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Effect of different cooking methods on proximate and mineral composition of fish meat (Carassius gibelio)

Balla L. Mahmood[1] and *Azad B. Sabow[2]

[1]Department of Fish Resource and Aquatic Animals, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, Kurdistan Region, Iraq

[2]Department of Animal Resources, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, Kurdistan Region, Iraq

*Corresponding author's Email: azad1979sabow@yahoo.com[2]; azad.sabow@su.edu.krd[2]; ORCID: 0000-0003-2920-5811

*Corresponding Author

Azad B. Sabow[2].

[2]Department of Animal Resources, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, Kurdistan Region, Iraq

*Corresponding author's Email: azad1979sabow@yahoo.com[2]; azad.sabow@su.edu.krd[2]; ORCID: 0000-0003-2920-5811

Abstract

Fish meat is a major source of good quality protein and minerals which is essential for humans. However, it may sometimes contain unwanted components such as heavy metals. The aim of the study was to find whether the nutritive value and heavy metal content of fish meat may be influenced by cooking methods. Proximate and mineral compositions were assessed in cooked Carassius gibelio fish meat. There were used two cooking methods: grilling and frying. The results clearly reveal significant differences in the proximate analyses between fresh and cooked fish meat. Fat and protein amounts in fried meat were significantly higher. The increase might be mainly due to water losses when the fish meat is subjected to the high temperature of frying. No concentration of studied heavy metals except nickel differed between cooked meat samples. The concentration of nickel was significantly lower in grilled fish meat. According to the results, grilling is suggested as the best cooking method for lowering the initial content of heavy metals and lipids in the studied fish meat.

Keywords: Carassius gibelio, cooking methods, heavy metals, proximate composition

Introduction

Fish meat (flesh) is gaining preference by many meat consumers, thanks to its one of the most complete foods and provides nutrient quality and quantity. According to Bastías et al. (2017), an average 100 g portion fish provides more than 50% of the recommended daily protein intake, between 10% and 20% of minerals, variable quantities of water-soluble vitamins, and an important percentage of lip soluble vitamins A, D, and E. It is recommended that fish be compulsory in the diet for a number of health benefits. Different studies have established that there is an opposite relationship between consumption of fish and the incidence of heart and immunological diseases in which unsaturated fatty acids play a vital role (Teague et al., 2016). Fish fat is characterized by its significant polyunsaturated fatty acid content, especially eicosapentaenoic acid and docosahexaenoic acid of the omega-3 series that are enormously important as cellular membrane components (Schuchardt et al., 2010). In addition, it has been reported that these fatty acids noticeably decrease plasma triglyceride levels, fulfil different physiological functions, such as reducing plasma low-density lipoprotein cholesterol levels, and exhibit antithrombotic, anti-inflammatory, antiarrhythmic, and vasodilating properties (Sokoła-Wysoczańska et al., 2018; Loughrill and Zand 2016).

The nutritional value of fish can be recognized by quantifying the protein and fat content, as well as determining the concentration of minerals, such as calcium, iron and zinc. Furthermore, information about chemical composition comes from international tables that are often constructed with data obtained from raw fish. The chemical composition in raw fish tissue cannot provide clear information about the nutritional value of fish after cooking. Although fish is sometimes consumed raw in some preparations, such as sushi and ceviche, it is usually undergoes a cooking process before being consumed. Cooking such as boiling, baking roasting, frying and grilling can be both beneficial and detrimental to nutrient content of fish. During cooking chemical and physical reactions take place which either improve or impair the fish nutritional value. In fact, cooking improves hygienic quality of the food by inactivation of pathogenic microorganism and enhances digestibility and bio-availability of nutrient in the digestive tract. It also improves the sensory quality of food by formation aroma compounds, attractive color and texture (El-Lahamy et al., 2019). However, the effect of different cooking methods invariably affects the nutritive value of fish. Some of the principal changes that occur during processing and final preparation of cooked fish are due to fat oxidation which is catalysed by heat, light, trace metals, or enzymes, and it consists in generating free radicals. It can also provoke protein denaturation and mineral solubilisation (Stephen et al., 2010; Devi and Sarojnalini, 2012). In Kurdistan region, consumption of Prussian carp (Carassius gibelio) fish is commonly used after frying and grilling form. In view of the fact that there are no available original data on nutritional value and content of metals in fried or grilled Prussian carp fish, study was carried out to investigate the effects of different cooking methods of proximate composition and polyunsaturated fatty acid of Prussian carp fish.

