Influence of thermal preparation method on mineral composition of Pangasius fish

Gheorghe Valentin GORAN, Liliana TUDOREANU, Boglarka BORBATH, Emanuela BADEA, Victor CRIVINEANU
Faculty of Veterinary Medicine, UASVM of Bucharest, 105 Splaiul Independentei, 050097, 5th district, Bucharest, Romania,
gheorghegoran@fmvb.ro

Abstract

Determination of metallic/mineral elements in seafood, such as fish, is of great importance in assessing both their nutritional quality and also the risk of environmental contamination, and use of fish as a biomarker for aquatic environment pollution could represent a reliable approach. Cooking method changes the mineral concentrations and could contribute to loss or increment of some essential, non-essential or toxic elements concentration. This study aimed to evaluate the effects of three different cooking methods (boiling, roasting, and microwave cooking) on the mineral concentrations of Pangasius fish filets from the Bucharest (Romania) market. Mineral content in raw and cooked Pangasius fish samples was evaluated by ICP-OES, after microwave digestion, and the relative humidity of Pangasius fish samples was assessed by thermogravimetric method used. Ca, K, and Mg levels were higher in cooked samples compared to raw Pangasius fish, with the highest level in microwaved samples. Na levels were significantly higher in roasted and microwaved Pangasius fish, and significantly lower in boiled samples. The highest Fe concentration was found in roasted samples. Al and Zn levels registered the same pattern with the highest level in roasted samples, and Se level in roasted samples was insignificantly different compared to raw samples. Pb levels were significantly increased in boiled and roasted Pangasius fish meat samples and Cd levels registered the highest concentration in raw samples.

Keywords: *pangasius fish, mineral, heavy metal, thermal preparation*

Introduction

Overpopulation determined the need to increase the amount of food, and exploitation of seas and oceans for fish was one of the solutions. However, this has led to overfishing, and then to the development of aquaculture, a viable solution to these problems (Stankovic *et al.*, 2012), but not always a healthy one.

Among the aquaculture fisheries food supply, *Pangasius* sp. is one of the commonly farmed fish in the Mekong River fishery, one of the largest and most important inland fisheries in the world (www.fao.org). Pangasius fish fillets marketed in Romania are imported from Vietnam.

Metallic pollutants contamination of freshwater is a matter of concern because of their toxic potential ability to be accumulated in the food chain (Elnimr, 2011), particularly in some parts of the world, thus it is important to evaluate the aquatic environment. Fish are considered as one of the most susceptible aquatic organisms to pollutants (Alibalić *et al*., 2007). Fish that occupies the highest level of the aquatic food chain may concentrate an important level of hazardous chemicals, which could reach to humans. (Pourang, 1995; Adeyeye *et al*., 1996; Mansour and Sidky, 2002; Kah *et al*., 2016; Nor *et al*., 2017) Therefore, using the fish as a biomarker for aquatic environment pollution could represent a reliable approach (Rudneva *et al.*, 2011). The determination of metallic/mineral elements in food, such as fish, is of great importance in assessing both their nutritional quality and also the risk of environmental contamination (Conti *et al*., 2012).

Cooking method changes the mineral concentrations (Mesko *et al.*, 2016), and could contribute to loss or increment of some essential, non-essential or toxic elements concentration. In spite of knowledge about the toxicity of heavy metals and the great economic importance of the

Pangasius hypophthalmus, there is a lack of information available about the influence of different cooking methods on metallic/mineral elements as quality parameters which are considered quality indicators of fish. Most of the studies about *Pangasius hypophthalmus* refer individual chemical parameters such as mercury (Orban et al., 2008; Guimarães *et al*., 2016), or thermal preparation influence on lipid composition (Domiszewski et al., 2011).

This study aimed to evaluate the effects of three different cooking methods (boiling, roasting, and microwave cooking) on the mineral concentrations of Pangasius fish filets from the Bucharest (Romania) market. Mineral content in raw and cooked Pangasius fish samples was evaluated by ICP-OES, after microwave digestion, and the relative humidity of Pangasius fish samples was assessed by thermogravimetric method used.

Materials and methods

Samples preparation

The samples were represented by imported frozen fish fillets of *Pangasius hypophthalmus* without skin purchased from the supermarkets in Bucharest, Romania.

Before analysis the samples were thawed, weighed, labelled and packed in temperature resistant food plastic bags (samples of 100 g ± 5% each were placed in resistant plastic cooking bags). All Pangasius fish samples (n=30) were dived into four groups: raw samples, samples cooked by boiling (boiled in water with no contact between samples and water, for about 17 minutes, 100^{o}C), samples cooked by roasting (with no contact between meat samples and oven tray, 12 minutes, electric oven, 180^{o}C), and samples cooked by microwave irradiation (with no contact between meat samples and microwave plate, 5 minutes, consumer microwave oven, 850W).

