

Research Paper

Determination of Heavy Metals in Two Common Street Foods (Falafel and Chicken Shoulder & Wing) Consumed in Qom City, Iran



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ABSTRACT

Background & Aims: Street foods are ready-to-eat foods and drinks prepared and sold by vendors on the streets and other public places for immediate consumption or consumption at other times without any processing steps and are welcomed by a wide range of people for reasons such as the economy and easier access. This study aimed to investigate the status of heavy metals such as lead (Pb), cadmium (Cd), aluminum (Al), arsenic (As), and manganese (Mn) in the most common street foods in Qom City, Iran, (Falafel, shoulders and wings) according to the particular cultural, social, pilgrimage, and tourism conditions of the city.

Materials and Methods: After preparing and collecting 18 samples of Falafel and 18 samples of shoulders and wings in the summer via quota stratified sampling method from supply and distribution centers in the city, the samples were transferred to the instrumental analysis laboratory of the faculty of health. After crushing, grinding, and weighing 2g of the samples, dry ashing was performed while maintaining the temperature program. White ash was dissolved in 5% nitric acid, and finally, the concentrations of Pb, Cd, As, Al, and Mn in the samples were measured by graphite furnace atomic absorption spectrometry (GFAAS).

Results: According to this study, Mn, Al, and Pb metals had the highest concentrations in falafel, shoulder, and wing samples. Mean concentrations of Al, As, Cd, Pb and As in falafel samples were 10.07 ± 9.82 , 0.0005 ± 0.0002 , 0.0007 ± 0.0003 , 2.65 ± 1.33 , 24.50 ± 11.91 $\mu\text{g/g}$, respectively, and in the shoulder & wing samples 11.12 ± 7.70 , 0.0009 ± 0.0006 , 0.050 ± 0.018 , 1.62 ± 1.24 , 18.50 ± 14.64 $\mu\text{g/g}$, respectively. Also, the concentrations of Al, Pb, and Mn were higher than the standard level in all samples. The results showed that the mean concentration of As and Cd in Falafel, shoulder, and wing samples were less than the standard level.

Conclusion: According to the results of this study, the concentration of aluminum, lead, and manganese in all samples is higher than the standard level; it seems that if the necessary hygienic measures are not taken during the various stages of production and supply of these foods, it will seriously threaten the health of consumers. The usefulness and enjoyment of street food are essential factors in encouraging consumers to purchase this type of food, so with the widespread acceptance of this type of food by society, essential strategies should be adopted by health authorities to create a proper food culture in society by emphasizing the correct understanding of food safety hazards and the quality of food consumed.

Keywords:

Heavy metals, Food, Food safety, Atomic absorption

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1. Introduction

Street food refers to ready-to-eat foods and drinks prepared and sold by vendors on the street and in other public places for immediate consumption or consumption at any other time without processing [1]. Street food has been welcomed by a wide range of people, the poor and low-income strata of society, for various reasons, such as economic efficiency and quick access to this type of food in all countries of the world, especially developing countries. It is estimated that about 2.5 million people worldwide consume this type of food daily, mainly due to the lower cost of street food. Of course, the acceptance of this type of food by any society is directly related to their eating habits and culture [1, 2]. Street food is more popular globally, including in Asian and African countries. In Iran, people in the southern cities are more welcoming to this type of food, which perhaps is the heat and easier access to these foods by citizens at night. Of course, the tourist attractions of a city are another important factor in the creation and prosperity of the street food business. In Qom City, Iran, pilgrimage, tourism, citizens, and travelers welcome food and drinks such as fried chicken, shoulders and wings, Falafel dumplings, leaf juices, Sambooseh, and other items offered by vendors in the late hours of the night due to weather conditions. In addition to the public's economic benefits that lead to the choice of these foods, there are also health and food safety concerns such as low nutritional value, the type of dyes used in these products, microbial conditions, and chemical contamination foods. Since these foods are usually prepared and sold in crowded and high-traffic areas of the city in the open air, in tiny stalls and shops, they may be contaminated by pathogenic microorganisms and chemical toxins, such as heavy metals [2]. Aggravating factors of these contaminants, especially heavy metals in this type of food, are improper preparation and packaging conditions, exposure to vehicle exhaust fumes, and unsanitary collection and disposal of waste in these places [2, 3].