Materials and Methods

Sample collection preparation and cooking

Fresh Prussian carp (Carassius gibelio) fish a length 20-30 cm and width (5-8) cm and weight of 250- 300 g was collected from different markets of Erbil city, Iraq. Fresh fish were gutted, washed with taped water several times and filleted, and then fish fillets were divided into three groups. The first group was raw fish not cooked (control group). The other two groups were cooked in the grill oven at 200 °C for 11 min or fried in sunflower oil using a domestic pan (2 liter capacity) at temperature 200 °C for 5 min following the procedure described by Diaconescu et al. (2013). A representative and homogenous sample was taken from all fish sample groups for analysis proximate mineral composition.

Proximate Composition

Proximate composition of the fish samples was determined in triplicates per sample following the procedures of AOAC (2000).

Moisture determination in meat

The meat samples were individually weighed (approximately 20 g) and recorded as initial weight (W1). The weighed samples were dried in an oven at 105 °C for 5 h. After a constant weight obtained, the samples were immediately weighed and recorded as W2. The percentage of moisture was calculated as the difference between sample initial weight and sample weight after 48h drying divided by sample initial weight.

Moisture (%) = [(W1- W2) ÷ W1] × 100

Protein determination in meat

The samples used for moisture determination were collected, prepared and used for determining protein concentration. Crude protein was determined by the Kjeldahl method. The method was conveniently divided into three steps which are digestion, neutralization and titration. Briefly, the organic component in meat sample (1 g) was digested at 420 °C for 2 h with strong sulfuric acid in the presence of tow catalyst tablets VST (code A00000277; 3.5 g K2SO4, 0.0035 g Se) in order to convert total nitrogen to ammonia sulphate (digestion stage). In the neutralization or distillation stage, the nitrogen in digested solution was converted to ammonia hydroxide by ammonium hydroxide then being distilled with a boric acid solution and converted to ammonia borate which was titrated with strong hydrochloride acid (titration stage). Because the Kjeldahl method does not measure the protein content directly, the following equation was used to determine the nitrogen (N) concentration of meat sample that weighs m grams using xM HCl acid solution for the titration:

Moisture determination in meat

The meat samples were individually weighed (approximately 20 g) and recorded as initial weight (W1). The weighed samples were dried in an oven at 75 °C for 48 h. After a constant weight obtained, the samples were immediately weighed and recorded as W2. The percentage of moisture was calculated as the difference between sample initial weight and sample weight after 48h drying divided by sample initial weight.

Moisture (%) = [(W1- W2) ÷ W1] × 100

Protein determination in meat

The samples used for moisture determination were collected, prepared and used for determining the concentration of protein. Crude protein was determined by the Kjeldahl method. The method was conveniently divided into three steps which are digestion, neutralization and titration. Briefly, the organic component in meat sample (1 g) was digested at 420 °C for 2 h with strong sulphuric acid in the presence of tow catalyst tablets VST (code A00000277; 3.5 g K2SO4, 0.0035 g Se) in order to convert total nitrogen to ammonia sulphate (digestion stage). In the neutralization or distillation stage, the nitrogen in digested solution was

converted to ammonia hydroxide by ammonium hydroxide then being distilled with a boric acid solution and converted to ammonia borate which was titrated with strong hydrochloride acid (titration stage). Because the Kjeldahl method does not measure the protein content directly, the following equation was used to determine the nitrogen (N) concentration of meat sample that weighs m grams using xM HCl acid solution for the titration:

$$N = \frac{\text{x moles} \times (V_s - V_b)\, cm^3 \times 14\, g}{1000\, cm^3 \times \text{m g}} \times 100$$

Where:

