Tracing the contamination of some bakery products with heavy metals in Gharbia governorate, Egypt

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Abstract: The study was conducted to determine five heavy metals (HMs): cadmium (Cd), lead (Pb), iron (Fe), copper (Cu), and zinc (Zn) in some bakery products in Gharbia governorate, Egypt. Three districts: Kafr El-Zayat, El-Mehalla and El-Santa were chosen for sampling procedures. Zinc (Zn) as an essential metal exhibited significant levels in Feno bread (44.56 mg/kg dry w) in El-Santa, followed by Baton Sale (37.68 mg/kg dry w) in Kafr El-Zayat. Iron (Fe) exhibited the greatest regional mean values 147.40 and 230.81 mg/kg dry w in Feno bread and Baton Sale, followed by Zn (36.37-32.13 mg/kg dry w). Cadmium (Cd) and Lead (Pb) as potential toxic metals exhibited positive responses in all measured samples arising regional means (0.31-0.32 mg/kg dry w) and (2.14-2.34 mg/kg dry w) upper permissible limits set by European Union. Such these accumulations may impose adverse health risks for Gharbia residents. So, regulatory issues and procedures from decision-making must be done for food safety.

Keywords: Heavy metals; Bakery products; Feno bread; Baton Sale.

1. Introduction

Bread is a basic food prepared by baking a dough of flour, water and other ingredients, with leavening material, mixed, formed into loaves, and baked. It is one of the oldest foods and found all across the planet. Bread is an important dietary grain that provides 50-90 percent of total calorie and protein intake **(Faridi and Finney, 1980).** Pollution of bread by heavy metals (HMs) may associated with flour, which formed from polluted wheat and/or water used **(Magomya *et al*., 2013).** Some HMs e.g. nickel (Ni), cadmium (Cd), and lead (Pb) are extendedly recycled in numerous industrial procedures **(Harmankaya *et al*., 2012)**. They are non-essential for approximately all living individuals **(Khaniki, 2005; Harmankaya *et al*., 2012)**. It has been stated that all types of grain comprise metals e.g. manganese (Mn), copper (Cu), magnesium (Mg), iron (Fe), and zinc (Zn), which are uptake from cultivated media cultivation, rain, and air **(Demirozu and Saldamli, 2002; Onianwa *et al*., 2001)**. Providing of chemical fertilizers and sewage sludge during the cultivation of cereals can markedly increase levels of Pb, Zn, and Cd **(Hassan *et al*., 2013).** Equipment and containers used in process have been long accepted as a basis of HMs such as Fe, Cu, Pb, and chromium (Cr) in the processed diets **(Onianwa *et al*., 2001)**. Levels of HMs in foodstuffs have been described in the worldwide: Sweden, USA, Egypt, China, Nigeria, Italy, and Turkey **(Salama and Radwan, 2005).** Lead (pb) occurs in the environment both naturally and, to a greater extent, from anthropogenic activities such as mining and smelting, battery manufacturing and the use of leaded petrol (gasoline). Lead contamination of food arises mainly from the environment or from food processing, food handling and food packaging. Atmospheric lead can contaminate food through deposition on agricultural crops. Water is another source of lead contamination of food. Although lead exists in both organic and inorganic forms, only inorganic lead has been detected in food. The presence of cadmium in food results from contamination of soil and water both from natural sources and from anthropogenic activities. Crops differ with respect to absorption of cadmium, and cadmium is known to accumulate in the tissues (particularly the liver and kidney) of terrestrial animals and in aquatic animals (particularly detritus feeders, such as molluscs) **(Codex Alimentarius Commission, 2003).**

Cereal manufacturing and its derived yields have a large commercial and social rank worldwide, where wheat flour is a product for all bread manufacturing **(Tejera *et al*., 2013)**. Lead (Pb) can affect young children's brain development and intelligence, while long-term exposure in both children and adults can harm the kidneys, reproductive, and immune systems. Cadmium (Cd) is a kidney toxin **(Jarup, 2003)**. The study aims to determine HMs levels in the bakery products collected from some districts of Gharbia governorate, Egypt.

2. Material and Methods

2.1. Samples collection:

Gharbia governorate was chosen to track the contamination of bakery products with some different HMs. Three districts: Kafr El Zayat, El Mehalla, and El-Santa were chosen for sample collection (Figure 1). The regions were divided according to contamination sources; brick making factories, fertilizers and pesticides in Kafr El Zayat city which operate with diesel and raised smokes which act as a main source of air pollution. Secondary, El Mehalla district which

famous with textile industries, and has the biggest factory for textile in the Middle East. Thirdly, El Santa district which considered as rural region. Twenty samples from different places for each district and draw a map with their locations and directions by using Global Positioning System (GPS) for the factories, which considered the main source of urban pollution.

