

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/343852164>

EFFECT OF COOKING METHODS ON HEAVY METALS CONTENT OF FOOD

Article in *Xi'an Dianzi Keji Daxue Xuebao/Journal of Xidian University* · August 2020

DOI: 10.37896/jxu14.8/076

CITATIONS

0

READS

271

1 author:



Stanley Okonkwo

Osaka Kyoiku University

5 PUBLICATIONS 0 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Improving the teaching and learning of chemistry in Nigerian secondary schools using the Japanese model [View project](#)

EFFECT OF COOKING METHODS ON HEAVY METALS CONTENT OF FOOD

¹Inobeme, A., ²Ajai, A.I., ¹Eziukwu, C., ³Obigwa, P.A., ⁴Okonkwo, S., ⁵Ekwoba, L., M.

¹Department of Chemistry, Edo University Iyamho, Nigeria

²Department of Chemistry, Federal University of Technology Minna

³Science complex Abuja, Nigeria

⁴Department of Chemistry, Osaka Kyoiku University, Osaka, Japan
Department of Chemistry, Kogi State University, Anyigba

Abstract

The presence of heavy metals in processed food has been reported by various researchers. This has become of more pressing concern because of the deleterious effects associated with some of these metals such as lead, mercury and cadmium. Different cooking methods are known to exist and these methods also affect the presence of heavy metals in the cooked food. Studies have been carried out using methods such as smoking, grilling, boiling, and frying amongst others. Different concentrations of these metals have also been reported and in some available studies even beyond the permissible limits based on international standards. There is however varying reports on the effect of different cooking methods of the contents of these metals in food. While some researchers reported a decrease in concentrations, other studies reports a different finding. This paper reviews the effect of different cooking methods on contents of these metals. Information was gathered from published papers and the findings from various authors carefully looked into. Attempt was also made to highlight the varying reasons responsible for their observations.

Key words: Cooking, food, heavy metals, toxicity

Introduction

Various kinds of food materials are vital for human diets because they are necessary in ensuring balanced diet. Some of these foods include fish, meat, vegetables, and grains amongst others. Some are consumed raw while others must be processed through cooking before consumption (Kananke et al., 2015). Various methods of cooking are available for the processing of raw food materials before consumption. Some of the commonly employed methods include boiling, frying, roasting, barbequing and grilling. Basically, cooking using some of these methods is done so as to enhance taste, flavor and make it convenient to eat this meat. The different methods of cooking have been reported to significantly affect the amounts of contaminants such as heavy metals present in the final product (Kobia et al., 2016).

The term heavy metal is commonly used to refer to those metallic elements that have a relatively high density, higher than 5g/cm^3 . These groups of metals are of concern in that unlike organic contaminants they cannot be degraded by microorganisms their transformation only occurs in terms of changes in oxidation number. Although these metals are ubiquitous hence found in all aspects of the environment, under such conditions they do not constitute harms since they are less bio-available. However human activities such as industrialization, agriculture and modern technological explorations have contributed greatly to the higher contents of these metals in the environment thereby making them to have serious lethal consequences on human and other organisms. Food substances such as meat and fish are known to have remarkable nutritional values due to their high proteins contents notwithstanding, their complex nature makes it possible for the bioaccumulation of toxic heavy metals (Oyekunle et al., 2020).

Reduction of heavy metals contents in food could occur during processing. Some food substance could also absorb some metals when the medium, water and oil are contaminated with metals. The metallic material used for grilling may also be a potential source for this rise. Contacts of food with surfaces already contaminated by these metals also occur. Metal contamination has also been pointed to the inappropriate storage system, such as putting acidic food materials in metallic materials rather than plastic, which gradually results to rise in metal contents. Most people come in contact with heavy metals through contaminated food (Gheisari et al., 2016).

There are different cooking methods and each of this method may affect the levels of heavy metals in the food through various mechanisms such as elemental solubilization, moisture evaporation and lose of other volatile materials, binding with other nutritional components of the food materials such as lipids, carbohydrates and proteins. Heavy metals do not evaporate or disintegrate into harmless substances but rather when detached during cooking and processing will only migrate into the processing medium and retained in the food (Gheisari et al. 2016).

Several studies have been carried out in which researchers investigated the heavy metals contents of different kinds of food materials including fish, beefs, and vegetables amongst others. There is however limited studies and reviews which sufficiently account for the discrepancies in the finding from different researchers. While some studies reported a remarkable increase on the heavy metals contents due to different methods of cooking, some other studies have documented the opposite. Hence there is no established consensus on how different cooking processes contribute to the variations in the heavy metal contents of the final products. It is against this backdrop that this review focuses on some of the studies carried out and their findings with regards to the effect of cooking methods on heavy metal contents. Attempts was also made to highlight some of the different factors they adduced to be responsible for the reported findings (Igwegbe et al., 2015).