Lead, cadmium, mercury, aluminum, arsenic, and tin are the most influential heavy metals that, according to studies, can contaminate food [4, 5]. Lead is the most toxic heavy metal recognized as an environmental and industrial pollutant that enters the human body through eating water and food, and respiration. As soon as the body's biomolecules swallow this metal, proteins and enzymes become stable biotoxic compounds; as a result, their structure changes, and their biological interactions become problematic. Lead contamination prevents the

synthesis of hemoglobin and reduces the life of red blood cells and the development of anemia. Acute and chronic damage to the central nervous system in the form of lead encephalopathy is commonly seen in children with symptoms such as headache, hypomnesia, attention deficit hyperactivity disorder (ADHD), restlessness, and irritability, and in the peripheral nervous system as lead paralysis due to the effect of lead on stimulatory nerves [6, 7]. Cadmium is also an element with no structural role in the human body. This element and its solution compounds are toxic, even in minimal amounts, and are stored in organs and the environment. Inhalation of Cadmium powder quickly causes respiratory and kidney problems that can be fatal (often due to renal failure). Eating any significant amount of Cadmium can cause rapid liver and kidney poisoning.

Cadmium-containing compounds also cause poisoning [2]. Cadmium is rapidly and uniformly absorbed in plants and spreads and accumulates in its tissues. Cadmium accumulation in animal tissues mainly includes liver, kidney, and milk. The long half-life of Cadmium (10-30 years) and its high potential for accumulation lead to complications such as renal failure, reproductive defects, osteomalacia, prostate cancer, mutagenesis, and fetal death [6, 7]. Other heavy metals such as copper (Cu), nickel (Ni), and mercury (Hg) are toxic and dangerous to humans, even in small amounts. After entering the body, these elements accumulate in living organisms' bodies or are transferred to higher nutritional levels and then become toxic and dangerous substances due to chemical interactions. In this way, these substances disrupt the normal functioning of living organisms and can even cause the death of existing organisms. Heavy metals are not usually metabolized in the body. In fact, after entering the body, heavy metals are no longer excreted from the body but deposited in adipose tissue, muscles, bones, and joints, which in turn leads to several diseases [8]. The most important way for chemicals and toxins to enter the body is through food, so monitoring the food consumed by society is essential and inevitable. In the world, monitoring the performance of street food vendors began in the early 14th century [2]. With the acceleration of globalization and the growth of tourism, street food safety has become one of the significant concerns in public health, and as a result, more efforts have been made by health authorities in different communities to raise awareness in this area. Indeed, the first step towards achieving this goal is to analyze and examine the food status of citizens. This study aimed to examine the status of heavy metals Lead, Cadmium, Aluminum, Arsenic, and Manganese in the most common street foods in Qom (Falafel, shoulders, and wings) according to the

particular culture, social, pilgrimage, and tourism conditions of the city.

2. Materials and Methods

Sampling, sample preparation, and determination of heavy metal concentrations

Sampling was performed by stratified quota sampling in the summer. After preparing and collecting samples from preparation and distribution centers in the city, 18 samples of Falafel and 18 samples of shoulders and wings (36 in total) were transferred to the instrumental analysis laboratory of the Faculty of Health. The samples were first crushed and then well homogenized by the mill, and 2 g of the homogenized sample was weighed. In the next step, the samples were dried in the oven for 12 hours at a temperature of 60°C -80°C and then maintained the temperature program (increasing the temperature by 50°C per hour to prevent the destruction of the sample tissue); ashing was performed at 450°C in an electric furnace. The samples were kept at this temperature for about 18 to 24 hours to complete the ashing process. The white ash was then dissolved in 5% nitric acid, filtered and made with double distilled water up to 50 mL, and finally exposed to working standards. Concentrations of lead, cadmium, arsenic, aluminum, and manganese were measured by the PG instrument (GFAAS). The concentration range of the working standards for measuring Pb metal was 0.01-10 ppm, Mn 1-60 ppm, Al 0.1-40 ppm, Cd 0.05-0.35 ppm, and As 0.001-0.01 ppm. Table 1 lists the Limit of Detection (LOD) and limit of quantitation (LOQ) for each metal [7, 9].

