J Food Sci Technol (May–June 2012) 49(3):373–377
DOI 10.1007/s13197-011-0418-9

SHORT COMMUNICATION

Effect of different cooking methods on proximate and mineral composition of striped snakehead fish (*Channa striatus*, Bloch)

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Revised: 5 May 2011 / Accepted: 25 May 2011 / Published online: 6 July 2011

Abstract The effects of different cooking methods (boiling, baking, frying and grilling) on proximate and mineral composition of snakehead fish were investigated. The mean content of moisture, protein, fat and ash of raw fish was found to be 77.2±2.39, 13.9±2.89, 5.9±0.45 and 0.77±0.12% respectively. The changes in the amount of protein and fat were found to be significantly higher in frying and grilling fish. The ash content increased significantly whereas that of the minerals (Na, K, Ca, Mg, Fe, Zn and Mn) was not affected in all cooking methods. Increased in Cu contents and decreased in P contents were observed in all cooking methods except grilling. In the present study, the grilling method of cooking is found to be the best for healthy eating.

Keywords Snakehead fish · *Channa striatus* · Cooking methods · Proximate composition · Minerals

Introduction

The striped snakehead, *Channa striatus*, (Bloch) is a native freshwater fish of tropical Africa and Asia (Ng and Lim 1990). Snakehead fish has long been commercially cultured in Thailand, Philippines, Vietnam, and Cambodia. It belongs to the family of Channidae and is one of the highly demanded food fish species. The fish is well known for its taste, high nutritive value, recuperative and medicinal qualities. It has fine white flesh without any intra-muscular bones and is believed to contain recuperative and strength-giving substances, and, therefore specially given to elderly people and those in convalescences (Ling 1977). It is also used by the patients in the post-operative period in the belief that it promotes wound healing and reduces post-operative pain and discomfort (Mat Jais et al. 1997; Zakaria et al. 2004). The fish is also known to contain polyunsaturated fatty acids that can regulate prostaglandin synthesis and hence induce wound healing (Bowman and Rand 1980; Gibson 1983). Certain amino acids like glycine, aspartic and glutamic acid are also known to play an important role in the process of wound healing (Chyun and Griminger 1984). Hence, this species is gaining prominence as a cultured freshwater fish for medicinal purposes in the Asian market.

In general fish has long been recognized as an excellent source of animal protein in the human diet. Fish is widely consumed in many parts of the world by humans not only for its high quality protein content but also for the low saturated fat. It contains important n-3 polyunsaturated fatty acids that are likely to lower the risk of heart diseases in adults and are important for neuro-development in infants and young, and are known to support good health (Uauy et al. 2003). In recent years, fish lipids have also assumed great nutritional significance, because of their high poly-unsaturated fatty acid levels. Fish are also considered very rich source of minerals and vitamins. The total content of minerals in the raw flesh of fish and invertebrates is in the range of 0.6–1.5% of wet weight. Mineral components such as sodium, potassium, magnesium, calcium, iron, phosphorus and iodine are important for human nutrition (Sikorski et al. 1990). The contents of Na, K, Ca, Mg and P are up to

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1 mg/100 g, whereas those of Fe, Zn and I are less than 1 mg/100 g (Kietzmann et al. 1969).

In Malaysia, snakehead fish is rarely eaten raw and it is usually processed by various cooking methods, such as boiling, grilling, baking, and frying, before consumption. Heating process (boiling, grilling, baking and frying) is applied to enhance flavour and taste of food and inactivate pathogenic microorganisms (Bognar 1998). The use of the microwave oven grilling method of cooking has increased greatly during the recent decades (Garcia Arias et al. 2003a). The various cooking methods invariably affect the nutritive value of fish and especially vitamins, flavour compounds and polyunsaturated fatty acids. The effects of different cooking methods on proximate and mineral composition of several fish species have been reported (Ersoy et al. 2006; Gokoglu et al. 2004; Kucukgulmez et al. 2006; Rosa et al. 2007; Weber et al. 2008; Stephen et al. 2010). Early developments in the field of nutrition predicted that certain substances, important for the proper functioning of the human body, are lost during cooking of foods. It is imperative to conserve nutrients of food products and also is a major consumer concern related to food preparation. Therefore, it is important to determine the retention of nutrients in fish cooked using several common domestic practices, namely boiling, baking, grilling and frying. To date there is no information available in the literature on the nutritive values of raw and cooked snakehead fish. Hence the present study was aimed to investigate the effects of different cooking methods on the proximate and mineral composition of snakehead fish *Channa striatus*. The possible effects of different cooking methods on the nutritive value of this species were evaluated; the values obtained in the cooked samples were compared with the values found in raw fish.