Studies on effect of cooking methods on heavy metal contents in food

Oyekunle et al. (2020) in their study reported that method of processing plays a significant role in affecting the content of heavy metals in food. The contents of the potentially toxic metals investigated were observed to follow the trend: Freeze dry > sundry > oven dry. They attributed this observation to the higher water and other volatile materials present in the sample studied. The mean contents of the heavy metals assessed were observed to be in the order: lead < arsenic < cadmium < cobalt. Naseri et al. (2014) investigated the impact of two methods of cooking on the content of cadmium, chromium, cobalt, nickel and lead in selected rice brand from markets in Iran. The findings from the study showed presence of the metals in the raw and cooked food, however the contents of the metals studied were found to reduce due to the cooking process. However the effect on the metal contents was not significant. Kananke et al.

(2015) did a study with the aim of assessing the effect of processing methods on heavy metal content. The determination of heavy metals was done on the raw, cooked and fried. The food examined was green leafy vegetable that are commonly eaten in Sri Lanka. The results from the study revealed that the heavy metal contents (lead, cadmium, nickel, copper and chromium) were not affected significantly by the cooking methods adopted at $p < 0.05$. Inobeme et al. (2018) investigated the heavy metals contents in raw and grilled meat with a view to determining the effect of grilling on the contents of the metals. They observed from their study that grilling brought about a reduction in the content of zinc, cadmium, copper and manganese. However the concentration of iron was observed to be higher in the grill meat. The highlighted the need for grilled meat sellers to carry out the processing away from open environment which could be responsible for the increase in the content of lead. Devesa et al. (2001) in their work reported a decrease in the concentration of chromium in catfish due to cooking. The methods of cooking assessed include: grilling, baking and microwave. The contents of the metals in the raw catfish fillets were found to be higher than the cooked irrespective of the method of cooking used. The concentration of lead however was not affected significantly by the different cooking methods at $p > 0.05$. The content of chromium was significantly low in the microwave and grilled samples. Cadmium however was not present in all the samples analyzed. Ziarati et al. (2013) carried out their investigation on how commonly used cooking methods affect the contents of cadmium and lead in edible mushrooms collected from Iran. The result from the study showed that the heavy metal contents were higher in the processed sample when compared to the raw. Among the different methods of processing, microwave mushroom had higher content when compared to the directly cooked using boiling. Kobia et al. (2016) studied the impact of smoking on the heavy metal contents of raw and smoked bush meat. They employed three cooking methods which include grilling, frying and boiling. They deduced from their study that grilling method help in the reduction of heavy metal content. Based on the outcome of their study they recommended that consumers should preferably use grilling due to food safety concern. Among the various metals studied arsenic and cadmium showed the lowest heavy metal content. They also recommended the need for washing smoked food as this could also help in the reduction of the heavy metals present. Gheisari et al. (2016) investigated three different food processing method (steaming, boiling and frying) and how they affect the content of heavy metals. Their study was focused on lead and cadmium in lobster and shrimp. The

highest content was observed in the fried samples. The change in the concentration of cadmium was not significant. The content of lead was higher in the fried sample. They therefore recommended the use of steaming and boiling since they have the potential of reducing the content of these toxic metals. Ersoy (2011) used four different cooking methods which include baking, frying, grilling and micro waving in determining the heavy metals (nickel, chromium, cadmium and lead) in african cat fish. The content of lead and arsenic did not differ significantly ($p > 0.05$) between all the processing methods employed. They however suggested from their study the need to use grilling, microwave preferable as it favors a decrease in metal content. Diaz et al. (2004) carried out a thorough study on impact of four different cooking methods (baking, stewing, boiling and pureeing) on the content of heavy metals in vegetables and cereals. The finding from their study showed that boiling method helps in reducing the content of arsenic. They attributed their findings to the acceleration of the bond breaking process due to the heat treatment as well as other processes such as solubilization in the water. The contents of cadmium, lead and chromium in white fish was investigated by Zahra et al. (2018). They focused on the raw samples and other samples processed using grilling, frying, steaming, and microwaving. Statistical comparison was then done between the metal content in the raw and the processed. The result revealed that all the cooking methods brought about a decrease in the concentration of the metals. Igwegbe et al. (2015) investigated the effect of seasons and smoking on the content of heavy metals in fish following wet method of digestion. They observed that when the smoked fish samples were washed three times using distilled water, there was a remarkable decrease in the metal concentration. Perello et al. (2008) studied the effect of some Spanish methods of cooking on the heavy metal content of some food stuffs. The finding from the study showed that boiling brings about a significant reduction of arsenic content of the vegetables, while there was an increase with frying though the differences observed were not significant at $p > 0.05$. Jortiem et al. (1994) conducted a research in which they reported that the content of nickel, cobalt and cadmium in crayfish decreased on cooking. They attributed this observation the effect of the applied heat in bringing about the degradation of proteins, which in turns also affected the heavy metals present. Atta et al (1997) reported that cooking methods such as baking and steaming brings about a reduction of heavy metals contents in different organs of fish.

