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Assessment Of Heavy Metals Content In Fresh And Dried Pepper Grown In Côte d'Ivoire

Coulibaly Moussa, Yoboue Béhibolo Antoinette, Soro Doudjo, Assidjo Nogbou Emmanuel

Department of Nutrition and food Technology Group (GNTA), Laboratory of Industrial Processes of Synthesis and Environment (LAPISEN) Felix Houphouet-Boigny National Polytechnic Institute, Yamoussoukro, Côte d'Ivoire)

Abstract:
In Order To Assess The Safety Of Pepper Produced In Côte d'Ivoire, The Concentrations Of Lead, Mercury, Arsenic, Chromium And Cadmium Were Analyzed In Samples Of Fresh And Dried Pepper. Concentrations Of Certain Metals (Lead, Mercury, Cadmium, Chromium And Arsenic) Were Determined Using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).
Lead, Mercury, Cadmium, Chromium And Arsenic Concentrations In Fresh And Dried Pepper Samples Ranged Successively From 0.006-0.082 Ppm; 0.07-1.18 Ppm; 0.002-0.09 Ppm; 0.006-0.066ppm And 0.16-2.12 Ppm. The Maximum Concentration Of Lead Was Determined In Samples Taken At Yakasseme And Was 0.02 And 0.08 Ppm, The Maximum Concentration Of Mercury Was 0.12 And 0.17 Ppm, Determined In Pepper Samples From Guibéroua And Assouba, Then, The Maximum Concentration Of Arsenic Was Observed In Samples From Guibéroua And Danané Was 2.12 And 2.17 Ppm, While The Maximum Concentration Of Chromium Was 0.025 And 0.0008 Ppm In Samples From Niablé And Lopou Respectively For Fresh And Dried Pepper. Finally, The Maximum Cadmium Concentration Was Determined In Pepper Samples From Maféré With 0.1 Ppm.
According To The Results Obtained, The Concentrations Of Toxic Elements Analyzed In Fresh And Dried Pepper Samples Were Below The Maximum Permissible Limits (10 Ppm For Arsenic; 2 Ppm For Chromium; 10 Ppm For Lead; 0.3 Ppm For Cadmium; 1 Ppm For Mercury) Declared By Legislation As Not Dangerous For Human Consumption.
***Key Word**: Contents, Piper Nigrum, Heavy Metals, Arsenic.*

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I. Introduction

Spices are defined as strong-tasting, aromatic plant substances used in cooking. They are used to flavour dishes to enhance their taste. They can be derived from bark (cinnamon), leaves (tea, laurel), bulbs (garlic, onion, ginger), seeds (fennel, coriander) or fruit (mustard and pepper). Pepper (Piper nigrum L.) is one of the best-known and most widely used spices. It originates from the Malabar region of southern India. It is mainly grown in India, Malaysia, Brazil, Indonesia and Sri Lanka. World production was estimated at 714,296 tonnes in 2020, with production in Africa estimated at 22,342 tonnes. In Côte d'Ivoire, the quantity of pepper harvested was estimated successively at 57.46 and 45.03 tonnes in 2020 and 2021[1]. Depending on the processing method, there are different types of pepper. Firstly, green pepper is harvested from ripe berries. Secondly, black pepper is produced from ripe, still-green, sun-dried fruit, while white pepper is a ripe fruit that is skinned and sun-dried. Pepper is consumed for its flavor and pungency. It is considered the queen of spices because of its use in industry worldwide[2]. Heavy metals are very dangerous due to their non-biodegradable nature and their potential to accumulate in various parts of the body, while most of them are extremely toxic due to their solubility in water. Some heavy metals, such as mercury, lead and arsenic, are highly toxic in low concentrations, causing adverse effects on people [3]. Lead is considered the most toxic environmental pollutant, reacting with numerous biomolecules. Mercury is known as one of the most potent neurotoxins, but exposure to arsenic is strongly associated with increased risks of carcinogenic and systemic health effects. These toxic heavy metals have a negative effect on the gastrointestinal, immune, cardiovascular, reproductive, renal and nervous systems [4],[5]. However, according to the work of Angelova and colleagues in 2006, spices contain toxic heavy metals in a wide range of concentrations. Their content varies according to the location and type of cultivation soil, fertilizers, herbicides and water resources used for irrigation, climate and environmental pollution levels. Industrial processing, packaging, transport and storage conditions can play an important role in increasing levels of heavy metal contamination, which can affect spice quality [6].