For each cooking method, the time for cooking was estimated after several tests in order to achieve eatable samples. After cooking, samples were cooled, stored at 6^{o}C for 24 hours, and then raw and cooked samples were drained off before they were ground using the GRINDOMIX GM 200 knife mill. From each sample, 0.5 g (wet weight – ww) were digested using a Spedwave MWS-2 Berghof microwave oven as follows: Step 1: 120^{o}C, power 50%; Step 2: 180^{o}C, power 75%; Step 3: 100^{o}C, power 40%.

Spectrometric analysis

Digested samples were diluted to 25 mL with ultrapure water and analyzed by Thermo iCAP ICP–OES spectrometer (RF1100 W; reading time 30 s, washing time 30 s, nebulizer gas flow L•min^{-1}; auxiliary gas flow 0.5 L•min^{-1}; sample injection pump flow 50 rpm). Calibration curves were developed using standard solutions of 0.001 ppm, 0.01 ppm, 0.1 ppm, 1 ppm, 5 ppm, 10 ppm, 50 ppm obtained by dilution from a multi-element ICP MERCK standard containing 1000 mg•L^{-1} of Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Na, Ni, Pb, Se, Sr, and Zn. Analyzed minerals for which no concentrations are reported in the present work were below method detection limit.

Relative humidity

The relative humidity of raw and cooked Pangasius fish samples was measured before digestion by thermogravimetry. The operating parameters of the thermogravimeter were: t = 9 minutes, T = 100°C.

Statistical analysis

Statistical analysis was performed using the software of VassarStats: Website for Statistical Computation (http://vassarstats.net/). One-Way ANOVA was performed for all samples' mineral concentrations, and when ANOVA generated $p \leq 0.05$, means comparison was carried out by all-pair Tukey HSD Test.

Results and discussions

In Table 1 are presented the mean heavy metal and mineral levels in Pangasius fish meat samples. Analyzed minerals for which no concentrations are reported in the present work were below method detection limit.

In general, mineral/heavy metal levels were significantly different between mussel meat samples independent of thermal preparation method.

Cooking method significantly influenced the level of Fe only in roasted and microwaved samples reported to raw ones, suggesting a high level of an insoluble fraction of this element in Pangasius fish. The highest Fe concentration was found in roasted samples, insignificantly different compared to microwaved samples.

Al and Zn levels registered the same pattern with the highest level in roasted samples. In the case of the other two types of cooking, Zn mean levels were insignificantly different compared to raw samples.

Se level in roasted samples was insignificantly different compared to raw samples, and it was significantly decreased in the case of the other 2 thermal preparation methods. Cu concentration in raw Pangasius fish meat samples was not significantly different compared to those in boiled and microwaved samples and significantly increased in roasted samples.

Ca, K, and Mg levels were higher in cooked samples compared to raw Pangasius fish, independent of cooking method, with the highest level in microwaved samples. Reported to raw samples, Na levels were significantly higher in roasted and microwaved Pangasius fish, and significantly lower in boiled samples.

Table 1. Mean heavy metal and mineral levels in Pangasius fish meat samples (ppm)

Element	Pangasius fish meat				*p*-value
	Raw	Boiled	Roasted	Microwaved	
Al	0.45[a]	0.43 [a]	0.56 [b]	0.265 [c]	<.0001
Ca	11.0 [a]	13.2 [b]	33.5 [c]	59.4 [d]	<.0001
Cu	0.016 [a]	0.017 [a]	0.025 [b]	0.018 [a]	<.0001
Cd	0.043 [a]	0.028 [b]	0.032 [c]	0.029 [b]	<.0001
Fe	0.4 [a]	0.4 [a]	1.4 [b]	1.3 [b]	<.0001
K	56.9 [a]	69.5 [b]	117 [c]	176.6 [d]	<.0001
Mg	8.8 [a]	9.5 [b]	18.6 [c]	22.4 [d]	<.0001
Na	1445 [a]	1297 [b]	2752 [c]	2839 [d]	<.0001
Ni	0.009 [a]	0.026 [b]	0.015 [c]	0.019 [d]	<.0001
Pb	0.004 [a]	0.006 [b]	0.007 [b]	0.005 [a]	0.0305
Se	0.022 [a]	0.003 [b]	0.02 [a]	0.001 [c]	0.0014
Zn	0.3 [a]	0.3 [a]	0.63 [b]	0.33 [a]	0.0011

*Levels not connected by the same letter are significantly different. The comparison can be made only between thermal preparation methods for the concentration of one element and not between different

Pb levels were insignificantly different in microwaved samples, but they were significantly increased in boiled and roasted Pangasius fish meat samples. Also, Ni levels in Pangasius fish meat samples were significantly increased in cooked samples, with the highest level in boiled samples.