Statistical calculations

In this study, SPSS software v. 21 was used for statistical analysis. To compare the mean concentration of the evaluated elements in the studied samples, the Kruskal-Wallis non-parametric statistical test was used, and to compare the mean concentration of the evaluated elements with the food and drug administration (FDA) standard, a one-sample t test was used. The Mann-Whit-

ney non-parametric test was also used to compare the mean concentrations of elements in the two groups of Falafel, shoulder, and wing using samples.

3. Results

The results of laboratory analysis on the concentration of heavy metals in different samples of Falafel, shoulder, and wings were statistically processed to assess the risk of heavy metals. In this study, SPSS software v. 21 was used for statistical analysis. Table 2 indicates that the highest mean concentrations of heavy metals in Falafel, shoulder, and wing samples belong to manganese, aluminum, lead, cadmium, and arsenic, respectively. On the other hand, the mean concentrations of lead and manganese in Falafel samples were higher than in shoulder & wings samples, and the mean concentration of aluminum, arsenic, and cadmium metals in shoulder & wing samples was higher than in Falafel samples.

Table 3 presents that among heavy metals, a significant difference was observed between the two groups only for Arsenic ($P=0.001$).

Table 4 presents the mean concentration of aluminum, arsenic, cadmium, lead, and manganese metals in Falafel and shoulder & wing compared to the FDA standard. The results showed that the mean concentration of As and Cd in Falafel samples was lower than the FDA's standard level. Furthermore, with 95% confidence, no more contamination than FDA standard level was observed in Falafel samples with As and Cd elements ($P=0.001$). The mean concentrations of Al, Pb, and Mn in all samples were higher than the FDA's standard level. Moreover, with 95% confidence, more contamination than the FDA's standard level was observed in Falafel samples with Al, Pb, and Mn ($P=0.002$ and $P=0.001$). In shoulder & wing samples, the mean concentration of As and Cd is less than the FDA's standard level. Additionally, 95% confidence that the shoulder & wing are not contaminated with cadmium and lead ($P=0.001$). Also, the mean concentration of aluminum, lead, and manganese in the shoulder & wing samples is higher than the

Table 1. Limit of Detection (LOD) and Limit of Quantitation (LOQ) for Cadmium Cd), Lead (Pb), Arsenic (As), Aluminium (Al), and Manganese (Mn)

Metals	Cd (ppb)	Pb (ppm)	As (ppb)	Al (ppm)	Mn (ppm)
LOD	0.3	0.234	0.095	0.39	0.34
LOQ	1	0.78	0.31	1.3	1.16

Table 2. Mean±SD of heavy metal concentration in Falafel, shoulder, and wing samples

Type of Material	Heavy Metal	Mean±SD (µg/g)	Min-Max (µg/g)	Kruskal-Wallis	P
Falafel	Aluminum	10.7±9.82	0.10-34.44	76.62	0.001
	Arsenic	0.0005±0.0002	0.0001-0.0020		
	Cadmium	0.0007±0.0003	0.0001-0.0030		
	Lead	2.65±1.33	0.0001-9.9400		
	Manganese	24.50±11.91	8.10-42.26		
Type of Material	Aluminum	11.12±7.70	0.96-24.41	68.64	0.001
	Arsenic	0.0009±0.0006	0.0001-0.0030		
	Cadmium	0.050±0.018	0.0001-0.2000		
	Lead	62.1±24.1	0.01-4.98		
	Manganese	18.50±14.64	0.0001-51.4400		

FDA's standard FDA. In addition, with 95% confidence, more contamination of Al, Pb, and Mn was observed in the shoulder & wing than at the FDA's standard level (P=0.015 and P=0.025).