Materials and methods

Sample preparation and cooking

A total of 25 live snakehead fish (*Channa striatus*), with a length (25–30 cm) and weight of (250–400 g) were obtained from the local fish market in Sungai Petani, Kedah Darul Aman, Malaysia. They were kept in a plastic container and transported to the laboratory. Upon arrival at the laboratory, the fish were washed with tap water several times to remove adhering blood and excessive mucus. The fish were then placed in ice-cold water (hypothermia) for five minutes prior to eviscerating and beheading. Subsequently the fish samples were filleted and fillets were divided into five groups and each group consisted of five fillets. The first group was uncooked while the other four groups were cooked in the following methods; boiling, baking, frying and grilling. Boiling was performed at 99–101 °C (water temperature) for 12 min. Baking of fillets was performed in a conventional oven with the temperature set at 200 °C for 20 min. The frying of fillets was performed in a domestic frying pan of 2 L capacity at temperature approximately of 180 °C for 15 min. Sunflower oil was used as the medium for frying. Grilling of fish fillet was performed on a local charcoal griller. The fish were placed on the grill and cooked for 10 min each side. The fresh and cooked fish were hand de-boned and ground in a kitchen blender to ensure homogeneity and representative samples taken for analysis. Samples were packed in a polythene bags and kept under frozen conditions (−20 °C) until analysis.

Proximate composition analysis

Proximate composition analysis for homogenized samples of cooked and raw fish fillets were done in triplicate for protein, moisture, lipid and ash contents. The crude protein content was determined by the Lowry method (Lowry et al. 1951). Moisture content was determined by oven drying at 105 °C to a constant weight. Total lipid was extracted from the muscle tissues by chloroform: methanol (2:1, v/v) solvent system (Folch et al. 1957). The lipid content was gravimetrically determined. Ash content was determined gravimetrically in a muffle furnace by heating at 550 °C to a constant weight (AOAC 1995).

Mineral analysis

For mineral determination, 5 g of respective cooked and raw samples were digested in concentrated HNO_3 (AOAC 1995). The digest was quantitatively transferred to a 50 ml volumetric flask and made up to volume with distilled water. A blank digest was carried out in the same way. All minerals were determined using atomic absorption spectrometry (AAnalyst 700, Perkin-Elmer, Waltham, MA, USA) against aqueous standards. The mineral concentration was expressed as mg mineral/kg fish dry weight.

Statistical analysis

The effect of different cooking methods on the proximate and mineral composition of snakehead fish was analyzed using one-way analysis of variance (ANOVA) and the significant differences between means were determined by post hoc Duncan's multiple range test. Differences were considered to be significant when $p<0.05$. Data were analysed using SPSS package (Version 11).

Results and discussion

The proximate composition and mineral content of raw fish and fish fillets after various cooking methods of snakehead fish (*C. striatus*) are presented in Table 1. The proximate composition of raw fillets is similar to earlier reports in snakehead fish (Zuraini et al. 2006). Proximate composition of moisture, protein, fat and ash of snakehead fish was varied in all the cooking methods. Significantly higher protein content (17.3±1.26) was recorded in fried fillets followed by (16.1±0.1) in grilling than the rest of the cooking methods and raw fish fillets ($P<0.05$). Significantly higher fat content (10.7±1.85) was observed in fried fillets followed by (8.6±0.67) in grilling fish fillets than baked, boiled and raw fish fillets ($P<0.05$). There was no significant difference observed in fat content among boiled, baked, grilling and raw fish fillets ($P>0.05$). The increase in fat content of the fried fish fillets is related to oil absorption during the cooking process. Further the increase of fat content can be attributed to the oil penetration on the food after water is partially lost by evaporation (Saguy and Dana 2003). Similar results were reported for sardine and African catfish fried in vegetable oil (Candela et al. 1996).