Cd levels were significantly decreased in cooked samples reported to raw samples, in which registered the highest concentration.

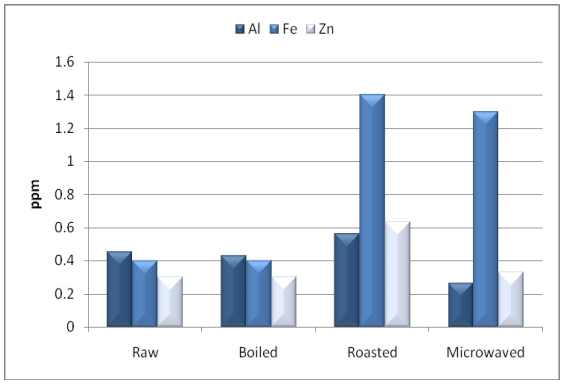

Fig. 1. Mean Al, Fe, and Zn levels in Pangasius fish meat samples (ppm)

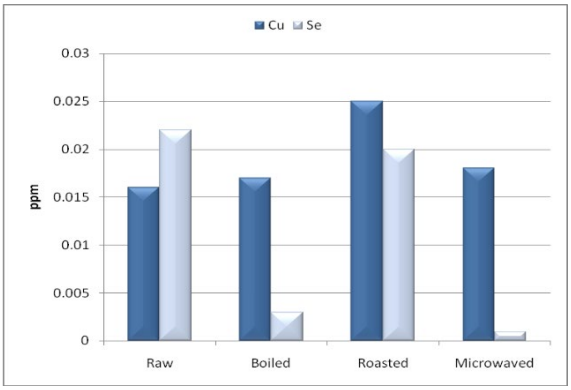

Fig. 2. Mean Cu and Se levels in Pangasius fish meat samples (ppm)

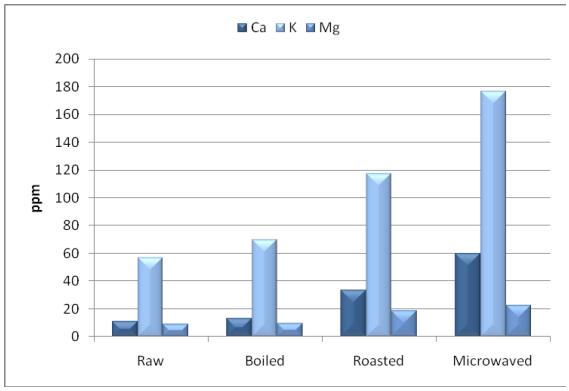

Fig. 3. Mean Ca, K, and Mg levels in Pangasius fish meat samples (ppm)

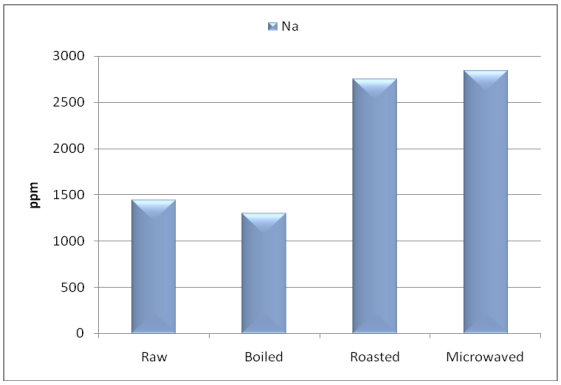

Fig. 4. Mean Na levels in Pangasius fish meat samples (ppm)

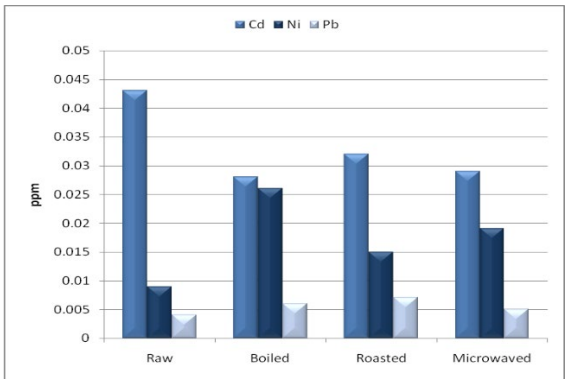

Fig. 5. Mean Cd, Ni, and Pb levels in Pangasius fish meat samples (ppm)

In cooked Pangasius fish samples, the highest mean relative humidity was registered in the case of boiling (84.49%), the lowest after microwave cooking (70.94%), while in the case of roasting, relative humidity was 75.64%. One-way ANOVA was performed for identifying significant differences between the relative humidity of cooked samples. The relative humidity of cooked samples was significantly different between cooking methods (p<.0001). The percentage of water loss during microwave cooking was higher than the other two thermal preparation methods.