Vs and Vb are the titration volumes of the sample and blank, and 14g is the molecular weight of nitrogen N. Once the nitrogen content was determined, it was converted to a protein content using the following equation:
Protein (%) = N × 6.25 (equivalent to 0.16 g nitrogen per gram of protein)

Fat determination in meat

Fat content of dried meat samples was determined by Soxhlet extraction method using hexane. The dried meat sample was individually weighed (approximately 1 g) and recorded as initial weight (W1) and placed into a dried and pre-weighed filter paper (W2). The sample was then put in a distillation path or extraction tube. The cleaned distillation flask was filled up to ¾ with hexane then tidily attached with other parts of the Soxhlet device and put the device on a head source after the water passing through the condenser was opened. After hexane started to evaporate in the condenser then dropped into the meat sample which was placed in the distillation path, the fat extracted from the sample and the hexane filled with fat went back to the distillation flask reaching the end of the side tube of the distillation path (siphon). The process of siphon is repeated at a rate of 5 to 10 siphon per hour and continued for 3 hours. After extraction, the meat sample was dried to take the hexane, cooled and then re-weighed (W3). The percentage of fat concentration is calculated using the following equation:

Fat (%) = [(W2- W3) ÷ W1] × 100

Ash determination in meat

For ash determination, the samples of both fresh and frozen meat were individually weighed and recorded as initial weight (W1) and placed into a dried and pre-weighed porcelain crucible (W2). The samples were then burned in a muffle furnace at a temperature of 550 °C for 48 h. The burned samples were removed from the muffle furnace, equilibrated to room temperature in a desiccator and reweighed (W3). The ash percentages were calculated using the following equation:

Ash (%) = [(W3- W2) ÷ W1] × 100

Elemental analysis

In order to obtain the dry mass of the samples about 50g of meat was homogenized and dried at 75 °C for 48 h. The dried samples were crushed using a ceramic mortar. About 2g of fine powder was used to analyse the elements using X-ray fluorescence spectrometer (Genius 9000 XRF, USA) following the procedures described by Yakup et al. (2018).

Data analysis

The experimental results were presented as means ± standard error. Variables were analysed using the General Linear Model (GLM) procedure of Statistical Analysis System package (SAS) Version 9.1.3 software (SAS Institute Inc., Cary, NC, USA). Duncan's test was carried out to determine the differences among means with a p value of 0.05. All values were reported as the means ± standard errors.

Results and Discussion

Proximate composition of different types of cooked fish meat

Fish meat is an important part of a healthy diet because it is considered to be an excellent source of high value protein and essential nutrients. Proximate composition of fresh, fry, grill fish meat are presented in Figure 1. Fat content was found to be 14.922 ± 0.10% in fresh fish meat and highest content in the fried fish (43.830 ± 0.68%) and lowest in grill fish (9.122 ± 0.61%). Fried fish had significantly higher level of fat than raw or grilled fish. Fat increase can be due to the oil penetration into the meat after water is partially lost by evaporation. The increase in fat content of the fried fish is also related to oil absorption during the cooking process. These results are in accordance with Diaconescu et al. (2013) who reported that the fat content in fried fish meat was significantly higher than the fresh and other cooked fish. The moisture percentage was found to be 79.399 ± 0.49, 25.189 ± 0.51, 76.648 ± 0.56 in fresh and fry and grill meat fish, respectively. According to statistical findings, the water content of fried fish meat was significantly lower than the fresh and grilled fish. In agreement with the results of this study, Bastías et al., (2017) and Devi and Sarojnalini (2012) have similarly reported a decrease in moisture concentration of fried fish as compared to the raw and grilled samples. The concentrations of protein were 4.764 ± 0.32% for fresh fish samples, 26.738 ± 2.32% for fried fish and 11.973 ± 0.61% for grilled fish. The protein content was generally high which is an expected outcome is since fish are a good source of protein. The higher protein content in the fried fish is due a result of moisture loss. Further evidence of this is seen in the fact that grill cooked fish had lower protein content but had higher moisture contents. This can be attributed to absorption of water from the cooking medium thereby causing dilution of the muscle tissue analysed. The highest protein content observed in fried fish was similar to those reported by Devi and Sarojnalini (2012). According to Devi and Sarojnalini (2012), water losses

