

EFFECTS OF COOKING METHODS ON THE HEAVY METAL CONCENTRATIONS OF THE AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT

Arsenic (As), cadmium, Chromium (Cr), cobalt, nickel (Ni) and lead (Pb) were analyzed in cooked African catfish. Various cooking methods were used such as grilling, frying, microwaving and baking. The Pb and As concentrations of the samples varied between 0.09 and 0.15 mg/kg and 0.01–0.02 mg/kg, respectively. There were no significant differences ($P > 0.05$) in Pb and As concentrations between the raw, grilled, fried, baked and microwave-cooked fish. Ni contents decreased in grilled fish. Cr concentrations in grilled and microwave-cooked fish decreased significantly ($P < 0.05$). The results show that the grilling, microwave cooking and baking are suitable methods.

PRACTICAL APPLICATIONS

Heavy metals can be hazardous to consumers' health. Therefore, it is important to determine the concentrations of heavy metals in raw and cooked fish. The present study has shown that the heavy metal concentration of fish can be affected by processing or cooking methods. Consequently, it can be recommended that the baking, microwave cooking and grilling are suitable methods.

INTRODUCTION

African catfish *Clarias gariepinus*, which has a wide distribution from the South and Central Africa to the Middle East and Turkey, is a common

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commercial species in southern region of Turkey, especially in Hatay province. It is sold to Eastern Anatolia (Turkey) and Syria (Yalçın 2001). Four hundred eighty-six tons of African catfish were caught in 2007 (Anon 2007). This species is generally consumed fresh and it is relatively cheap in Turkey. Therefore, it is an important source of cheap, high-quality protein in developing countries such as Turkey.

It is a versatile fish that may be prepared in various ways, such as boiled, fried, baked, grilled (Lee 1991) and minced ball (Ersoy and Yilmaz 2003). Fish is a major source of minerals. The mineral content of fish can be affected by processing or cooking methods (Küçükgülmez *et al.* 2006). Chromium (Cr) and nickel (Ni), which are present in fish, are essential for human life at low concentrations and these elements can be toxic at high concentrations (Türkmen *et al.* 2008). However, heavy metals such as cadmium (Cd), cobalt (Co), lead (Pb) and arsenic (As) are nonessential metals as they are toxic, even in traces. Many consumers regard any presence of these elements in fish as hazardous to health (Oehlenschläger 2002). Therefore, it is important to determine the concentrations of essential and nonessential metals in raw and cooking fish in order to evaluate the possible risks of fish consumption for human health (Cid *et al.* 2001). Previous studies have shown that the heavy metal concentration of fish can be affected by processing or cooking methods. Atta *et al.* (1997) described a decrease in the concentrations of Cd, Cu, Pb and Zn in fish (*Tilapia zilli*) after steaming and baking. Jorhem *et al.* (1994) reported that some changes occurred during cooking in the Cd, Ni, Co, Pb, Cu and Mn concentration in crayfish. It was reported that the As concentration was significantly increased in fried *Dicentrarchus labrax* (Ersoy *et al.* 2006). Devesa *et al.* (2001) reported the total and inorganic As content in some seafoods. In the present work, the concentrations of heavy metals were determined in African catfish fillets cooked by various methods and were compared with the concentrations found in raw fish.

MATERIALS AND METHODS

Sample Preparation and Cooking

African catfish *C. gariepinus* (average length: 25–30 cm and weight: 250–300 g) used in this study were obtained from the fish bazaar in Hatay, Turkey. They were kept in an ice chest and transported to the laboratory. Fish were gutted, washed with tap water and filleted, and then fish fillets were divided into three groups (eight fish each). The first group was uncooked. The other two groups (two replicates) were cooked in the microwave oven (2,450 MHz, 4 min.), baked in the oven (200°C, 15 min.), in the grill oven

(200C, 10 min) and fried (200C, 4 min). Sunflower oil was used for pan frying. Raw and cooked samples were homogenized in a stainless-steel meat mincer and prepared for metal analysis. All analyses were run in duplicate.

Digestion Procedures

Fish samples were digested according to the AOAC (1995) method using concentrated nitric acid (HNO₃). The digest was quantitatively transferred to a 25-mL volumetric flask and made up to volume with deionized water. A blank digest was carried out in the same way. All metals were determined against aqueous standards.

Analytic Procedure

All metals were determined using inductively coupled plasma atomic emission spectrometry (Varian model- Liberty Series II) against aqueous standards. The following absorption lines were used: arsenic 193.696, cadmium 226.502, cobalt 228.616, chromium 267.716, nickel 231.604, lead 220.353. The metal concentration was expressed as mg metal/kg dry weight. Metal analyses were done in the Central of Science Research and Application of Mustafa Kemal University.

Statistical Analyses

To test the differences between the element concentrations, one-way analysis of variance (ANOVA) was performed. Post hoc test (Tukey) was applied to determine statistically significant differences following ANOVA (SPSS 13 for windows, Chicago, IL).

