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ORIGINAL ARTICLE

Metals that are Important for Food Safety control of bread Product

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ABSTRACT

Breads are among the most important elements of our daily diet. Knowing about the heavy and essential elements content in bread is required for different purposes such as estimating accumulation of major and trace elements in the bread that may influence water, soil, air, and environment quality as well as the role of bread in nutrition. This study focuses on content of elements such as As, Hg, Cd, Pb, Ni, Fe, Cu and Zn in Bread products available in Shahrekord, Iran. Totally 40 bread samples were collected in January 2014. The mean concentrations of As, Hg, Cd, Pb, Ni, Fe, Cu and Zn in bread samples were 12.5±0, 4.38±0, 9.48±4.75, 931.25±722.5, 98.03±26.89, 2324.69±248, 14276.69±10100.79 and 30316.88±6802.19 µg/kg, respectively. In addition, the concentration of the lead was higher than maximum allowable concentration that probably it is associated to activities of industrial factories around the farms and machine activities.

***Keywords**: Heavy metals, Essential element, Bread, ICP-OES.*

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INTRODUCTION

Bread is a staple food prepared by baking a dough of flour and water and other ingredients, usually combined with a leavening agent, blended, shaped into loaves, and baked. It is popular around the world and one of the world's oldest foods.

Bread is an important diet cereal product that provides as 50-90% of total calorie and protein intakes [1]. A case of environmental pollution, which is confronted very frequently and threatening to food safety is heavy metals. Heavy metals such as arsenic, cadmium, lead and mercury are natural chemical compounds. They can be present at various levels in the environment, e.g. soil, water and atmosphere. Metals can also occur as residues in food because of their presence in the environment, caused by human activities such farming, industrial activities or car exhausts or from contamination during food processing and storage. People can be exposed to these metals through the environment or by ingesting contaminated food or water. Their accumulation in the body can lead to harmful effects over time. The major path for heavy metals to enter human's body is by ingesting contaminated food [2]. The effect of environmental pollution on contamination of foods and on their safety for human consumption is a serious global public issue and widely addressed [3-5]. The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic [6]. The main concern in relation to the toxicity of mercury in the general population is the potential effect of organic forms of mercury, e.g. methylmercury, on the brain and intellectual development of young children. Lead also has an effect on brain and intellectual development in young children, while long-term exposure in both children and adults can cause damage to the kidneys, reproductive and immune systems along with effects on the nervous

system. Cadmium is toxic to the kidney. Exposure to inorganic arsenic is concern because of its cancer-causing properties. Given the wide spectrum of effects on health and the fact that these toxic metals accumulate in the body, it is essential to monitor contents of foodstuffs in order to protect human health. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported [7]. Contamination of bread by heavy metals could be due to flour, which may have been produced from contaminated wheat. Water used for backing bread could also be a source of heavy metal contamination [8]. The aim of this study is to investigate and measure the levels of heavy metal such as As, Hg, Cd, Pb, Ni, Fe, Cu and Zn in breads available in Shahrekord, Iran.

MATERIAL AND METHODS

Samples Collection

The Shahrekord city was divided into four districts and samples from each district was collected independently and equally from different Bakery in January 2014 (n=40).

Chemical and reagent

All chemicals and standards were obtained from Merck (Darmstadt, Germany).

The purity of argon as carrier gas was 99.999% (grade5), with a flow rate of 0.7 L/min for supplementary and Modified Lichte nebulizer and 13 L/min for coolant flow. The speed of 4 channel peristaltic pump was 60 rpm for 45 S in pre-flush condition and 30 rpm for analysis. The power level was adjusted on 1400 KW.

ICP-OES

The trace element content were measured by Inductively Coupled Plasma Optic Emission Spectrometry End of Plasma (ICP-OES EOP, Spectroacros, Germany) Model Varian Vista-MPX.

Sample Preparation

The glassware containers used for analysis were washed with detergent and rinsed several times with tap water to remove absorbance due to detergent; then they were soaked overnight in 6 N HNO_3 (Merck) solutions and finally rinsed with deionized water. All aqueous solutions and dilutions were prepared with ultrapure water. 10 g of bread sample was weighted by a digital analytical balance with ±0.0001g precision and then was added to a beaker containing a volume of 10mL HNO_3 (65%) and 4mL $HClO_4$ and covered with a watch glass; the mixture was then heated to decreasing the volume to 3–5mL through evaporation. Afterward, 10–15mL deionized water was added to the solution and then passed through an acid washed paper filter. Finally, the solution was diluted to 50mL with deionized water in an acid washed volumetric flask. Upon preliminary preparation, the toxic and essential metals were measured by ICP-OES. The blank solution was prepared in similar way without bread [9].