occurring during frying resulted in higher protein content in fried fish as compared to the fresh fish. In this study, the effects of cooking methods on the concentration of ash were studied. According to the results, the concentrations of ash increased in fried (4.241 ± 0.35%) and grilled (3.856 ± 0.53%) samples showing significant differences as compared to the fresh fish (0.913 ± 0.05%). The higher ash content in the cooked fish might be due to its higher bony consistency and high scaly nature. Such fish offer minerals in their edible forms more abundantly than large-sized fish do (Gheisari et al., 2016).

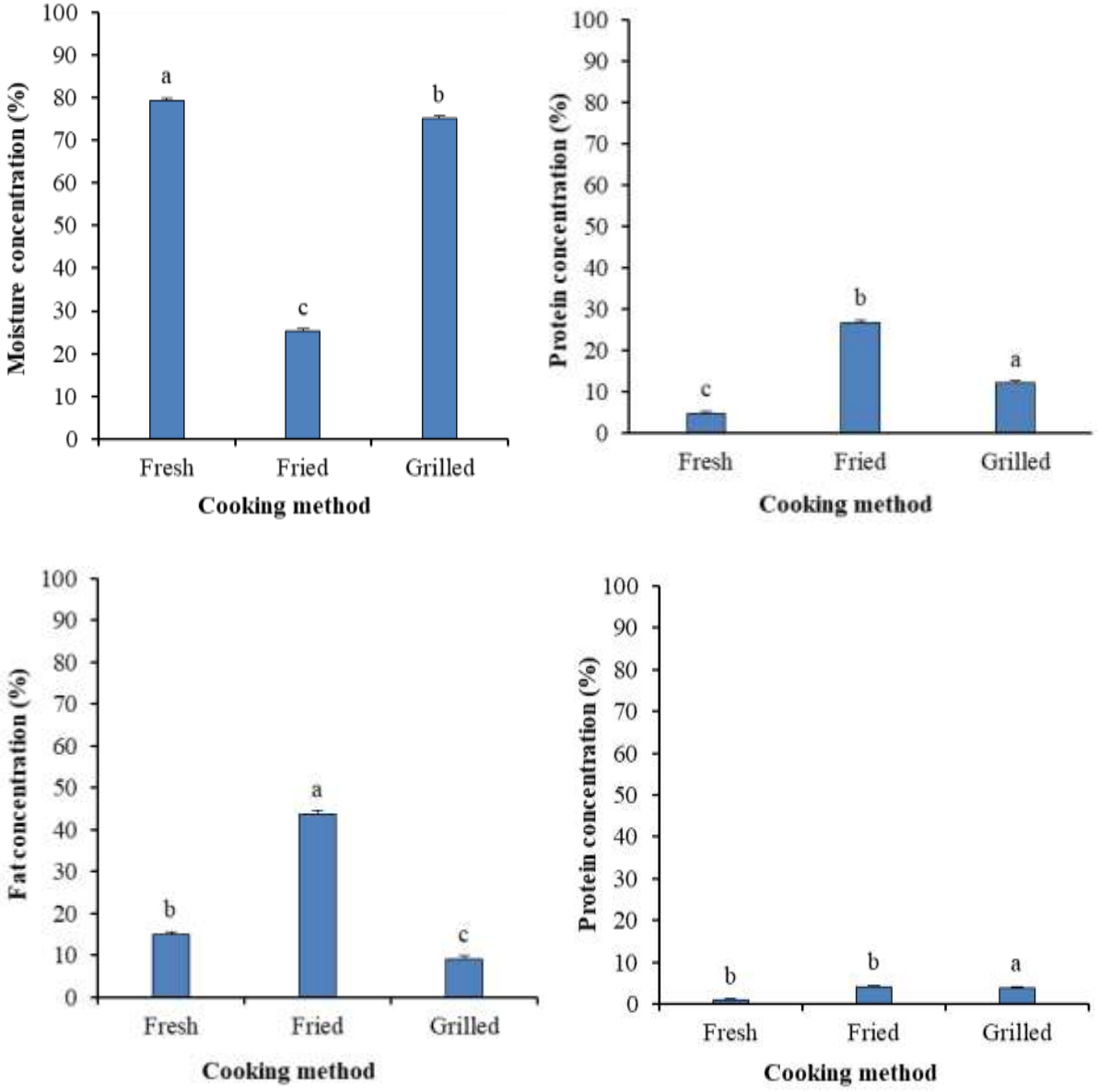

Figure 1: Chemical composition of fresh and cooked fish meat (Carassius gibelio)

[a,b] Means with different letters are significantly different at p<0.05.
Values are means ± standard error

Mineral composition of different types of cooked fish meat

The mineral contents of fresh and cooked form of fish meat are shown in Table 1. Iron has the highest concentration in all fish meat samples as compared to the other essential elements. The fresh fish meat contained significantly high concentration of iron (4.851 mg/kg meat), cobalt (0.040 mg/kg meat) and copper (0.046mg/kg meat), than grilled (3.355, 0.003 and 0.036 mg/kg meat, respectively) and fried fish meat (1.835, 0.006 and 0.023 mg/kg, respectively). These results are in accordance with Devi and Sarojnalini (2012) who reported that concentrations of the iron, cobalt and copper elements were lower in cooked fish meat than the fresh one. In current study, iron, cobalt and copper concentrations in all investigated fish meat samples were lower than the maximum iron level allowed by FAO (2011).

The concentrations of nickel, mercury and lead which are classified as non-essential elements in the fresh and cooked fish meat are presented in Table 2. The level of nickel in studied meat samples was present in the range of 0.073 and 0.095 mg/kg meat. The lowest value of mercury was significantly detected in grilled fish meat while the highest concentration was detected in fresh and fried fish meat. However, the obtained results for nickel were lower than the standard