Thus, the present study was conducted to assess the sanitary quality of pepper grown in Côte d'Ivoire. The aim of the study was to examine the concentration of lead, mercury, arsenic, chromium and cadmium in fresh and dried pepper samples.

II. Material And Methods

Plant material

The plant material consists of various *Piper nigrum L*. (green and black pepper) collected from selected plantations in Côte d'Ivoire.

Figure 1: Black pepper without grapes and green pepper with grapes

Methods

Choice of sampling sites

An analysis of the database of the Côte d'Ivoire Pepper Growers' Association shows that there are currently 38 plantations in production in Côte d'Ivoire. Given the geographical configuration and soil distribution of Côte d'Ivoire, these plantations can be grouped into 10 different entities. These plantations are mainly located in Azaguié, Maféré, N'douci, Guibéroua, Danané, Niablé, Yakasseme, Lopou, Assouba and Pk 103.

Sampling

Fresh and dried pepper samples were taken in ten (10) localities. Sampling was carried out over two (2) years, with one sample taken in each of the ten (10) localities during the production season (March to April). In each locality, three (3) 1.5 kg samples of fresh pepper and three (3) 1.5 kg samples of dried pepper were taken in the first year. Then, two (2) samples of 1.5 kg fresh peppers and two (2) samples of 1.5 kg dried peppers were taken in the second year. Finally, the samples were taken from the bags and stored in a cool box (fresh pepper) before being transported to the laboratory for analysis.

Digestion of pepper samples

Dried peppers were digested using a sand bath digestion procedure (model CF 1201, France) based on sand bath laboratory systems (user manual). 0.3g of pepper sample was weighed into the crucibles and 5 mL nitric acid (HNO3 1N) was added. After complete evaporation, 5 mL hydrochloric acid (HCl 1N) was then added for total evaporation of the contents. Sand bath digestion treatments lasted 30 minutes at 600 W power. The temperature of the sand bath was 300°C. At the end of the treatments, the samples were removed and allowed to cool, then decanted into the conical tubes. Next, 30 mL hydrochloric acid (HCl 0.1N) was added to the mixture and the whole was filtered through a 0.45 micrometer syringe filter. The filtered samples were quantitatively transferred to a 50 mL glass volumetric flask and made up to the mark with deionized water, prior to ICP-MS metal analysis.

ICP-MS analysis of samples

Digested samples were analyzed for heavy metal concentrations using the inductively coupled plasma mass spectrometry technique (Thermo Fisher Scientific Chromatography and Mass Spectrometry Hanna-Kunath-Strasse 11, Bremen, Germany).

Statistical analysis

The numerical data obtained were entered using Excel version 2016 and processed using STATISTICA 7.1 software. Statistical differences between means were tested by analysis of variance (ANOVA). The significance of differences between samples was determined using Duncan's test. The significance level was set at $p < 0.05$.

III. Results

Determination of lead concentration in fresh and dried pepper

The lead results obtained are shown in **Figure 2**. The highest lead concentration was observed in samples collected at Yakasseme (0.082 ppm), PK103(0.082 ppm), Azaguié (0.082 ppm) and Yakasseme (0.02 ppm) for fresh and dried pepper respectively. The lowest lead concentrations were found in fresh and dried pepper samples collected at N'douci (0.041 ppm) and Assouba (0.006 ppm).

