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Detection of Physiochemical and Some Heavy Metals in Potato and Corn Chips Products in Iraqi Markets with their Daily Intake

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Abstract

The study of heavy metals in the human diet is important due to their dual effects as either essential or toxic to the human body. In this study, we determined the concentration of selected heavy metals in common potato and corn chips brands in Iraq markets. Ten common brands were selected and analyzed for their concentrations of the studied heavy metals by ICP-MS. The results shown that the average heavy metals level in potato and corn chips in (mg kg^{-1}±SD) were 2.68±0.67 and 2.96±3.00 for Mn, 4.64±1.99 and 5.82±5.45 for Fe, 0.29±0.33 and 1.36±0.95 for Cu and 2.84±1.26 and 6.26±1.67 for Zn respectively. Corn chips were found to contain higher heavy metals than potato chips. The daily consumption of heavy metals from potato and corn chips (20 g daily intake) is lower than the recommended level set by the World Health Organization and Food and Agriculture Organization. Also, Daily intake of these metals is lower than the oral suggested amount and the upper tolerable daily intake set by the US. The contamination risk for the Iraqi population especially children from heavy metals exposure by this study performs to be non-significant, emphasizing the need to conduct more studies and confirm examining of heavy metals in foodstuffs especially chips brands.

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Introduction

The study of heavy metals in the human diet is important due to their dual effects as either essential or toxic to the human body (Hariri *et al.*, 2015). Manganese, iron, copper and zinc are essential nutrients and have the therapeutic application (Gopalani *et al.*, 2007; Hariri *et al.*, 2015). They play a vital role in biological systems (Darwish and Al-Zahra, 2012). They are also concerned in several metabolism processes and are required to preserve regular biological functions. These heavy metals are required in amounts less than 100 mg per day (Damastuti *et al.*, 2011). Metals are natural components of products but in some cases consuming of diet causing human exposure to metals due to contamination of the food as a result of agricultural activity, manufacturing, preparation and processing (Damastuti *et al.*, 2011; Dada *et al.*, 2017; Jaradat, 2021), leads to increase the concentration of these metals in diet (Fadhel and Gathwan, 2022), which is a negative indicator and will convey over food chains. Due to the absence of a good mechanism in the human body for heavy metals elimination, high level intake can lead to health problems and damaging effects (Gopalani *et al.*, 2007; Hariri *et al.*, 2015; Dada *et al.*, 2017; Jaradat, 2021).

Potato and corn chips are extremely common snacks that are consumed by people, particularly children all around the world (Salvador *et al.*, 2009; Ali *et al.*, 2019; Vaitkevičienė et al, 2022). But these types of chips are thought harmful for

consumer`s health because they contain high levels of fat and salt (Zhang *et al.*, 2005; Yi *et al.*, 2015). Though, throughout the day, due to its acceptable taste usually improved by adding of monosodium glutamate, these types of chips are consumed as a snake especially by children (Halagarda and Swata, 2016; Ali *et al.*, 2019). From a consumer's point of view, besides the characteristics of chips such as texture, specific gravity, total solid, color after frying and microbial content which are extremely important (Nawaz *et al.*, 2021). They have an important role as a source of heavy metals, protein and carbohydrates (Hannon *et al.*, 2016). Numerous companies produce different types of chips in terms of nutritional quality (Halagarda and Swata, 2016).

Numerous studies reported metals contamination above recommended levels in processed foods such as chips are consumed in Iraq and other countries (AL-rajhi, 2014; Vaitkevičienė *et al*, 2022). The consumption of ready-to-eat foods such as chips by children with its associated fear of contamination may be more noticeable in Iraq, in view of the fact that manufactures are not systematically controlled by the government and also consumption of these types of chips are very common by children in big amounts. therefore, this study aims to assess the concentration of heavy metals such as Mn, Fe, Cu and Zn in some commonly consumed different types of chips such as potato and corn types.

Methods and Materials

Sampling and preparation

Ten salted chips samples were collected from local markets and produced by different brands. The samples were purchased in Halabja and Sulaymaniyah provinces supermarkets with original package, included of seven potato types including (Lays Chees, Local, Pringles Original, Kish, Patos Spicy, Misk Lemon, Bato Salat, and Vinger,) and three corn types (Bushar Chess, Lucy Chess, and Dunya Tortella Chees). The samples were transferred to the laboratory, and then 100 g of each sample were milled with stainless steel grinder. They were labelled and kept in a sterilized tube, and stored in refrigerator at 4°C for further analysis.