RESULTS AND DISCUSSION

Table 1 shows the concentration of heavy metal with means $\pm$ standard deviations.

The As content of raw fish was found as 0.01 mg/kg. The As concentrations for all the samples ranged from 0.01 to 0.02 mg/kg. ANOVA showed insignificant differences between measured concentrations. Similarly, Devesa *et al.* (2001) reported that in all types of seafood observed, the concentrations of inorganic As varied between 0.008 and 1.08 μ g/g dry weight.

The Cd concentration of raw, baked, grilled and microwave-cooked samples were not detectable (below limits of detection [<0.02 mg/kg]). However, the mean Cd concentration of fillets subjected to frying method was found to be 0.05 mg/kg. Similarly, the Cd concentrations of raw, baked, grilled

TABLE 1.
THE MEAN HEAVY METAL CONCENTRATION OF THE RAW AND COOKED AFRICAN
CATFISH FILLETS (MG/KG, DRY WEIGHT)^{a,b,c}

Cooking methods	As	Cd	Cr	Co	Ni	Pb
Raw	0.01 ± 0.00	ND	1.34 ± 0.04 ^{c,d}	ND	0.50 ± 0.04 ^{a,b}	0.15 ± 0.01
Grilled	0.01 ± 0.00	ND	0.88 ± 0.18 ^a	ND	0.36 ± 0.10 ^a	0.12 ± 0.05
Fried	0.02 ± 0.01	0.05 ± 0.01	1.47 ± 0.02 ^d	ND	0.59 ± 0.04 ^b	0.13 ± 0.05
Microwave cooked	0.02 ± 0.00	ND	1.13 ± 0.04 ^b	ND	0.53 ± 0.12 ^b	0.09 ± 0.03
Baked	0.01 ± 0.00	ND	1.28 ± 0.06 ^{b,c}	ND	0.48 ± 0.04 ^{a,b}	0.11 ± 0.01

Within the column, values with different letters are significantly different ($P < 0.05$), values without letters are not significantly different ($P > 0.05$).

a ND, not determined (below the limits of detection).

b Values are shown as mean ± standard deviation, $n = 2$.

and fried sea bass were not detectable in other studies (Ersoy *et al.* 2006). In the fried samples, the concentration of Cd increased significantly, but the factors responsible for the increase are not known. In our opinion, the increase of metal concentrations may be related to evaporation that occurs during frying processing.

The determined Cr concentration in raw fish was 1.34 mg/kg. The highest value was found in the fried samples as 1.47 mg/kg, while the lowest value was detected in the grilled samples as 0.88 mg/kg. The decrease in Cr concentration was significant ($P < 0.05$) for grilling and microwave cooking methods when compared with the raw control. Ersoy *et al.* (2006) reported insignificant changes in Cr concentration of cooked sea bass. This result is not in accordance with our study.

Co concentration was below the detection limit (<0.05 mg/kg) in raw and cooked samples. Similarly, the Co concentration of raw and cooked sea bass were not detectable in the study made by Ersoy *et al.* (2006). Topcuoğlu *et al.* (2002) have reported that the mean Co concentration of uncooked sea bass was found as 0.24 mg/g; however, as in our study, the mean Co concentrations of shad and whiting were not detectable (below limits of detection [<0.05]) in their study.

The Ni concentration of raw fish was found as 0.50 mg/kg. The increase in Ni concentrations of microwave-cooked and fried samples when compared with the grilled fish was significant ($P < 0.05$). The highest value found in the fried samples was 0.59 mg/kg. The Ni concentrations of cooked samples are lower than that reported by Ersoy *et al.* (2006) who found that the Ni contents ranged from 0.21 to 0.93 mg/kg in grilled, fried, microwave-cooked and baked sea bass.

The Pb concentration of raw fish was found as 0.15 mg/kg. The Pb content of all samples ranged from 0.09 to 0.15 mg/kg. There was no

significant difference in Pb concentrations between the raw, grilled, fried, microwave-cooked and baked fish. Atta *et al.* (1997) have reported a decrease in the concentrations of Pb in *Tilapia nilotica* after baking. In our study, decrease of Pb concentration of baked samples was found insignificant.

No previous study on the effect of cooking methods on heavy metal concentrations of African catfish was found to compare with our results.

CONCLUSION

Frying method had a more pronounced concentration raising effect on the heavy metal contents in fish than the other cooking methods. Therefore, this method was found inappropriate for human consumption. Baked, microwave cooked and grilled samples lost a moderate amount of heavy metals during cooking. Consequently, it can be recommended that baking, microwave cooking and grilling are the most suitable methods to reduce heavy metal concentration. It is possible to reduce the heavy metal concentration in fish samples by choosing a suitable method of cooking. Further studies should be carried out on cooking methods at different conditions (time, temperature, medium of cooking) for reducing the dangerous effect of heavy metals.

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