Conclusion

Cooking influenced the mineral composition of Pangasius fish, with impact on the essential mineral nutrient intake.

In this research work, thermal preparation increased macromineral concentrations in cooked samples compared to raw Pangasius fish.

The highest mineral concentrations were identified in roasted samples.

Essential and non-essential minerals registered highest levels in roasted samples.

Cd registered significantly decreased levels in cooked samples.

The results obtained in this study can be a recommendation for consumers to choose the most effective method of cooking Pangasius fish in order to maintain or improve their nutritional qualities.

References

1. Adeyeye E.I., Akinyugha N.J., Fesobi M.E., Tenabe V.O. (1996). Determination of some metals in *Clarias gariepinus* (cuvier and valenciennes), *Cyprinus carpio* (L), and *Oreochromis niloticus* (L) fish in a Polyculture fresh water pond and their environments. *Aquaculture* 147(3/4): 205–14.
2. Alibalić V., Vahčić N., Bajramović M. (2007). Bioaccumulation of metals in fish of *Salmonidae* family and the impact on fish meat quality. *Environ. Monit. Assess* 131:349-64.
3. Conti G.O., Copat C., Ledda C., Fiore M., Fallico R., Sciacca S., Ferrante M. (2012). Evaluation of heavy metals and polycyclic aromatic hydrocarbons (PAHs) in *Mullus barbatusfrom* Sicily Channel and risk-based consumption limits. *Bulletin of Environmental Contamination and Toxicology* 88(6):946-50.
4. Domiszewski Z., Bienkiewicz G., Plust D. (2011). Effects of different heat treatments on lipid quality of striped catfish (*Pangasius hypophthalmus*) *Acta Sci. Pol., Technol. Aliment.* 10(3): 359-73.
5. Elnimr T. (2011). Evaluation of some heavy metals in *Pangasius hypothalmus* and *Tilapia nilotica* and the role of acetic acid in lowering their levels. *International Journal of Fisheries and Aquaculture* 3(8):151-7.
6. Guimarães C.F.M., Máralém E.T., Monteiro M.L.G., Lemos M., Mano S.B., Conte Junior C.A. (2016). The chemical quality of frozen Vietnamese *Pangasius hypophthalmus* fillets. *Food Science & Nutrition* 4(3): 398-408.
7. Idris N.S.U., Low K.H., Koki I.B., Kamaruddin A.F., Md. Salleh K., Md. Zain S. (2017). *H. emibagrus* sp. as a potential bioindicator of hazardous metal pollution in Selangor River. *Environl Monit Assess* 189: 220.
8. Low K.H., Idris N.S.U., Md. Zain S., Kamaruddin A.F., Md. Salleh K. (2016). Evaluation of elemental distributions in wild-caught and farmed *Pangasius* sp. using pattern recognition techniques, *International Journal of Food Properties* 19(7): 1489-503.
9. Mansour S.A., Sidky M.M. (2002) Ecotoxicological Studies. 3. Heavy Metals Contaminating Water and Fish from Fayoum Governorate, Egypt. *Food Chemistry* 78(1): 15-22.
10. Mesko M.F., Toralles I.G., Hartwig C.A., Coelho Jr. G.S., Muller A.L.H., Bizzi C.A., Mello P.A. (2016) Bromine and iodine contents in raw and cooked shrimp and its parts, *J. Agric. Food Chem.* 64 (8): 1817-22.
11. Orban E., Nevigato T., Di Lena G., Masci M., Casini I., Gambelli L., Caproni R. (2008). New trends in the seafood market. Sutchi catfish (*Pangasius hypophthalmus*) fillets from Vietnam: nutritional quality and safety aspects. *Food Chem.* 110: 383-9.
12. Pourang, N. (1995).Heavy metal bioaccumulation in different tissues of two fish species with regards to their feeding habits and trophic levels. *Environmental Monitoring and Assessment* 35(3):207-19.
13. Rudneva I.I., Skuratovskaya E.N., Dorokhova I.I., Grab Y.A., Zalevskaya I.N., Omel'chenko S.O. (2011) Bioindication of the environmental state of marine areas with the use of fish biomarkers. *Water Res.* 38:107-12.
14. Stankovic S., Jovic M., Stankovic A.R., Katsikas L. (2012). Heavy Metals in Seafood Mussels. Risks for Human Health in Lichtfouse E., Schwarzbauer J., Robert D. (Eds) *Environmental Chemistry for a Sustainable World, Volume 1: Nanotechnology and Health Risk* (pp. 311-373). Springer Dordrecht Heidelberg London New York.
15. ***http://www.fao.org/fishery/culturedspecies/Pangasius_hypophthalmus/en, accessed 2nd of August 2017