Physiochemical analysis

The total ash and the moisture contents of the samples were determined according to (AOAC, 1990). The salt content determined by converting the amount of sodium in each samples to sodium chloride. The fat content in the studied samples was determined by using the Soxhlet method according to the method reported by (James, 1995). Briefly, about 2.0 g of each sample were wrapped in a filter paper and placed in a Soxhlet reflux flask that is connected to a condenser on the upper side and a weighed oil extraction flask filled with 250 mL diethyl ether. The solvent was heated to the boiling point, and the vapor was condensed into the reflux flask immersing the samples completely for extraction. All processes took 4 hours then the extracted oil in the flask was dried in the oven at 60˚C for 30 min and then weighed. The fat contents were calculated from the ratios of mass of fat to the mass of chips samples used for extraction. The moisture content was determined in samples after drying sampling for 48h at 45C in the oven and then the percentage of moisture was calculated by the difference between the fresh and dryad weight of each sample.

Element analysis

The all chips samples were analyzed for their heavy metals content after digesting about 0.2 g of each sample under microwave heating (Anton Parr, Multiwave 3000) for about 45 mins at 2 MPa in 4.0 mL of 68% HNO_3 and 2 mL H_2O_2. Digested samples were diluted to 20 mL with Milli-Q (Its Milli-Q water, its type of distilled using Milli-Q water instrument, it's very common term used in researches) water and stored at room temperature (±22°C). Heavy metals in the digested solutions were measured by

ICP-MS (Thermo Fisher scientific ICAP Q, Germany), following the procedure of (Arnold *et al.,* 2010; Rasheed and Salih, 2020).

Daily Intake Measuring

The daily intake of heavy metals in chip samples was calculated using to the following equation1: (Hannon *et al.,* 2016).

$$\text{Daily intake}\left(\frac{\frac{\text{mg}}{\text{kg}}}{\text{day}}\right)=\frac{\text{Mconc.}}{20*33} \qquad (1)$$

Were, M_{conc} is the concentration of heavy metal in chips samples, 20 is the amount of chips consumed each day in (g), and 33 is the body weight of child in (kg).

Statistical analysis

For all parameters done for the evaluation of chips type, analysis was done using three replicated and the average value was calculated by using SPSS program (Version 26). Least of Significant Difference (LSD) test was used for significant difference at $p\leq 0.05$.

Results and Discussion

Some chips properties

The data of total ash, moisture, fat, and salt contents of all the studied chips types are conveyed as an average of three separate samples (n=3), each analyzed in two replicates, and are presented in table 1, a significant difference was found between chips under ($p\leq0.05$), where the average value of each type of chips shown. The total ash content ranged from 0.35% for Pringles to 2.74% for Dunia. In contrast, Halagarda and Swata; Ali *et al.,* (2016, 2019) resulted in higher total ash content for different types of chips. However, similar ash content of different types of chips was reported by Junior *et al*, (2018).

Moisture content ranged from 2.73% to 8.60%, fat content ranged from 7.94 to 35.2% and salt content ranged from 0.14% to 2.82% for all types of chips. The results indicate that studied parameters such as ash, moisture and salt contents in corn type are higher than potato type. However, fat content in potato chips is higher than corn chips. This is due to the oil used to fry potato slices and some of the oil will absorb by slices. The higher amount of ash content in corn chips than potato chips may be due to the fact that corn contains a high amount of solid compared to potato which is a vegetable.

This study showed that Bushar contained the highest amount of moisture and Kish contained the lowest. Generally, the shelf life and texture of chips mainly depend on the amount of moisture content. The results are slightly higher than the results reported by Halagarda and Swata (2016). Nawaz *et al.,* (2021) reported that high moisture content causes high microbial growth, rapid spoilage, and high oil uptake which cause rancidity, and blistering during frying. Therefore, low moisture content inhibits the product against spoilage and is required for chips making products. The results are slightly lower than those reported by Ali *et al.,* (2019).

The total oil content varied from 7.94% to 35.2% for all types of the studied chips. This variance directly impacts the final energy assessment of the chips (Caetano *et al.,* 2017). The results indicate that the potato types had higher oil content than the corn types. This is due to the fact that typically during potato chips production high amounts of oil are used to frying potato slices and the difference between the percentage of oil content may be referred to some factors such as variety, frying time duration and the texture and thickness of slices (Xu and Kerr, 2012). Buck and Barringer; Vaitkevičienė et al (2007, 2022) reported that frying temperature and oil composition affect oil uptake by potato slices. High oil uptake influences health risks such as fatness and cardiovascular disease and raises the cost. The quality of chips depends on the percentage of oil and causes a moldy smell and taste. The results are approximately in

agreement with the results reported by (Albuquerque *et al.,* 2012; Halagarda and Swata, 2016; Vaitkevičienė *et al.,* 2022). They reported that the quality of used oil to frying affects the quality of food. Adeniji and Tenkouano (2007) reported that high fat content reduces the shelf life of chips due to lipid oxidation.