Calibration standards

Individual stock standard solutions (10µg/mL) were prepared. Spiked calibration standards were prepared by addition of 0.5, 2.5µL, 5µL, 10µL, 100µL, 200µL, 300µL, 500µL and 1000µL of mixed standard stock solution respectively to 10 g of blank bread samples in each case.

Recovery studies

For recovery determination, spiked tea blank samples at concentration levels of 15, 25, 75, 150, 250, 500 and 750 µg/mL were prepared in triplicates and then treated according to the procedure described in sample preparation. The recoveries were calculated using the spiked calibration curves.

Statistical analysis

Data were analyzed using SAS 9. P values <0.05 were considered as statistically significant.

RESULTS AND DISCUSSION

Table 1 lists the concentrations of the heavy metal and essential element in the bread samples analyzed. Commonly, Metal concentrations in foodstuffs depend on soil features, example content of organic matter, pH, and clay, which can affect the bioavailability of elements. Besides environmental pollution, a matter of concern is the addition of chemical products such as fertilizers, fungicides, insecticides and herbicides to crops [1]. Excessive content of these heavy metals in food is related with a number of diseases, particularly cardiovascular, renal, nervous and skeletal systems diseases [7]. These heavy metals are also involved in carcinogenesis, mutagenesis and teratogenesis [11]. Several articles in the field of food contaminants have been published by authors [12-18].

Statistical analysis showed significant ($p < 0.05$) difference between the amount of Cd, Pb and Zn in 40 samples. But, There was no significant difference ($p<0.05$) between As, Hg, Ni, Cu, Fe in 40 bread samples.

Mercury

Acute mercury exposure may give rise to lung damage. Chronic poisoning is characterized by neurological and psychological symptoms, such as tremor, changes in personality, restlessness, anxiety, sleep disturbance and depression.

The mean detected level of Hg in the bread sample was 4.38 µg/kg and 100% samples had Hg content lower than permissible limit for Mercury in food (30µg/kg) [20]. Thus, all samples in our study were Safe regarding Mercury content. The concentration of mercury exceeding the Maximum permissible limit (30 µg/kg) in food and food stuff cause serious health problems for human. These values were reported by [19] as 3µg/kg of edible portion. Few data is available on the assessment of mercury levels in bread.

Table.1 Major and trace elements content in bread samples (µg/kg)

Element	Mean±SD	Q1	Q2	Q3	P<0.05
As	12.5±0	12.5	12.5	12.5	0
Hg	4.38±0	4.38	4.38	4.38	0
Cd	9.48±4.75	6.125	8.625	12.84375	0.003
Pb	931.25±722.5	471.875	612.5	1025	0.006
Ni	98.03±26.89	84.375	93.75	112.5	0.23
Cu	2324.69±248	2134.375	2331.25	2437.5	0.501
Zn	14276.69±10100.79	8875	11400	16909.38	0.033
Fe	30316.88±6802.19	26487.5	28868.75	34278.13	0.791

Arsenic

Arsenic is extremely toxic. Intake of large quantities leads to gastrointestinal symptoms, severe disturbances of the cardiovascular and central nervous systems, and eventually death. Allowable level of Arsenic in food is 100 µg/kg [20]. The results showed that the mean concentration of arsenic found in breads was 12.5µg/kg. The results of our study indicated that the Arsenic levels in bread samples were at permissible level. Naghipour *et al* [21] reported that the concentration of as was below detectable limits in all of the bread samples. Christophe *et al*. showed that as were not detectable in commercial wheat flours Sold in Calabar-Nigeria [22]. The levels of as in our study were higher however.

Cu, Zn and Fe are nutritionally essential metals. They are presented as trace elements and are commonly found naturally in foodstuffs. However, they can be toxic when taken more than body needs.

Cadmium

The mean detected level of Cd in the bread samples ranged from 6.25 to 19 µg/kg. Permissible limit for Cd in food is 50µg/kg [23]. As the results showed, all the samples had Cd concentration lower than permissible limit this.

The principal toxic effect of cadmium is its toxicity to the kidney, although it is has been found to be associated with lung (including induction of lung tumors) and skeletal changes in occupationally exposed populations [24]. Magomya *et al.* [8] reported that the level of Cd in the bread samples ranged from 0.13-0.98 mg/kg. Dawood Al-Kamil reported that Cd was not detected in bread samples [25]. Cd levels in bread samples of our study were less than by [26] with mean level of 7-40 µg/kg.

Lead

The quantity of lead found in the bread samples ranged from 375 – 2887.5 µg/kg (Table 1). Results of this study revealed that all of samples exceeded the legal limit of lead content in food that the range of 200-2500 µg/kg [27].