In a related study, Kalogeropoulos et al. (2004) observed that the concentration of metals in cooked fish using grilling and frying were higher than in the raw samples. They gave the possible reasons for this observation to be due to the size of the fish that was cooked. They explained that the fish size was related inversely to the oil uptake and loss of water during the cooking process. Hence when smaller portions are cooked, there is higher loss of water which also leads to higher metal concentration. Loss of water and weight occurs during thermal treatment bring about a change in the chemical substances and inorganic contaminants (Cabanero et al., 2004).

Table 1: Summary of effect of cooking methods

S/No	Authors	Samples	Method of treatment	Heavy metals	Reduction significant for	Decrease significant for
1	Kobia et al. (2016)	Fresh and smoked bush meat	Boiling	Fe, Cu, Cd, Pb, Mn and Zn	Fe, Pb, and Cu	
			grilling		Fe, Cu	Pb, Zn and Mn
			frying		Zn and Pb	Fe, Cu and Mn
2	Igwegbe et al. (2015) Ersoy 2011	Fish samples Cat fish	smoking	Pb, Cd, Hg and As		Pb
			Grilling	As, Cd, Cr, Co, Ni and Pb		Ni, Cr
			Frying			

			Microwaving			Cr
			baking			
3	Gheisari et al. 2016	Shrimp and Lobster	Steaming	Pb and Cd		Pb and Cd
			Boiling		Pb and Cd	
			frying		Pb and Cd	
4	Diaconescu et al., 2013	Fin Fish	Grilling	Cr, Ni, Cd and Pb		Cr, Ni, and Pb
			Frying		Cr, Ni, Cd and Pb	
			microwaving			Cr, Ni, and Pb
			Baking			Cr, Ni and Pb
5	Inobeme et al. (2018)	Smoked meat, chicken and beef		Fe, Mn, Cd, Cu, Cr, Pb and Zn	Pb, Fe	Cu, Zn
6	Kananke et al., 2015	Green leafy vegetable	Frying	Ni, Cd, Cr, Pb Cu	Cr	Cd
7	Zahra et al., 2018	White fish	Frying	Pb, Cr and Cd		Pb, Cr and Cd
			grilling			Pb, Cr and Cd

Boiling	Pb, Cr and Cd
Steaming	Pb, Cr and Cd

- Indicates elements studied but were not detected

Reasons for the change in concentration

Lee et al. (2019) in their work carried out the analysis of oil seeds, tea leaves and nodules in order to ascertain the effect of method of processing on the contents of heavy metals. They concluded that the heavy metals that are present in food substances are soluble in water hence will decreased during to processing or cooking in watery medium. They attributed the decrease in metal content in the fried sample to be due to the loss of water at high temperature. Many factors such as the initial concentration of heavy metals in the meat, aquatic species, can affect the reduction or increase of these elements in the flesh as the result of cooking processes.

Conclusion

There have been no consistencies as with regards to the effects of various methods of cooking on the contents of different heavy metals. Also most of the findings from available studies also seem to be conflicting. Sufficient reasons have not been adduced for the varying observations. In some of the available studies contributions from the environment during the cooking process has been attributed as a possible source of the rise in heavy metals. Which invariably imply that the cooking method or heat treatment is not the major factor for such studies. There is therefore need for controlled in this area, using larger amount of samples. Further studies need to be performed on cooking methods at different conditions (i.e. time, temperature, cooking mediums), aimed at reducing the dangerous effect of heavy metals in food.

Conflict of Interest

The authors declare that they have no conflict of interest.

References:

Amin O. Igwegbe, Charles A. Negbenebor, Elizabeth C. Chibuzo, Mamudu H. Badau and Gervase I. Agbara (2015). Effects Of Season And Fish Smoking On Heavy Metal Contents Of Selected Fish Species From Three Locations In Borno State Of Nigeria. *Asian Journal of Science and Technology*, 6:2, 1010-1019.

Atta M., El-Sebaie L., Noaman M., Kassab H (1997). The Effect of Cooking on the Content of Heavy Metals in Fish (*Tilapia Nilotica*), *Food Chemistry*, 58(1): 1-4.

Beyza Ersoy (2011). Effect of cooking methods on the heavy metal concentrations of the Africa Catfish (*Clarias gariepinus*) *Journal of Food Biochemistry*, 35(2)DOI: 10.1111/j.1745-4514.2010.00386.x

Cabañero A.I., Madrid Y., Cámara C., (2004). Selenium and Mercury Bioaccessibility in Fish Samples: an in Vitro Digestion Method, *Analytica Chimica Acta*, 526(1):51-61.