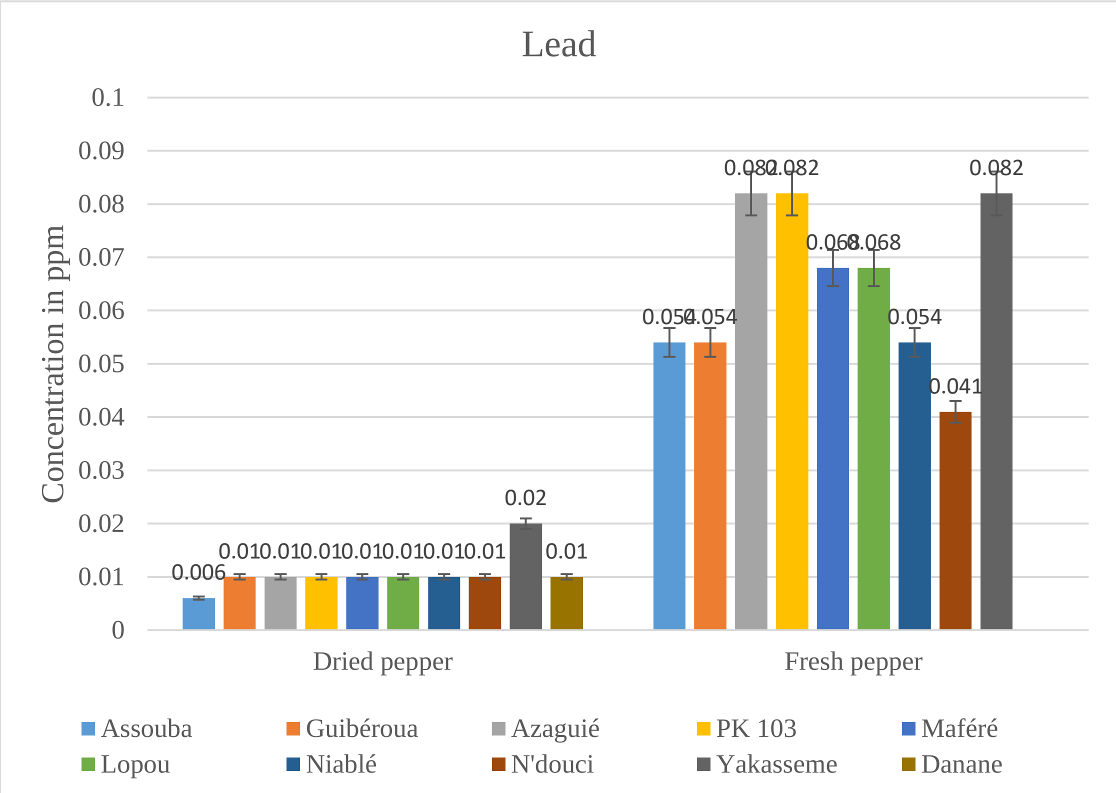

Figure 2: Lead concentration in fresh and dried pepper.

Determination of cadmium concentration in fresh and dried pepper

Figure 3 shows the cadmium concentration results for the various fresh and dried pepper samples analyzed. The fresh and dried pepper samples with the highest cadmium concentrations were those collected successively at N'douci (0.019 ppm), Yakasseme (0.019 ppm) and Maféré (0.09 ppm). The lowest cadmium values for fresh and dried pepper were found in samples collected in Lopou (0.01 and 0.002 ppm).