Thus, the bread samples in our study were not safe retarding lead content. The toxic effects of lead have been principally established in studies on people exposed to lead in the course of their work. Short-term exposure to high levels of lead can cause brain damage, paralysis (lead palsy), anemia and gastrointestinal symptoms. Longer-term exposure can cause damage to the kidneys, reproductive and immune systems in addition to effects on the nervous system [23]. Lead levels in bread samples of our study were less than those reported by [26, 27, 8]. They reported Lead levels at ranges 340-3130, 35900-375000, and 270-520 µg/kg respectively. In addition, lead levels in our study were higher than those reported by [28, 29, 30] 87.5-874µg/kg,15.5 µg/kg respectively.

Nickel

Nickel is probably an essential element for humans; it may be useful as an activator of some of enzyme systems [31]. However, if the concentrations of the elements exceed the permissible limits it may create toxic effects in human. Its toxicity at higher levels is more outstanding. The most common adverse health effect of nickel in humans is allergic reaction. Range of Ni concentration in the sample was 62.5-212.5

µg/kg. The World Health Organization (1994) recommends 100–300 µg/kg bw nickel for daily intake [24]. The content of Ni in the 32.5% of samples were higher than the WHO's recommended ADI of Ni. The levels of Ni in our study was lower than what was reported by an Italian study [19] (556µg/kg) and less than an Iranian study [29] (430-2288µg/kg).

Iron

Iron is an essential trace element required by all forms of life. Iron plays a key role in the immune system of human. Iron is the most important constituent of different enzyme systems and other important constituents like myoglobin, the cytochromes and catalase. Various groups (male, female, children, pregnant, lactating) differ regarding their requirement for iron. Iron may also exhibit its health benefits in curing anemia resulting in women during pregnancy or menstruation. Iron is helpful in the treatment of severe disorder called iron deficiency anemia, which results due to lack of iron.

The concentrations of Fe in the bread samples ranged from 19312.5-47450 µg/kg. The permissible limit for Fe in food is 2500-5000 µg/kg depending on the foodstuff [27].The content of Fe in 5% bread samples were below the standard range. [26] Reported that level Fe in bread is range of 620-8450 µg/kg. The result of our study was higher that the reports by [23] who found that Fe levels was (13-40 µg/kg) and more similar with [25].

Copper

Copper is present in various food. Copper has many important roles to play in maintaining a healthy body. The health benefits of copper relates to its anti-inflammatory actions to assist reducing the symptoms of arthritis. Copper is highly essential for normal growth and health. Thus, it is definitely important to include this element in regular diet. It is helpful in protecting skeletal, nervous and cardiovascular systems. Copper is either an element or a cofactor of as many as 50 different enzymes that take part in various biological reactions in the body. Also it helps in producing of red blood cells, hemoglobin, and bone.

The concentration of Cu in the samples ranged from 1975-3250 µg/kg. These concentrations are far below the permissible level of Cu in food (10000 µg/kg) [24]. The result of our study was higher comparing with [26] (16-30µg kg) and also [8] that reported the content of Cu levels in fifteen different bread brands ranged from 130 to 660µg/kg.

Zinc

Zinc is an essential trace element for human. It is vital for many biological functions and plays a crucial role in more than 300 enzymes in human body. It is especially important during pregnancy, skin care, and wound healing and immune resistance. In human, high levels of zinc has been associated with acute effects such as vomiting and gastrointestinal irritation (nausea, cramps, diarrhea).

The range of Zn concentration in the bread samples was 1567.5-61625 µg/kg. These values are lower than the permissible level of Zn in foods (50000µg/kg) [32]. In another Iranian study for four types of flat breads levels of Zn ranged from 10420 to14250 µg/kg. Other studies have reported zinc concentration at the range 2960-4600 µg/kg, 240-2110 µg/kg, and 8.8-12 µg/kg. [25, 26, 8].

CONCLUSION

Results indicated that except for lead, the others elements were within the standard range in bread samples produced in Shahrekord. The level of lead concentration is a big health threat. It is highly recommended that controlling measures such as implementing a food control systems (i.e. GAP), flour proper storage, and educating farmers should be taken promptly to reduce contamination. Additionally, it is suggested that future studies should examine heavy metals contamination in different stages of bread preparation and determine which factors are involved in heavy metals contamination.

Furthermore, the results of our study showed that bread products backed produced in Shahrekord are poor sources for supplying essential trace elements. In the case of essential elements, Cu and Zn were far below the permissible level. It is also recommended to add the essential elements for human health within the standard range to flour.

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COMPETING INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article.

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