Fig. 1: Map represents Gharbia governorate location for samples collection (arrow)

2.2. Heavy metal (HM) analysis:

Different bread samples were dehydrated at 70 ˚C. After drying, they were grinded into a fine powder and stored in dissector until used for acidic digestion. The samples were digested with 10 ml of ultrapure concentrated HNO_3 (69%), and heated on a hot plate for clear solution. After cooling, 10 ml of deionized water were added, filtered and made up to the final volume 20 ml with water **(Salvo *et al.*, 1998)**. During experimental procedures, deionized water was used. All plastic and glass wears were washed in nitric acid for 15 min and rinsed with deionized water before use. Instrumental calibrations with standard solutions were done for optimum conditions.

The limits of detection (LODs) for these metals were intended as a double the standard deviation of a sequence of quantities of a solution against the blank absorbance (**ISO/IEC, 1990**). Working standards were used, quality assurance procedures and precautions were approved to confirm the dependability of the results. Samples were carefully held, and deionized water was used to escape impurity. A recovery trial was accepted out by spiked the blank with 20 and 50 ppm of multi-standards of these metals, and the procedures were done as described above.

The desirable HMs were measured on MP-AES under pump speed 15 rpm, sample uptake time 15 sec, stabilization time 15 sec and reading time 3 sec. The samples were measured in duplicates.

The exposure pathways for breads in the studied region may be induced as follows:

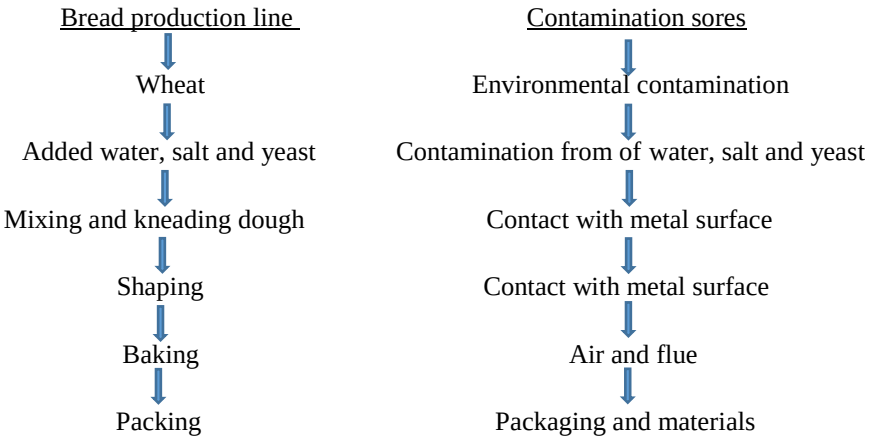

Fig. 2: Possible Contamination sources during bread production

2.3. Data analysis: The results were administered by Microsoft Excel (Microsoft 2000) and statistical analysis was directed using the program of SAS Release 6.12 (**Gomez and Gomez, 1984**).

3. Results and Discussion

The obtained data showed positive responses in all measured samples. The selected conditions for measurements were suitable to determine the following metals: Pb, Cd, Fe, Cu, and Zn at wavelengths: 340.46, 228.80, 259.94, 324.75 and 213.85 nm with sensitivity on AES instrument through detection limits: 1.6, 1.4, 1.6, 0.6 and 2.8 ppb, respectively (Table 1). The used method for sample preparation displayed recovery percentage 90.0-110.0%.

Table 1: The selected conditions used in atomic emission spectrometry (AES) instrument

Element	Wave Length (nm)	Detection Limit (ppb)	Recovery (%)
Pb	340.46	1.6	
Cd	228.80	1.4	
Fe	259.94	1.6	90.0-110.0
Cu	324.75	0.6	
Zn	213.85	2.8	