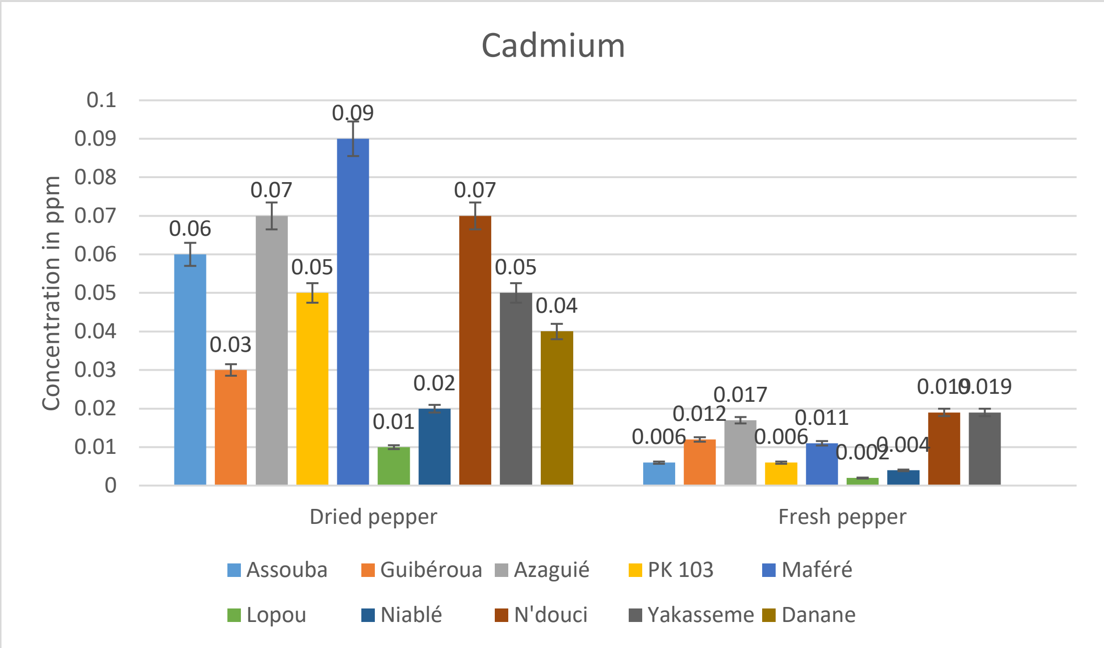

Figure 3: Cadmium concentration in fresh and dried pepper

Determination of mercury concentration in fresh and dried pepper

The mercury concentration results for fresh and dried pepper are shown in **figure 4**. The highest mercury levels were observed in samples taken in Guibéroua (1.18 ppm) and Assouba (0.17 ppm), for fresh and dried pepper respectively. Next, the lowest mercury levels were obtained in Azaguié (0.52 ppm) and N'douci (0.07 ppm) for fresh and dried pepper respectively.

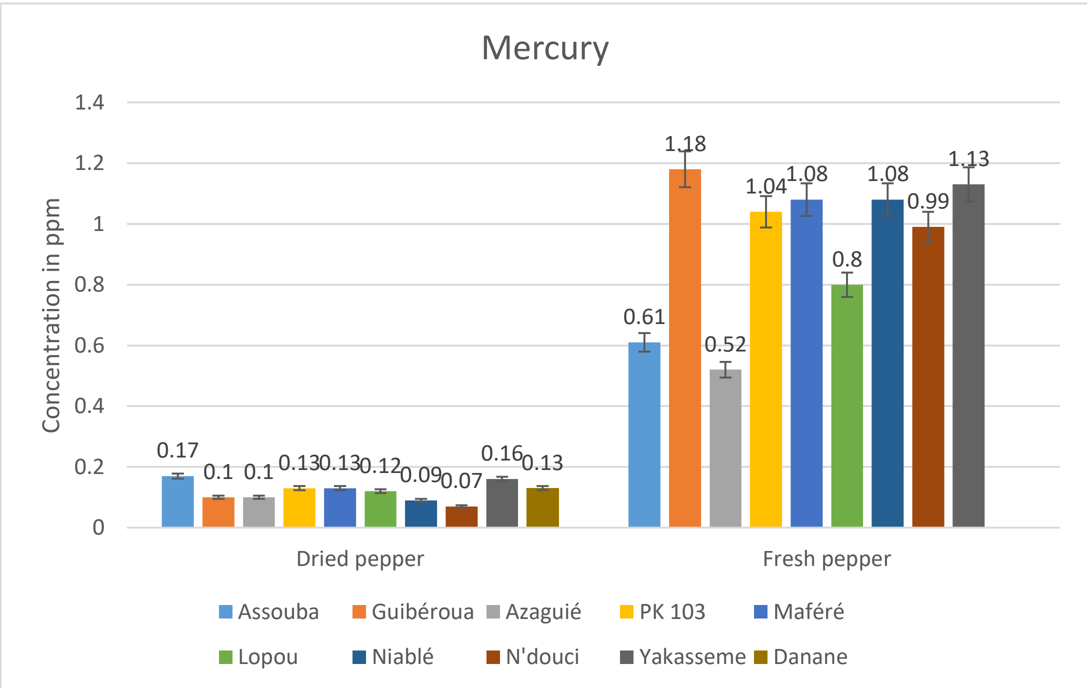

Figure 4: Mercury concentration in fresh and dried pepper.