The increase in dry matter content was observed in fried and grilling fish fillets. The highest moisture content (77.2%) was recorded in raw fillets and decreased moisture content was noticed in all method of cooking except for the boiled fillets (Table 1). Increased ash content was noticed in all the cooked fillets when compared to raw fish fillets. Moisture loss was also recorded in baked fillets of snakehead fish. However, dehydration rate comparatively was lower than during frying and grilling. These changes were similar to those reported by Gokoglu et al. (2004) in rainbow trout and Garcia-Arias et al. (2003b) in sardines. Water losses, occurring during frying and grilling resulted in higher protein content in fried and grilling fish as compared to the raw fish fillets (Garcia-Arias et al. 2003b). Accordingly, the increase in ash, protein and fat content found in cooked silver catfish fillets is explained by the reduction in moisture. Differences in water contents between fresh and smoked rainbow trout were found to be significant (Unlusayin et al. 2001).This findings also supported by Gall et al.(1983), that deep fried fish fillet had significantly higher protein content than raw fillet.

The Na content of raw fish was found to be 346 mg/kg DM. The highest Na content (451 mg/kg DM) was observed in grilling followed by (404 mg/kg DM) in fried fish fillet. However the value was not significantly different from fish fillets of other cooking methods. The Na content of trout, ranging from 380 to 3200 mg/kg DM was reported by Wheaton and Lawson (1985) and 335–607 mg/kg by Gokoglu et al. (2004). A similar finding was reported by Rosa et al. (2007) indicating significantly increased Na content in fried and grilling African catfish. The K content of raw fish was found to be 2195 mg/kg DM. Significantly highest K content (2930 mg/kg DM) in fried fish and lowest K content (2058 mg/kg DM) was noticed in baked fish fillets. The changes in K content of grilling, baked and raw fish fillets were insignificant ($P>0.05$). This result is similar to K contents in other freshwater fish species such as trout (2800–3580 mg/kg) reported by Wheaton and Lawson (1985) and in African catfish (1871–2770 mg/kg) by Ersoy and Ozeren (2009). The Ca content of raw fish was found to be 290 mg/kg DM. This value is higher than that reported by Rosa et al. (2007); Ersoy and Ozeren (2009) in African catfish and lower than that reported by Gokoglu et al. (2004) in rainbow trout. No significant difference of Ca content was noticed in all the cooking methods ($p>0.05$). The mean Mg content ranged from 215–246 mg/kg DM in all fish fillets. However no significant difference was noticed in all the method of cooking and raw fish fillets ($p>0.05$). This value was higher than that

Table 1 Proximate (%) and mineral composition (mg/kg DM) of raw and cooked fillets samples of *Channa striatus*

	Raw	Boiled	Baked	Fried	Grilled
Moisture (%)	77.2±1.39^{a}	77.0±0.31^{a}	74.9±0.33^{b}	71.6±1.48^{c}	72.0±0.53^{c}
Protein (%)	13.9±2.89^{b}	15.2±0.96^{ab}	14.2±1.82^{ab}	17.3±1.26^{a}	16.1±0.1^{a}
Lipid (%)	5.9±0.45^{b}	6.1±1.46^{b}	7.8±0.39^{b}	10.7±1.85^{a}	8.6±0.67^{ab}
Ash (%)	0.77±0.12^{c}	1.1±0.13^{b}	1.3±0.12^{b}	1.6±0.13^{a}	1.7±0.15^{a}
Na	346±47.10^{b}	390±15.11^{ab}	344±34.24^{ab}	404±16.32^{ab}	451±39.20^{a}
K	2195±214.1^{bc}	2462±219.43^{b}	2058±143.85^{c}	2930±138.66^{a}	2533±229.94^{b}
Ca	290±25.37^{ab}	242±51.12^{b}	313±11.48^{a}	270±47.25^{ab}	311±11.91^{a}
Mg	215±20.10^{a}	246±20.10^{a}	239±24.40^{a}	239±18.70^{a}	240±29.12^{a}
Fe	6.4±3.7^{a}	7.4±2.50^{a}	5.7±2.25^{a}	6.1±1.73^{a}	7.2±1.84^{a}
Zn	5.1±1.4^{a}	3.8±1.65^{a}	4.5±1.23^{a}	4.6±0.68^{a}	4.5±1.21^{a}
Mn	0.88±0.31^{a}	0.72±0.27^{a}	0.69±0.28^{a}	0.50±0.17^{a}	0.70±0.24^{a}
Cu	1.3±0.603^{b}	1.2±0.46^{b}	1.5±0.42^{b}	3.3±0.69^{a}	1.4±0.49^{b}
P	1240±144.56^{a}	752±101.15^{b}	937±97.55^{b}	771±51.59^{b}	1237±103.04^{a}

Values are shown as mean ±standard deviation of triplicates. Values within the same row have different superscripts are significantly different ($p<0.05$)

reported by Wheaton and Lawson (1985) (a mean value of 170 mg/kg) and similar to (value ranged from 184–265 mg/kg) by Ersoy and Ozeren (2009) in African catfish.