permissible levels, 0.1 mg/kg (FAO, 2011). The concentration of mercury in the fresh and cooked fish meat was not differ and ranged between 0.102 and 0.107 mg/kg meat. The values of Ni obtained from all fish meat samples in this study were lower than the permitted nickel limit of 0.4 mg/kg (FAO, 2011). The obtained values agree with those obtained by Diaconescu et al. (2013), showing a decrease nickel content of grilled fish meat, while there were no significant differences in nickel amounts between the uncooked and cooked fish meat. In the present study, lead which has been identified to cause reduced cognitive development and intellectual performance in children and a rise in blood pressure and cardiovascular diseases in adults has not been detected in all fish meat samples evaluated.

Table 1: Mineral composition of fresh and cooked fish meat (mg/kg, dry weight) (Carassius gibelio)

Metal concentration (mg/kg, dry weight)	Cooking method			SEM	IPL
	Fresh	Fried	Grilled		
Iron	4.851[a]	1.835[c]	3.355[b]	0.145	12
Cobalt	0.040[a]	0.006[b]	0.003[b]	0.001	0.1
Copper	0.046[a]	0.023[b]	0.036[ab]	0.003	1
Zinc	1.087	0.979	1.036	0.028	30
Nickel	0.086[a]	0.095[a]	0.023[b]	0.001	0.1
Mercury	0.107	0.103	0.102	0.002	0.4
Lead	ND	ND	ND	-	0.7

[a,b] Means in the same row with different letters are significantly different at p<0.05.
SEM - Standard Error of the Mean.
IPL - International Permissible Limits.

Conclusion

This research work has indicated that moisture content was significantly higher in fresh and grilled fish while protein and lipid content were recorded higher in fried fish. Heavy metal concentrations decrease by cooking. Grilling the fish meat lead to a significant decrease in nickel content during the cooking process. By choosing suitable methods of cooking, it is possible that the heavy metal concentration, initially present into fish meat, to be reduced. Thus, further studies need to be performed on cooking methods at different conditions like time, temperature and cooking mediums, aimed at reducing the dangerous effect of heavy metals in fish meat.

Conflict of Interest

There is no conflict of interest.

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