Salt (sodium chloride) is a chemical compound, the total salt content varied and ranged from 0.14% to 2.82% for all the studied chip types. The results indicate that corn types contained higher salt than potato types. The results are in agreement with the results reported by (Albuquerque *et al.,* 2010; Albuquerque *et al.,* 2012). They analyzed 18 brands of chips and found that the salt content ranged between 0.14-2.94% and 0.127-2.77% respectively. Compared to WHO/FAO recommendation (less than 5 g salt intake per day), the results in this study contain high amounts of salt, and may be an effect of public health. The difference between chip types in their salt content may be due to the non-controlled addition of salt by food factories. Most of the studied chips in this study have considerable amounts of salt, 80% of analyzed samples contain more than 1% of salt and of these, and one brand had more than 2.5%.

Table1. Physio-chemical properties of the studied potato and corn chips

No	Type	Source	Flavior	Ash	Moisture	Oil	Salt
				%			
1	**Lays**	**Potato**	**Cheese**	1.09	3.18	24.9	1.23
2	**Karad**		**Orignal**	0.50	3.40	24.6	0.14
3	**Pringles**		**Orignal**	0.35	4.20	18.5	0.98
4	**Kish**		**Normal**	1.50	2.73	35.2	1.37
5	**Patos**		**Spacy**	0.80	2.75	18.0	1.48
6	**Misk**		**Lomone**	1.40	5.14	9.30	1.54
7	**Bato**		**Salted vinger**	2.25	4.35	11.4	1.99
8	**Dunya**	**Corn**	**Cheese**	2.74	3.95	7.94	2.82
9	**Bushar**		**Cheese**	1.19	8.60	8.76	1.17
10	**Lacy**		**Cheese**	1.64	5.13	13.3	1.65
	Average ±SD	**Potato**		1.13±0.65	3.68±0.91	20.3±8.85	1.25±0.58
		Corn		1.86±0.79	5.89±2.42	10.0±2.90	1.88±0.85

Heavy metals concentration

The nutritional composition of chips is very important because it is a significant part of children's daily food. Thus, the nutritional content of chips cannot be ignored (Govender and Naicker, 2020). Each one of the studied heavy metals has its particular function which is presented in (Table) and also the deficiencies and toxicities of the studied heavy metals were also listed in table 2.

Table 2. The function, deficiency and excessive consumption of the studied heavy metals

Heavy metals	Function	Deficiency	Excessive consumption
Mn	involve bone formation, enzyme , in amino-acids, cholesterol, and carbohydrate metabolism	Poor reproductive performance, growth retardation, abnormal function of bone and cartilage	Elevated blood concentration and neurotoxicity

Fe	Component of hemoglobin and numerous enzymes, prevent microcytic hypochromic anemia	Anemia, impaired cognitive development, impaired learning ability	Gastrointestinal distress
Cu	Component of enzymes in iron metabolism	Normocytic, hypochromic anemia, leucopenia and neutropenia and inclusive osteoporosis in children	Gastrointestinal distress, liver damage
Zn	Component of multiple enzymes and proteins, involved in the regulation of gene expression	Growth retardation, loss of appetite, impaired immune function, hair loss, diarrhea, impotence, hypogonadism and mental lethargy	Reduced copper status, electrolyte imbalance, nausea and lethargy

Table 3 shows the concentration of the studied heavy metals in (mg kg^{-1}) in chips samples, a significant difference was found under ($p \leq 0.05$). The chips (No. 8, Dunya) contained the highest amount of heavy metals compared with all other chip types. Also, the results show that the concentration of heavy metals in corn chips is higher than potato chips (Fig. 1). This may be attributed to the fact that grains contain more metals than tubers (Hariri *et al.*, 2015). Additionally, corn has more sources for contamination such as soil, air and manufacturing than potato which has only soil and manufacturing. Similar to the current study Hariri et al; Hannon et al (2015, 2016) resulted in higher heavy metals concentration in corn chips than in potato chips in Lebanese and Iraqi markets respectively.