The Fe content of raw fish fillet was 6.4 mg/kg DM and the Fe content in all the cooking methods ranged from 5.7–7.4 mg/kg DM. However, the change in Fe content after cooking for all cooking methods was found to be insignificant ($P>0.05$). The value is higher than reported by Gokoglu et al. (2004) in rainbow trout and lower than that reported by Ersoy and Ozeren (2009) in African catfish. The Zn content of raw fish and cooked fish fillets ranged from 3.8–5.14 mg/kg DM. Similar to Fe content, Zn content also was found to be insignificant ($P>0.05$) in all the cooking methods. Similar range of Zn content (3.43–5.99 mg/kg) was reported in African catfish by Ersoy and Ozeren (2009) and higher Zn content (9.68 mg/kg DM) was reported in rainbow trout by Gokoglu et al. (2004). Further Gokoglu et al. (2004) reported that, decreased Zn content was noticed in fish fillets cooked in boiled, baked, fried and grilling when compared to raw fish fillets in rainbow trout. Controversially, an increased Zn content of fish after baking, microwave cooking and frying in African catfish (Ersoy and Ozeren 2009)

The Mn content of raw and cooked fish ranged from 0.50–0.88 mg/kg DM. However, the Mn content after cooking in different methods was found to be insignificant. This value is found to be higher than that reported in African catfish (0.22–0.42 mg/kg) by Ersoy and Ozeren (2009) and similar Mn content (0.78 mg/kg) was reported in rainbow trout by Gokoglu et al. (2004). Conversely, an increased Mn content was reported in the fried African catfish by Rosa et al. (2007). The Cu content of raw fish was found to be 1.3 mg/kg DM. Significantly highest Cu content (3.3 mg/kg DM) was recorded in fried fish fillet when compared to rest of the cooking methods ($p<0.05$). No difference was noticed among fish fillet cooked in baked, boiled, grilling and raw fish fillet. This result is in accordance with the reports of Gokoglu et al. (2004) for fried fish. Similar range of Cu contents (0.93–2.15 mg/kg) was noticed in African catfish (Ersoy and Ozeren 2009). The P content of raw and cooked fish fillets ranged from 752–1240 mg/kg DM. The highest P content was noticed in grilling fish fillet. The P contents of fried, baked and boiled fish fillets decreased significantly ($P<0.05$) than raw fish fillets. This value is lower than that reported by Wheaton and Lawson (1985) who found that the P contents ranged from 1520–2600 mg/kg in trout. Similar to our findings, increased P content was reported in grilling fish fillets and decreased P content in baked, boiled and fried fish fillets of rainbow trout (Gokoglu et al. 2004). Earlier studies have reported that the processing and cooking methods had little or no effect on the elements (Ackurt 1991; Gall et al. 1983; Steiner-Asiedu et al. 1991) but Ackurt (1991) reported that mineral levels in some fish samples were affected by cooking methods. In the present study also agrees with the earlier observation with regard to mineral composition of fish fillets cooked in different methods.

Conclusion

The increased dry matter, protein, ash content and Na was observed in fried and grilling fish fillets. In significant changes were observed for minerals Ca, Mg, Fe, Zn and Mn contents in all the cooked fish fillets. The fat content in fried fish fillet increased due to absorption of oil by the fish during frying. Hence this method of cooking is not advisable. On comparing the raw and cooked fish fillet, the results indicate that cooking had considerable effect on the proximate composition of snakehead fish fillets. Other cooking methods caused losses in important mineral contents especially Na, and P. No loss of minerals was noticed in grilled fish when compared to that of raw fish fillet. Based on the results obtained for proximate and mineral composition, the grilling fish fillets of snakehead fish were found to be the best among all the cooking method for healthy eating.

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