4. Discussion

According to the results of this study, manganese, aluminum, and lead have the highest concentrations in Falafel and shoulder & wing street foods. Also, the aluminum, lead, and manganese concentrations in all samples are higher than the FDA standard level (Table 4) [10]. However, arsenic and cadmium are less than FDA in Falafel and shoulder & wing samples (Table 4). In Iran, no specific study has been conducted on street food to assess the risk of heavy metals. In a similar study

conducted in the Philippines in 2014 by Abdulmajid et al. on three types of street food (eggs, grilled chicken, and dumplings), the concentration of lead and cadmium in all samples was higher than standard, and in comparison with the samples, grilled chicken contained higher amounts of these two heavy metals [11]. Another study was conducted in Nigeria by Ekhaton et al. in 2014 on 20 street food samples served at bus stations that examined the metals such as lead, cadmium, tin, manganese, and aluminum; the lead level in all samples studied was higher than the allowable limit [2]. In a study conducted by Bayoumi et al. in Egypt in 2018, the most contaminated cadmium and manganese were reported on several street foods [12]. According to Sharmila's review study, the issue of street food is one of the vital issues in public health. There are critical concerns about consuming

Table 3. Comparing heavy metal concentrations in two groups (Falafel and shoulder & wing)

Heavy Metal	Mean±SD (µg/g)		Mann-Whitney	P
	Falafel	Shoulder & Wing		
Aluminum	10.07±9.82	11.12±7.70	-0.886	0.376
Arsenic	0.0005±0.0002	0.0009±0.0006	-3.69	0.001
Cadmium	0.0007±0.00033	0.050±0.018	-1.85	0.064
Lead	2.65±1.33	1.62±1.24	-1.06	0.288
Manganese	24.50±11.91	18.50±14.64	-1.67	0.94

Table 4. Comparing heavy metal concentrations (ppb) with FDA standard levels by two samples (Falafel and shoulder & wing)

Street Food	Heavy Metal	Standard FDA Level	t-test	Mean	P
Falafel	Aluminum	1	3.72	9.82	0.002
	Arsenic	0.002	-15.29	0.0002	0.0001
	Cadmium	0.05	-308.72	0.0003	0.0001
	Lead	0.50	1.33	1.33	0.201
	Manganese	10	5.16	24.50	0.0001
Shoulder & wing	Aluminum	1	5.58	11.12	0.0001
	Arsenic	0.002	-7.15	0.0009	0.0001
	Cadmium	0.05	-2.69	0.018	0.015
	Lead	0.50	1.94	1.24	0.069
	Manganese	10	2.46	18.50	0.025

these foods due to the wide range of diseases caused by them. Issues such as the lack of proper understanding of the importance of food safety by producers and sellers in various stages of preparation, cooking and serving food, raw materials, and their hygiene, along with the widespread consumption of this type of food by the general public has exacerbated this concern [13]. Regarding the contamination of street food with chemicals, which mainly contain heavy metals, factors such as the consumption of water contaminated with heavy metals in different cooking and food supply stages, equipment, and utensils incompatible with food and environmental air pollution can be effective [14].

According to the results of this study, the highest concentrations of heavy metals in both food groups (Falafel and shoulder & wing) are related to Mn, Al, and Pb, respectively. The highest concentrations of Mn in the concentration range of 10-100 ppm among the foods include plants and grains. Also, researchers reported concentrations between 1 and 10 ppm in green tea leaves, fruits, milk, eggs, and meat. A total of 54% of Mn enters the body via plants and grains, 14% from potatoes, and 2% from red meat and fish, although these percentages vary depending on the geographical conditions of different countries and regions. Polluted air is also a way for manganese to enter food offered outdoors. Although individuals receive lower amounts of Mn through the respiratory tract than through the oral route, according to studies, the uptake and distribution of Mn in various tissues and organs of the body under respiratory conditions