On average, the heavy metals concentration in chip samples collected from different places in markets were 2.70 mg kg^{-1} for Mn, 4.77 mg kg^{-1} for Fe, 0.60 mg kg^{-1} for Cu and 3.75 mg kg^{-1} for Zn. The results indicate that the order of the heavy metals concentrations followed the trend: Fe>Mn>Zn>Cu for potato type and Fe>Zn>Mn>Cu for corn type. According to the World Health Organization`s and Food and Agriculture Organization`s allowable level of heavy metals in foodstuff, clearly the average concentration of all metals is below the permissible limits. This is suggesting that the chips are not contaminated with elements (FAO/WHO, 2011; AL-rajhi, 2014). Furthermore, the average concentrations of the heavy metals in the range that reported for Jourdan, Saudi Arabia, Kuwait, Lebanon and Turkey (Jaradat, 2021).

Moreover, the concentration of heavy metals in this study was less than those results reported by (Gopalani *et al.*, 2007; Darwish and Al-Zahra, 2012; Hariri *et al.*, 2015). Several factors may cause decrease the concentration of heavy metals including potato and corn cultivars and also the type of growing soil (Öztürk *et al.*, 2011; Tasrina *et al.*, 2015). They reported different concentrations of heavy metals in different potato cultivars. Soil is the main factor that affects heavy metals concentration in agricultural products. However, Cu concentration is similar to results reported by (Hannon *et al.*, 2016) for all types of chips in the Iraqi market. In contrast, they are higher than the results reported by (AL-rajhi, 2014). Moreover, the presence of higher concentrations of Mn and Fe than Cu and Zn in the studied samples refers to the ability of potato and corn to accumulate these metals in protein molecules (Narin, *et al.*, 2005; Hariri *et al.*, 2015). It is very essential to study heavy metals concentration in commonly consumed chips types to inform possible contamination that would signify human health especially children.

Table 3. Heavy metals concentrations in potato and corn chips

Sample No.	Brad name	Source	Concentration (mg kg^{-1})			
			Mn	Fe	Cu	Zn
1	Lays	Potato	3.56	7.11	0.10	2.74
2	Karad		3.02	4.30	1.02	4.12
3	Pringles		2.90	3.78	0.15	2.81
4	Kish		2.69	3.39	0.29	4.35
5	Patos		2.82	6.11	0.18	1.68
6	Misk		1.41	0.17	0.10	0.48
7	Bato		1.74	5.38	0.09	2.52
8	Dunya	Corn	6.82	12.3	2.01	8.33
9	Bushar		0.85	4.99	1.60	4.85
10	Lacy		1.20	0.18	0.47	5.59
	Average±SD	Potato	2.68±0.67	4.64±1.99	0.29±0.33	2.84±1.26
		Corn	2.96±3.00	5.82±545	1.36±0.95	6.26±1.67

