that the Pb level was 3.3-4.59 ppm, the Cd level was 0.04-0.4 ppm, the As level was 0.7-1.5 ppm and the Ni level was in the range of 2.82-5.76 ppm range. Pb and Ni levels determined in spices by Nkansah and Amoako (2010) and Pb and As levels determined by Inam et al. (2013) were higher than the levels determined in this study, Ni, Cd, As and Pb levels determined in red pepper by Dogan et al. (2014) were close to the levels determined in this study. Also, the Cd level detected in spices by Inam et al. (2013) was lower than the Cd level determined in this study.

EDI (Table 3), THQ and HI (Table 4) calculations were made in order to evaluate possible health risks arising from spice consumption. EDI values were compared with PTDI values. It has been determined that the calculated EDI values were below the limits in terms of Ni, As and Cd elements and that these metals do not pose any risk in terms of daily intake tolerance limits in spice consumption. However, Al levels in all spice samples and Pb level in black pepper were above the limits. For this reason, this spices threaten the public health of consumers in terms of Al and Pb. Therefore all spice samples have the risk of acute toxicity in terms of Al and black pepper samples in terms of Pb levels if they are consumed continuously (Table 4). Although it does not directly and precisely reveal the possible health risks of consumers in case of exposure to metal pollutants, the THQ value is an important parameter in order to determine the potential health risks. THQ>1; reveals that metal consumption poses a risk for the consumer. Among the THQ levels calculated using the amounts of metals measured in spices, the highest values were found in Ni. However, it was determined that the THQ values of all the metals examined were below the dangerous threshold (<1). The HI values were also lower than 1 (Table 5).

CONCLUSION

There is a high risk of contamination by pathogenic bacteria in spices that are kept under inappropriate storage conditions, which are offered for sale openly. Since red pepper is used in a substantial amount during consumption, even the smallest amount of toxin that can be taken into the body harms the image of safe food and carries a great risk for the consumer. Farmers dealing with red pepper production in Turkey need to be more careful in collecting the product, especially at harvest time, and raise awareness about drying and storage conditions, production and packaging techniques. As a result of this study, it was concluded that as many samples as possible should be taken from the red peppers to be consumed and should be offered for consumption after periodic residue analyzes in terms of aflatoxins.

In this study, according to the Maximum permissible limit determined by WHO/FAO, the Cd levels detected in black pepper and the Ni levels in all spice samples in this study were above the limit values. This situation poses a risk to public health. Regular analysis of more food types in the future will protect society from potential health risks. Also, in terms of risk assessment, Al levels in all samples and Pb levels in black pepper exceeds the daily tolerable limits. But, spice samples do not pose a significant risk of non-carcinogenic effects, as THQ exposure values are less than 1. The fact that the HI values were also lower than 1 showed that the consumption of these spices did not cause excessive exposure to these chemicals.

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Conflict of Interest

The author declares no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Author Contributions

Plan, design: UMY; **Material, methods and data collections:** UMY; **Data analysis and comments:** UMY; **Writing and corrections:** UMY.

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