Determination of chromium concentration in fresh and dried pepper

Figure 5 shows the chromium content of fresh and dried pepper analyzed. The highest chromium levels were observed in samples collected in the localities of Yakasseme (0.066 ppm) and Lopou (0.04 ppm) for fresh and dried pepper respectively. Fresh and dried pepper samples collected in Maféré (0.034 ppm), Niablé (0.034 ppm) and Assouba (0.006 ppm) showed successively lower chromium levels.

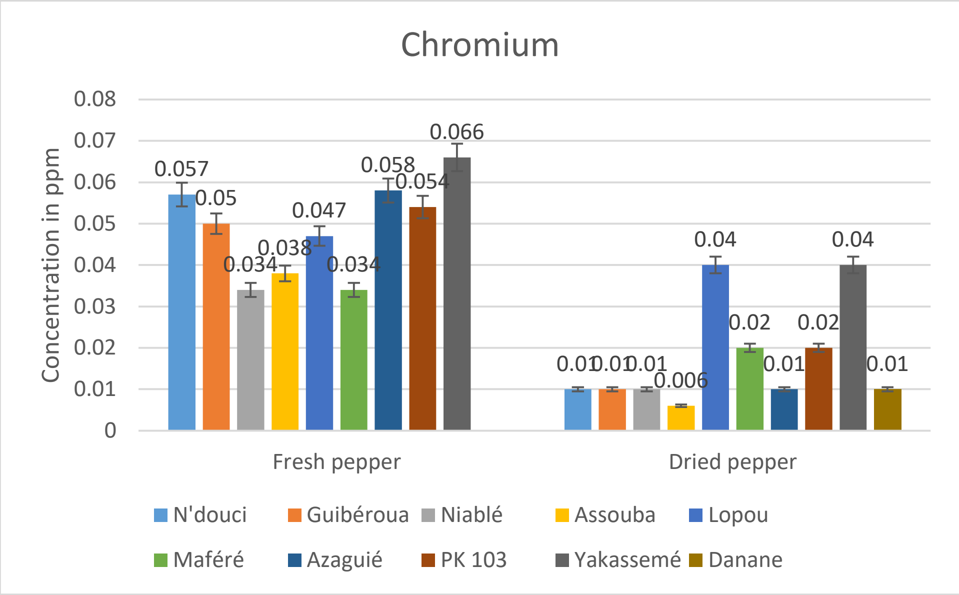

Figure 5: Chromium concentration in fresh and dried pepper

Determination of arsenic concentration in fresh and dried pepper

The arsenic results of the fresh and dried pepper samples obtained are shown in **figure 6**. The highest arsenic levels were found in samples from Guibéroua (1.12 ppm), Niablé (1.592 ppm) and PK 103 (1.592 ppm), alternating between fresh and dried pepper. The lowest arsenic levels were found in fresh and dried pepper samples collected in Assouba (0.071 ppm), Azaguié (0.071 ppm), Maféré (0.071 ppm) and Danane (0.53 ppm).