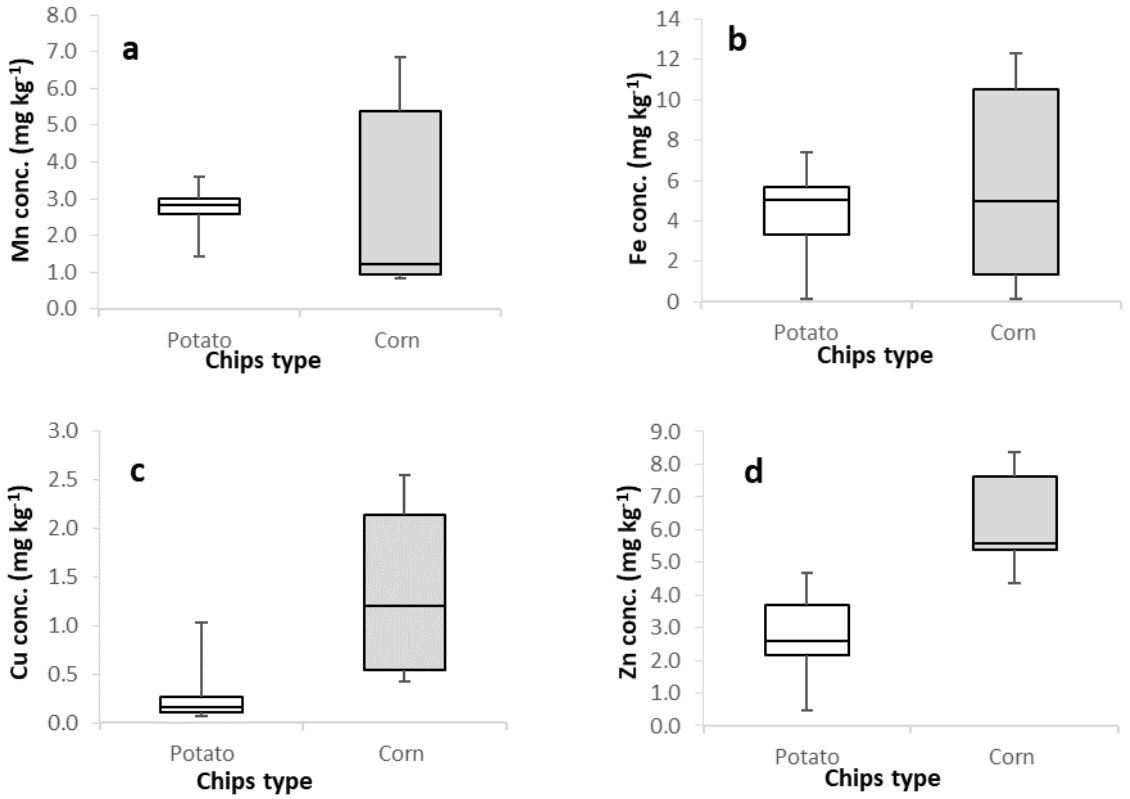

Figure 1. The concentration of heavy metals in the studied potato and corn chips; the figure shows the deference of heavy metals level between potato chips and corn based chips.

Daily intake of heavy metals

The daily intake of the studied heavy metals measured in 20 g chips to kg^{-1} body weight (Its daily intake of chips by children per body weight) according to the result of a questionnaire conducted by (Hannon *et al.*, 2016). They conducted a survey and resulted in consuming about 20 g of chips per week for an average 20 years population (190 samples used individually). The results presented in (Table 4), showed that the highest and lowest daily intake was

recorded for Fe in sample (No. 8 and 10, Dunya and Lacy brands respectively, Corn type). In general, high daily intake of the studied heavy metals was recorded for corn type due to higher content than potato chips.

Table 4. The daily intake of the heavy metals in both potato and corn chips

Sample No.	Brad name	Source	Daily intake (mg kg^{-1} d^{-1})			
			Mn	Fe	Cu	Zn
1	Lays	Potato	2.16	4.31	1.66	4.78
2	Karad		1.83	2.60	2.50	4.96
3	Pringles		1.76	2.29	1.70	4.02
4	Kish		1.63	2.05	2.63	4.17
5	Patos		1.71	3.70	1.02	7.81
6	Misk		0.85	0.10	0.29	1.04
7	Bato		1.05	3.26	1.53	2.25
8	Dunya	Corn	4.13	7.45	1.22	5.05
9	Bushar		0.51	3.02	0.97	2.94
10	Lacy		0.73	0.01	0.28	3.38
	Average±SD	Potato	1.57±0.46	2.62±1.37	1.62±0.81	4.15±2.15
		Corn	1.79±2.03	3.49±3.74	0.82±0.48	3.79.1.11

The heavy metals daily intake resulted from the current study then compared with its recommended dietary allowance (RDA) values to identify whether the children had a sufficient or excessive intake of heavy metals. Recommended dietary allowance is the average of daily intake amount that is adequate to meet the nutrition requirement of practically all (97-98%) healthy persons in all life stages and gender. The amount for those ages is presented in (Table 5) in the USA. However, the values of RDA are different between Americans and Iraqis. So, it may not give an accurate estimation for Iraqis due to differences in body mass index and typology (Damastuti *et al.,* 2011). The comparison showed that daily intake of the studied heavy metals is lower than recommended amounts. Thus, there is no risk of consuming 20 g of chips each day.

Table 5. The recommended daily allowance (RDA), allowable intake (AI) and upper limits (UL) of the studied heavy metals denuding people group and age

Heavy metals	Group	Age	RDA	AI	UL
		(year)	(mg d^{-1})		
Mn	Children	4s/d8	-	1.5	3

	female	9s/d13	-	1.9	6
	Male	9s/d13	-	1.6	6
	Children	4s/d8	10		40
Fe	female	9s/d13	8		40
	Male	9s/d13	8		40
	Children	4s/d8	0.44		3
Cu	female	9s/d13	0.70		5
	Male	9s/d13	0.70		5
	Children	4s/d8	-	5	12
Zn	female	9s/d13	-	8	23
	Male	9s/d13	-	8	23

Conclusion

This study, which was conducted to estimate the concentration of heavy metals in potato and corn chips in Iraqi markets, has indicated that the corn chips contained more heavy metals than the potato chips. Also, through comparing heavy metals intake in 20 g chips to their recommended daily intake standards, it is clear that children are not exposed to a harmful concentration of selected heavy metals. Finally, potato and corn chips could be considered as a support source for the daily intake requirement of heavy metals by children.

Conflict of Interest

The authors declare that they have no conflict of interest.

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