The concentrations of HMs in the collected bakery products are listed in Table 2. Zinc (Zn) exhibited the highest mean value 44.56 mg/kg dry w in Feno bread of El-Santa, followed by Baton Sale (37.68 mg/kg dry w) of Kafr El-Zayat and Feno bread (34.42 mg/kg dry w) of El-Mahalla district. The least value (24.99 mg/kg dry w) was found in Baton Sale samples of El-Mahalla. The highest values of Cu (14.15 and 15.76 mg/kg dry w) were found in Feno bread and Baton Sale of El-Santa. No significant differences were obtained in samples of Kafr El-Zayat and El-Mahalla districts, where Cu concentrations exhibited the values: 7.92, 7.62, 7.58 and 7.41 mg/kg dry w in Feno bread and Baton Sale, respectively. Iron (Fe) exhibited the greatest ranges in all samples. In Kafr El-Zayat, it exhibited 104.33 and 411.85 mg/kg dry w in Feno bread and Baton Sale samples, followed by 214.81 and 165.54 mg/kg dry w in El-Santa and 123.06 and 115.03 mg/kg dry w in samples of El-Mahalla district. Cadmium (Cd) exhibited the least values in the determined samples compared with other metals. The greatest mean values: 0.43 and 0.44 mg/kg dry w were obtained in Feno bread and Baton Sale of El-Mahalla, followed by Kafr El-Zayat (0.32 and 0.31 mg/kg dry w). The least values 0.18 and 0.21 mg/kg dry w were found in El-Santa district. Lead (Pb) exhibited the greatest mean values 3.35 and 2.18 mg/kg dry w in Feno bread and Baton Sale of Kafr El-Zayat district. No significant differences were obtained in samples of El-Mahalla (2.13 and 2.28 mg/kg dry w). The least mean values: 1.54 and 1.95 mg/kg dry w were found in Feno bread and Paton Saleh samples of El-Santa district.

The present study focused on the determination of HMs in an essential food matrix of the residents of Gharbia governorate, which is considered an industrial zone in Egypt. The major contributions to HMs pollution in this region are brick making factories, fertilizers, pesticides, oils and textile industries (**Abdel-Halim *et al.*, 2019**). The impacts of HMs on wheat flour are the main source for HMs in the bakery products. Heavy metals are considered the greatest common environmental contaminants. Such this accumulation into the soil and water rise to an alarming rate, triggering deposition and sedimentation in water reservoirs and affecting aquatic organisms (**Mohiuddin *et al.* 2010; Mohiuddin *et al.* 2011**). Fast, disorderly urban and industrial progresses have funded to the elevated levels of HMs in the urban situation of developing countries e.g. Egypt. On the other hand, vegetation contains amount of Cu, which is insufficient for usual growth of it. While, presentation of micronutrient fertilizers and copper-based fungicides may sometimes increase it to the worrying levels (**Radwan and Salama, 2006**).

The major route for humans' exposure to heavy metals is through the food pathway **(Hubbard et al., 1979).** Contamination of bread by heavy metals could arise from flour, which may have been produced from contaminated raw materials. Water used for bread making could also be a source of heavy metal contamination. Studies by **Ahmed and Fadel (2012)** revealed that the kind of baking fuel used for bread production could also be responsible for heavy metal contamination. Some of HMs are significant in nutrition, for their essential roles or for their toxicity, potential toxic effects of them have been widely defined by several investigators **(Khaniki, 2005)**. Metals such as Cd, Cr, are considered carcinogenic, while Fe, Cu, Zn, Ni, and Mn are considered as essential metals, however, if the concentration of the later elements are higher than their permissible limits they may create toxic effects in organisms **(Gulfrazi *et al*., 2003).** Potential toxic metals set up condition that promote inflammation in arteries and tissues, producing more calcium to be drawn to the area as a buffer, funding to acclimatization of the artery walls with progressive blockage of the arteries and osteoporosis in general, HMs have no role in the body and can be very toxic. They are systemic toxins with specific neurotoxic, nephrotoxic and

Table 2: Concentrations of HMs (mg//kg dry w) in some bakery products collected from districts of Gharbia governorate HMs (mg/kg dry w)

Region	Zn		Cu		Fe		Cd		Pb	
	(range)	Mean	(range)	Mean	(range)	Mean	(range)	Mean	(range)	Mean
1-Kafr El-Zayat										
Feno bread (n=21)	19.39-52.52	30.14 ±12.97[a]	5.12-15.93	7.92±0.42[b]	77.47-153.76	104.33±24.57[b]	0.21-0.41	0.32± 0.05[b]	2.08-10.07	3.35±2.75[a]
Baton Sale (n=21)	17.66-60.65	37.68±15.89[a]	5.34-8.61	7.62±0.75[b]	95.68-1080.74	411.85±380.03[a]	0.16-0.41	0.31±0.07[b]	BDL-2.88	2.18±0.18[a]
2-El-Mahalla										
Feno bread (n=21)	19.82-92.30	34.42±24.26[a]	6.75-8.30	7.58±0.42[b]	99.19-184.36	123.06±27.86[b]	1.79-3.03	0.43±0.06[a]	1.70-2.75	2.13 ±0.31[b]
Baton Sale (n=21)	2.11-32.22	24.99±6.27[b]	6.32-8.20	7.41±0.49[b]	58.35-213.02	115.03±53.29[b]	0.36-0.51	0.44±0.04[a]	1.79-3.03	2.28±0.41[b]
3-El Santa										
Feno bread (n=21)	20.94-128.0	44.56±38.10[a]	11.0-16.0	14.15±1.52[a]	109.36-656.8	214.81±198.28[a]	0.14-0.27	0.182±0.04[c]	1.22-1.77	1.54±0.18[b]
Baton Sale (n=21)	22.23-56.0	33.71±8.78[a]	12.68-17.78	15.76±1.35[a]	107.68-278.63	165.54±65.84[b]	0.16-0.25	0.206±0.04[c]	1.44-2.82	1.95±0.42[c]
Regional mean										
Feno bread	-	36.37±26.87	-	9.88±3.55	-	147.40±122.86	-	0.31±0.11	-	2.34±1.78
Baton Sale	-	32.13±12.30	-	10.26±3.89	-	230.81±261.79	-	0.32±0.12	-	2.14±0.43