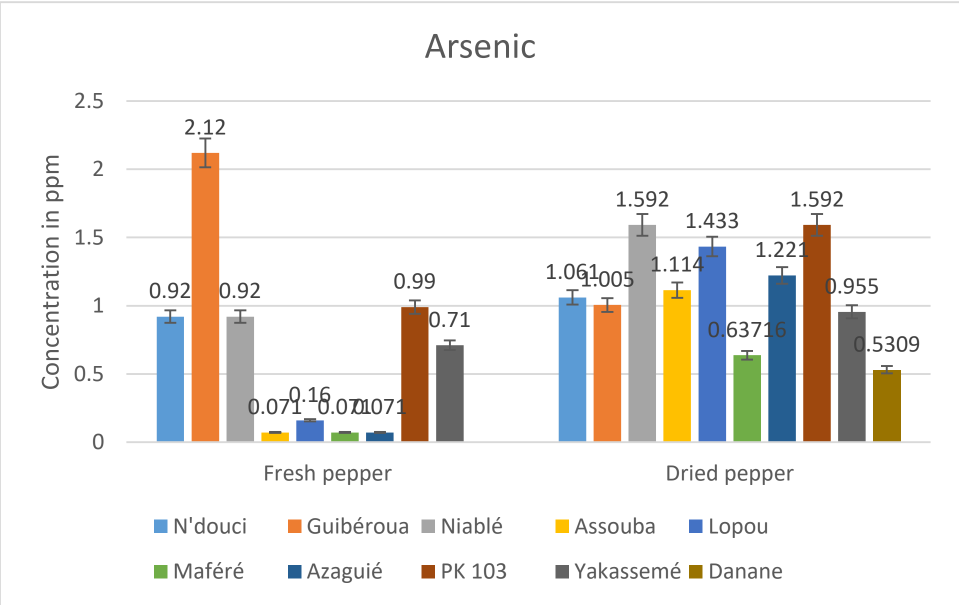

Figure 6: Arsenic concentration in fresh and dried pepper.

IV. Discussion

Heavy metals are inorganic substances that are highly toxic to humans, even in very low concentrations. Heavy metals are stored in various parts of plants and enter the plant's biological cycle. Moreover, ingestion of plants contaminated with heavy metals could also have dangerous consequences for human and animal health [7].

Lead concentrations in fresh pepper samples are higher than those obtained by Iwegbue et al. (2011) in piper nigrum (0.01 ppm) and piper guineensis (0.01 ppm). On the other hand, those of dried pepper are close to the same lead levels in piper nigrum and piper guineensis [8]. Furthermore, the lead concentrations obtained (0.041-0.082 ppm) are lower than those described by Sarpong et al. (2014) in piper nigrum (0.31 ppm)[9]. These values are below the maximum permissible level (10 ppm) recommended by FAO/WHO (2006)[10]. According to Seddigi et al. 2013, it is important to take the necessary steps to carry out routine monitoring of lead levels in pepper in order to avoid a risk to public health[11].

The cadmium levels observed in our study were lower than the Cd values (0.3-1.2 ppm) reported in some vegetable varieties from different locations in Ilorin, Nigeria [12]. Furthermore, our results were similar to those of Ozkutlu et al. (2006), who reported that cadmium concentrations ranged from 0 to 0.206 ppm successively in Mynstica fragrans and Piper nigrum L[13]. However, the cadmium levels observed with our fresh (0.002-0.019 ppm) and dried (0.01-0.09 ppm) pepper results were close to the cadmium concentrations observed in some Brazilian vegetables[8].

Fish consumption is considered the most important source of ingestion-related mercury exposure in humans. Plants and livestock also contain mercury, due to the bioaccumulation of mercury in soil, water and atmosphere. Mercury levels in fresh (0.52-1.18 ppm) and dried (0.07-0.17 ppm) pepper were higher than the various values obtained by Nkansah and Amoako in 2010 in spices (0.00123-0.02493 ppm) purchased at the Kumasi Metropolis market in Ghana[14]. In contrast, mercury levels in dried pepper were lower than those obtained by Ndelekwute et al. (2014) in spices in India (0.96 ppm).