Cristiana Diaconescu Gina Fantaneru Laura Urdes Diaconescu Ștefan (2013). Influence of cooking methods over the heavy metal and lipid content of fish meat. *Romanian Biotechnological Letters* 18(18 3):8279:8283

D'iaz, O .P ., I. Leyton, O . Munoz, N. Nunez, V . Devesa , M.A. Suner, D. Velez and R . Montoro, (2004) Contribution of water, bread and vegetables (raw and cooked) to dietary intake of inorganic arsenic in a rural village of Northern Chile. *J. Agric. Food Chem .*, 52 :1773 -1779 .

Devesa, V ., M. Luz Macho, M. Jalon , I. Urieta, O . Munoz, M A Suner, F . Lopez, D. Velez and R . Montoro (2001). Arsenic in cooked seafood products: study on the effect of cooking on total and inorganic arsenic contents. *J . Agric. Food Chem .*, 49 :4132 -4140

E. Gheisari , M. Raissy , E. Rahimi (2016). The Effect of Different Cooking Methods on Lead and Cadmium Contents of Shrimp and Lobster *ournal of Food Biosciences and Technology*, Islamic Azad University, Science and Research Branch, 6 (2) 53-58.

Ganja vi, M., H. Ezza tpanah , M.H. G ivianrad and A . Shams, (2010) . Effect of can n ed tuna fish p ro cessin g ste p s on lead and cadm ium contents of Iranian tuna fish. *Food C h e m .*, 118: 525-528.

Ibanga IJ, Moses EA, Edet EJ, Moses AE (2019). Microbial and some heavy metals analysis of smoked fishes sold in urban and rural markets in Akwa Ibom State, Nigeria. *Calabar J Health Sci* 3(2):73-9.

Jorhem , L., J . Engman , B. Sundstrom and A .M . Thim (1994). T r a c e elements in crayfish: regional differences and changes induced by cooking. *Arch. Environ. Contam . Toxicol.*, 2 6 :1 3 7 -1 4 2

Kananke T.C., Wansapla J. and Gunarane (2015). Effect of Processing Methods on Heavy Metai Concentrations in Commonly Consumed Green Leafy Vegetables Available in Sri. Pakistan *Jo u rn al of Nutrition* 14 (12): 1 0 26-1033.

Kobia Joyce, Emikpe BO, Asare DA, Asenso TN, Yeboah Richmond, Jarikre TA and Jagun-Jubril Afusat Joyce et al., (2016). Effects of Different Cooking Methods on Heavy Metals Level in Fresh and Smoked Game *J Food Process Technol* 2016, 7:9DOI: 10.4172/2157-7110.1000617

Lee J., Hwang J., Lee H., Kim T., Choi, J. and Gang, G. (2019). Efects of food processing methods on migration of heavy metals tofood. *Appl Biol Chem* , 62:64 <https://doi.org/10.1186/s13765-019-0470-0> ARTICLE to

Morgan J.N. (1999) Effects of Processing on Heavy Metal Content of Foods. In: Jackson L.S., Knize M.G., Morgan J.N. (eds) *Impact of Processing on Food Safety. Advances in Experimental Medicine and Biology*, 459. Springer, Boston, MA

N aseri, M., Z. Rahm anikhah, V . Beiygloo and S . Ranjbar, (2014) . Effects of Tw o Cooking M ethods on the C o n cen tratio n s of S o m e H eavy M etals (Cadm ium , Le a d , Chrom ium , N ickel and C o b alt) in S o m e R ice B ran d s A vailab le in Iranian Market. *J . C h e m . Health R isk s*, 4 : 65-72.

Oyekunle, J.A.O., Ore, O.T., Durodola, S.S. (2020). Heavy metal levels and changes in trimethylamine content of smoked fish and meat under different storage conditions. *SN Appl. Sci.* 2, 1004 <https://doi.org/10.1007/s42452-020-2844-7>

Pereilo, G., R. Marti-Cid, J.M. Llobet and J.E.L. Domingo, 2008. Effects of various cooking processes on the concentrations of arsenic, cadmium, mercury and lead in foods. *J. Agric. Food Chem.*, 56: 11262-11269.

Perelló G., Martí-Cid R., Llobet J.M., Domingo J.L., Effects of Various Cooking Processes on the Concentrations of Arsenic, Cadmium, Mercury, and Lead in Foods, *Journal of Agricultural and Food Chemistry*, 56(23):11262-9 (2008)

Ziarati, P., H. Rabizadeh, Z. Mousavi, J. Asgarpour and A. Azariun, (2013). The Effect of cooking method in Potassium, lead and Cadmium Contents in Commonly Consumed packaged mushroom (*Agaricus bisporus*) in Iran. *Int J. Farming and Allied Sci.*, 2: 728-733.