-BDL= below detection limit. -Each value represents the mean±SD

genotoxic effects **(Jarup, 2003)**. The effect of environmental pollution on contamination of foods and on their safety for human consumption is a serious global public issue and widely conducted (**Alegeria *et al.*, 1990, Ahmed, *et al.*, 2000**; **Moffat and Whittle, 1999)**. Lead (Pb) is present in the environment because of air, soil and water pollution (**Peter *et al.*, 2003**).

Iron (Fe) is a necessary element for all kinds of life. It is an important component of the human immune system. It is also the most critical component of various enzyme systems as well as other vital components such as myoglobin, cytochromes, and catalase. Various groups of individuals have differing views on Fe's importance. It may also have health benefits in the treatment of anemia in pregnant or menstruating women. It aids in the treatment of iron deficiency anemia, a serious condition. Copper (Cu) is found in a variety of diets. It plays a variety of important responsibilities in demonstrating how to keep a healthy physique. Copper's health advantages stem from its anti-inflammatory properties (**Feyzi *et al.*, 2017).** In fact, such these metals are essential for organisms for metabolic process and cell activities at tolerate levels, but over tolerance they recently impose adverse health effects. As noted, magnitude in the United States, West Europe, Russia, and Turkey is 55, 274, 164, and 400 grams per person. Mean daily intake of bread in the world is 330 to 410 gram per person **(Garcia-Rico *et al.*, 2007)**. So, cumulative exposure to such HMs in the present work evidence impose adverse health effects for Gharibia residents. Today, European Union has stated maximum levels of pollutants in foodstuffs only for Cd and Pb (**EU, 2001**). According to these values, Cd content in all samples of the present study were upper the limit established for cereals (0.117 mg/kg dry w), and for wheat grain and cereal bran (0.235 mg/kg dry w), respectively. Regarding Pb, the regional mean in this study ranged from 2.14 to 2.34 mg/kg dry w. It is exceeding the maximum permissible level imposed to all cereal foodstuffs (0.235 mg/kg dry w). It can concluded that, such these accumulations may impose adverse health risks for Gharbia residents. So, regulatory issues and procedures from decision-making must be done for food safety.

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تتبع تلوث بعض منتجات المخابز بالعناصر المعدنية الثقيلة في محافظة الغربية – مصر

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الملخص العربي:

أجريت هذه الدراسة لتقدير خمسة معادن ثقيلة هي الكادميوم، الرصاص، الحديد، النحاس والزنك في بعض منتجات المخابز في محافظة الغربية - مصر. تم اختيار ثلاث مناطق هي كفر الزيات، المحلة الكبرى والسنطه لإخذ هذه العينات. أظهرت النتائج أن الزنك عنصر معدني أساسي له مستويات معنويه في خبز الفينو (٤٤,٥٦ مجم | كجم وزن جاف) في مدينة السنطه، يليه الباتون ساليه (٣٧,٦٨ مجم| كجم وزن جاف) في كفر الزيات. عنصر الحديد كان متوسط القيم له من ١٤٧,٤٠ و٢٣٠,٨١ مجم| كجم وزن جاف في خيز الفينو والباتون ساليه، يليه الزنك (٣٦,٣٧ -٣٢,١٢ مجم| كجم وزن جاف). أظهرت النتائج أن الكادميوم والرصاص كمعادن سامة وجدت بقيم ايجابية في جميع العينات المقاسة بمتوسط قيم (٠,٣٢-٣١.٠ مجم| كجم وزن جاف) و (٢,١٤-٢,٣٤ مجم| كجم وزن جاف) والتي مثلت مستوي تلوث اعلى من الحدود القصوى المسموح بها والتي وضعها الاتحاد الأوربي. مثل هذا التراكم قد تؤدي الي مخاطر صحية سلبيه على سكان محافظة الغربية. لذلك، يجب اتخاذ الإجراءات والدراسات التنظيمية لصانعي القرار بهدف سلامة الغذاء.

الكلمات المفتاحية: عناصر معدنية – منتجات مخابز – الخبز الفينو- الباتون ساليه.