With regard to chromium, the chromium levels in fresh (0.034-0.066 ppm) and dried (0.006-0.04 ppm) pepper samples were close to the chromium concentrations in herbal samples analyzed by Meena et al. (2010), which ranged from 0.00725 to 0.00134 ppm[15]. In contrast, the chromium concentrations obtained in fresh and dried pepper were lower than those obtained by Tefera and Chandravanshi in 2018 in red pepper (27.5-73.6 ppm) analyzed in Ethiopia[16]. Similarly, chromium levels in fresh and dried pepper were also lower than the results obtained by Raphéal et al. (2011) in red pepper (7.15 ppm) sampled in Turkey[17].

The arsenic concentrations of fresh (0.16-2.13 ppm) and dried (0.53-1.5 ppm) pepper samples were higher than the arsenic levels obtained in native pepper (0.001328-0.00117 ppm) and Kerala pepper (0.004854-0.00427 ppm) in India [18]. Furthermore, the pepper samples (0.36 ;0.33-0.51 ppm) analyzed by Blagojevic et al. (2015) possessed higher arsenic concentrations than the results we obtained in fresh and dried pepper[19].
The various toxic element results were in line with WHO (2005) data (10 ppm for arsenic; 2 ppm for chromium; 10 ppm for lead; 0.3 ppm for cadmium; 1 ppm for mercury)[20].

V. Conclusion

Based on the results obtained, it can be concluded that pepper grown in Côte d'Ivoire does not contain high concentrations of heavy metals. Indeed, lead, mercury, cadmium, chromium and arsenic concentrations in fresh and dried pepper samples ranged successively from 0.006-0.082 ppm; 0.07-1.18 ppm; 0.002-0.09 ppm; 0.006-0.066ppm and 0.16-2.12 ppm. These concentrations are lower than the limits required by the World Health Organization. Despite these low levels of heavy metals, it is very important to take preventive measures through regular monitoring to control the accumulation of metals to toxic levels in the human body.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1]. FAOSTAT, « Pepper (Piper Nigrum) Production. Italy: FAO Statistics Division, Food, And Agriculture Organization. », 2023, Consulté Le: 16 Juin 2023. [En Ligne]. Disponible Sur: URL:Http://Www.Fao.Org/Faostat/En/#Compare

[2]. H. H. Jeleń Et A. Gracka, « Analysis Of Black Pepper Volatiles By Solid Phase Microextraction–Gas Chromatography: A Comparison Of Terpenes Profiles With Hydrodistillation », J. Chromatogr. A, Vol. 1418, P. 200-209, Oct. 2015, Doi: 10.1016/J.Chroma.2015.09.065.

[3]. T. E. Bahemuka Et E. B. Mubofu, « Heavy Metals In Edible Green Vegetables Grown Along The Sites Of The Sinza And Msimbazi Rivers In Dar Es Salaam, Tanzania », Food Chem., Vol. 66, Nº 1, P. 63-66, Juill. 1999, Doi: 10.1016/S0308-8146(98)00213-1.

[4]. P. B. Tchounwou, A. K. Patlolla, Et J. A. Centeno, « Invited Reviews: Carcinogenic And Systemic Health Effects Associated With Arsenic Exposure—A Critical Review », Toxicol. Pathol., Vol. 31, Nº 6, P. 575-588, Oct. 2003, Doi: 10.1080/01926230390242007.

[5]. A. Bhan Et N. N. Sarkar, « Mercury In The Environment: Effect On Health And Reproduction », Rev. Environ. Health, Vol. 20, Nº 1, Janv. 2005, Doi: 10.1515/REVEH.2005.20.1.39.

[6]. V. Angelova, K. Ivanov, Et R. Ivanova, « Heavy Metal Content In Plants From Family Lamiaceae Cultivated In An Industrially Polluted Region », J. Herbs Spices Med. Plants, Vol. 11, Nº 4, P. 37-46, Août 2006, Doi: 10.1300/J044v11n04_05.

[7]. S. Rai, D. K. Sharma, S. S. Arora, M. Sharma, Et A. K. Chopra, « Concentration Of The Heavy Metals In Aloe Vera L. (Aloe Barbadensis Miller) Leaves Collected From Different Geographical Locations Of India », 2011.