is much wider than the oral route [15]. The amount of Al in the human food chain is also increasing every day, which is said to play a crucial role in developing complications such as Alzheimer disease, anemia, and damage to neurons and nerve cells [16]. It should be noted that the origin of the people receiving Al in a society depends on the lifestyle and technology of food production in that society and certainly varies from region to region. Thus, researchers, responsible organizations, and academic institutions must conduct detailed and comprehensive studies in this area and calculate the amount of aluminum intake to take effective strategies to reduce it if the intake is high. In the United States, high-consumption additives such as aluminum sodium phosphate, aluminum sulfate, and aluminum silicates make up a large portion of the American's aluminum intake [17]. In Europe, too, the most received from other sources is via food packaging, although in Europe, this issue is completely under control and people's daily intake is deficient. At the same time, in the last 15 years, the use of Al utensils has become popular among the Iranian people; the main reason is the ignorance of the people and the provision of Al to them instead of zinc utensils. In Iran, the transfer of Al from Al cookware and the transfer from packaging containers constitute the largest share of the Iranian people. Based on the results of a study conducted to examine the level of aluminum in sunflower oils, it was found that these oils contain high amounts of Al, which is mainly due to the oil refining process in the bleaching stage by the bleaching earth. Exposure to oil at high temperatures greatly increases the transfer of Al to food, which can

be one of the reasons for the contamination of Falafel samples with Al metal in this study [16, 17]. On the other hand, the high concentration of aluminum metal in the results of this study is due to the use of Al cookware, and Al foils to store this type of food, especially in this type of food, shoulder & wing samples. These chemical interactions become more dangerous when the surface of meat or food is acidified with some lemon juice, paste, vinegar, or even yogurt, which food providers use to marinate shoulders and wings [17]. It should be noted that aluminum foils and containers contain some amounts of lead that can contaminate food with the heavy metals of Pb and Al simultaneously. Another side effect of Al foil is the Al oxide produced by the metal on its surface. Furthermore, it can increase the chemical load and contamination in the presence of food. In the long run, the entry of aluminum oxide ions into the body disrupts the central nervous system and memory and increases the risk of Alzheimer disease. The metal also increases the risk of osteoporosis by disrupting bone metabolism, increasing liver and kidney toxicity, accumulating Al in the joints, and causing arthritis [16]. In the long run, the gradual accumulation of Pb in the body causes the most damage to children less than six years old and, more seriously, less than three years old, leading to short stature and stunted growth. Also, it can cause digestive problems and kidney damage in adults. Lead is one of the most crucial heavy and toxic elements that have many toxic effects on public health. The most common ways this metal enters the body are via ambient air and food. According to many studies, some of which have been discussed in this study, Pb contamination in food has been higher than allowed, which can be attributed to urban climate pollution and its entry into food. Once ingested, the metal is converted to biotoxic compounds by the body's biomolecules such as proteins and enzymes and, due to its long half-life, accumulates in chronic exposures to soft tissues and bones. Anemia, acute and chronic damage to the central nervous system in the form of lead encephalopathy, headache, hypomnesia, ADHD, restlessness and irritability, and the effect on the peripheral nervous system in the form of lead paralysis due to Pb, impaired growth of gray brain cells and decreased intelligence quotient (IQ) of children are the toxic effects of Pb metal [18, 19]. In an article published in 2021, the usefulness and enjoyment of street food were mentioned as two vital factors in encouraging consumers to purchase this type of food. The other factors include food quality, service quality, physical environment, speed of access to food, and mainly its reasonable price. Therefore, with the widespread acceptance of this type of food by the community, basic strategies should

be adopted by health authorities to create the proper food culture in society by emphasizing the proper understanding of food safety hazards and attention to the quality of food consumed [20, 21].

5. Conclusion

The results of this study indicate that the concentrations of aluminum, lead, and manganese in all samples are higher than the standard level, and it seems that if the necessary hygienic measures are not taken during the various stages of production and supply of these foods, it will seriously threaten consumer health. The usefulness and enjoyment of street food are the crucial factors in encouraging consumers to repurchase this type of food; therefore, with the widespread acceptance of this type of food by the community, basic strategies should be adopted by health authorities to create a proper food culture in society by emphasizing the correct understanding of food safety hazards and the quality of food consumed.

Ethical Considerations

Compliance with ethical guidelines

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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