[8]. C. Iwegbue, C. Overah, J. Ebigwai, S. Nwozo, G. Nwajei, Et O. Eguavoen, « Heavy Metal Contamination Of Some Vegetables And Spices In Nigeria », Int. J. Biol. Chem. Sci., Vol. 5, Nº 2, Nov. 2011, Doi: 10.4314/Ijbcs.V5i2.72150.

[9]. Sarpong K, Dartey E, Et Owusu-Mensah I, « Assessment Of Trace Metal Levels In Commonly Used Vegetables Sold At Selected Markets In Ghana. », Int. J. Med. Plants Res., Vol. 3 (4), Nº 7, P. 290-295, 2014.

[10]. FAO/WHO, « The Use Of Microbiological Risk Assessment Outputs To Develop Practical Risk Management Strategies: Metrics To Improve Food Safety. Report Of A Joint FAO/WHO Meeting In Collaboration With The German Federal Ministry Of Food, Agriculture And Consumer Protection », Kiel, Germany, Avr. 2006.

[11]. Z. S. Seddigi, G. A. Kandhro, F. Shah, E. Danish, Et M. Soylak, « Assessment Of Metal Contents In Spices And Herbs From Saudi Arabia », Toxicol. Ind. Health, Vol. 32, Nº 2, P. 260-269, Févr. 2016, Doi: 10.1177/0748233713500822.

[12]. O. O. Dosumu, N. Salami, Et F. A. Adekola, « Comparative Study Of Trace Element Levels In Some Local Vegetable Varieties And Irrigation Waters From Different Locations In Ilorin, Nigeria », Bull. Chem. Soc. Ethiop., Vol. 17, Nº 1, Janv. 2003, Doi:

[13]. 10.4314/Bcse.V17i1.61741.

[14]. Ozkutlu, F., Sekeroglu, N, Et Kara, S. M, « Monitoring Of Cadmium And Micronutrients In Spices Commonly Consumed In Turkey. », Res. J. Agric. Biol. Sci., Vol. 2(5), 2006.

[15]. M. Nkansah Et C. Amoako, « Heavy Metal Content Of Some Common Spices Available In Markets In The Kumasi Metropolis Of Ghana », Am. J. Sci. Ind. Res., Vol. 1, Nº 2, P. 158-163, Sept. 2010, Doi: 10.5251/Ajsir.2010.1.2.158.163.

[16]. A. K. Meena, P. Bansal, S. Kumar, M. M. Rao, Et V. K. Garg, « Estimation Of Heavy Metals In Commonly Used Medicinal Plants: A Market Basket Survey », Environ. Monit. Assess., Vol. 170, Nº 1-4, P. 657-660, Nov. 2010, Doi: 10.1007/S10661-009-1264-3.

[17]. Tefera, M Et Chandravanshi, B. S., « Assessment Of Metal Contents In Commercially Available Ethiopian Red Pepper », Int. Food Res. J., Vol. 25(3), Nº 13, 2018.

[18]. Rapheal, O Et Adebayo, K. S, « Assessment Of Trace Heavy Metal Contaminations Of Some Selected Vegetables Irrigated With Water From River Benue Within Makurdi Metropolis, Benue State Nigeria. », Adv. Appl. Sci. Res., Vol. 2, Nº 5, 2011.

[19]. M. Md. Abukawsar Et Al., « Chemical, Pharmacological And Nutritional Quality Assessment Of Black Pepper (Piper Nigrum L.) Seed Cultivars », J. Food Biochem., Vol. 42, Nº 6, P. E12590, Déc. 2018, Doi: 10.1111/Jfbc.12590.

[20]. S. Blagojevic, S. Blagojevic, Et B. Begovic, « Lead, Mercury And Arsenic Content In Spices: Black, White And Green Pepper, Black Cumin And Ginger », Facta Univ. - Ser. Phys. Chem. Technol., Vol. 13, Nº 3, P. 191-202, 2015, Doi: 10.2298/FUPCT1503191B.

[21]. WHO, Quality Control Methods For Medicinal Plant Materials. Geneva: World Health Organization, 2005.