

Physicochemical and sensory properties of silver carp (*Hypophthalmichthys molitrix*) fillets as affected by cooking methods

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Abstract: To evaluate the physicochemical changes induced during processing, silver carp fillets were cooked in different methods (grilling, frying and steaming). Steaming had no significant influence on protein content of fillets whereas after frying and grilling protein content was increased significantly ($P < 0.05$). Decrease in moisture and increase in fat contents was the most prominent changes in proximate composition. After cooking, protein solubility of fillets decreased as grilled sample showed lower solubility compared to steamed samples. All cooking processes reduced L^* value and increased b^* value. a^* value increased significantly in grilled and fried samples compared to raw samples but there were no significant differences between steamed fillets and raw fillets. Using sensory evaluation by trained panelists, the fried samples gained higher acceptability compared to other cooking methods ($P < 0.05$).

Key words: physico-chemical properties, silver carp, cooking method, sensory evaluation

Introduction

Approximately 14% of the animal protein that has been consumed by humans comes from marine fisheries (Hall, 1992). However, there are tremendous variations between countries. Fish is a favorite meal for people of northern and southern regions of Iran. Among the large groups of fish species which have been consumed in Iran, silver carp (*Hypophthalmichthys molitrix*) is one of the most important reared fish in the world (FAO, 2008) that has an excellent economical importance in the Caspian Sea and also high acceptability among northern cities. Interest in the health benefits of seafood such as omega-3 fatty acids, decreased risk of prostate cancer (Terry *et al.*, 2001) and Alzheimer disease (Huang *et al.*, 2005) is responsible for the recent increase in seafood consumption.

Most high quality fresh sea foods are cooked for home consumption in order to improve the texture and taste. Therefore the basic scientific reason for heating a food product is to make it safe to eat or to prevent or minimize spoilage during storage. On the other hand, the degree of cooking or heating has a major effect on the biological safety of the product

and on the retention or destruction of certain nutrients. The effectiveness of a heating process is directly depending on the method of heating, which is related to the processing facilities. Cooking treatments could cause modifications in proximate composition, fatty acids and amino acids composition as well as changes in protein solubility and nutritional quality of fish (Pigot and Tucker, 1990). Fish are exposed to different conditions during cooking process which may, in turn, result in changes in their carotenoid content and may lead to color modifications (Bhattacharya *et al.*, 1994). Solubility is usually considered the premier functional properties of protein because of its relevance to other properties such as viscosity, gelation, foaming and emulsification (Hall, 1992). Although the pH-solubility relationship for proteins has been well-studied (Geirsdottir *et al.*, 2007; Bourtoom *et al.*, 2009) and reports are available on the composition of fish, there is lack of information on the chemical composition and nutritional profile of cooked silver carp fish in Iran. Therefore, in the present study, the effects of three common cooking methods used in Iran on physicochemical properties of *Hypophthalmichthys molitrix* were investigated.

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Materials and Methods

Preparation of samples

Raw fresh cultured silver carps (*Hypophthalmichthys molitrix*), with an average weight of 1000-1100g, were obtained from the fish market in Gorgan, Iran. They were immediately transported to the laboratory within less than 20 min in ice containing boxes. In the laboratory head, viscera and skin of fishes were removed, and then washed and filleted (81±15 g each one). These fillets were randomly divided in to 4 groups. The fresh and raw sample used as a reference and analyzed immediately without losing time. The other three samples were cooked by frying, grilling and steaming cooking methods. Frying was performed in frying vegetable oil (Ladan frying oil) at 180°C for 6 min in an automatic fryer (ADR2, Moulinex, Portugal). Frying vegetable oil was used because it is the most common oil in Iran used for frying. Grilling of fillets was performed for 20 min on a stainless steel grill (Bq100, Delongi, Germany) at 50-60 Hz frequency. Steaming of fillets has been done using a domestic steamer at approximately 98°C for 20 min (Tefal Steam Cuisine, Berkshire, UK).

Determination of proximate composition

The fillets were first minced and homogenized using a kitchen blender before analysis. The moisture was determined by oven-drying at 100-105°C until constant weight (AOAC, 1993). Fat was determined by the method described by AOAC (1990) using the Suxtec System (416 SE, Gerhardt, Germany). Ash was gravimetrically determined using a muffle furnace by heating at 500°C to constant weight (AOAC, 1993). Protein was determined by the kjeldahl procedure using conversion factor of 6.25 (AOAC, 1993).

Cooking loss measurement

Cooking loss was measured according to the method of Niamnuy et al. (2008) and was calculated from the differences in the mass of silver carp fillets before and after each cooking methods (frying and grilling)

% Cooking loss =

$$\frac{(\text{Mass before cooking} - \text{Mass after cooking})}{(\text{Mass before cooking})} \times 100$$

Protein solubility and isoelectric point

Protein solubility was determined according to the method of Lee et al. (1992), with some modification. To a 2g sample, 40 ml of distilled water was added

and the mixture was stirred using a magnetic stirrer at speed 2 at room temperature (RHB2, IKA, Germany). The pH of slurry was adjusted to desired pH (1-12) by the addition of 1N / 0.1N HCl or 1N /0.1N NaOH to desired acidic and alkaline pH values, respectively. The volume was adjusted to 50 ml with distilled water. It was shaken for 1h at room temperature (27°C), centrifuged at 5000 rpm for 20 min at 4°C and the pH of the supernatant noted. Protein content of supernatants was determined using the kjeldahl method. Percentages of soluble protein in the supernatant compared to the total protein were calculated at each pH value. The *pI* was estimated as the pH value corresponding to the minimum solubility percentage. All treatments were conducted on triplicate.

Color measurement

The color of fillets was measured using a colorimeter (CR200, Minolta Camera Ltd, Osaka, Japan) calibrated with a white tile to determine *L** value (lightness), *a** value (redness), and *b** value (yellowness) of the fish samples. Each analysis was carried out in triplicates.

Sensory evaluation

Ten trained panelists were selected and used for the organoleptic assessment of the cooked fillets. Questionnaires for the panelists were prepared using 5 points scale hedonic test previously described by Eyo (1983). The scores from each panelist were averaged for each sample.

Statistical analysis

Data were subjected to one-way analysis of variance (ANOVA) and the mean comparison was carried out using LSD test. The significance of differences among the means values was established at *p*<0.05 level (Snedecor and Cochran 1967). Statistical analyses were performed using the SAS software version 9.1. For sensory evaluation, data were analyzed by the method of least squares using the general linear model procedure of SPSS and results were expressed as least square means. Significant differences between means were indicated when *p*<0.05.

Results and Discussion

Proximate composition and cooking loss

The changes in moisture, ash, protein, and fat content of samples after cooking processes are shown in Table 1. The proximate composition of raw fillet is similar to that observed by Hossain et al. (2004)

for silver carp (*Rhamdia quelen*) and Wu and Mao (2008) for grass carp (*Ctenopharyngodon idellus*). The moisture content of the fish fillets ranged from 62% to 79% and decreased after cooking (Table 1). The ash content increased after cooking, the protein and fat content increased after cooking in all methods; however the increase in fat content was most obvious in fried fillets (Table 1). The decrease in the moisture content has been described as the most prominent change that makes the protein, fat and ash contents increase significantly in cooked fish fillets (Gokoglu *et al.*, 2004). When the data were expressed on a dry matter basis, the fat content of fried silver carp respect to other cooking methods was significantly higher than that of the raw fillets (Table 1). This indicates that the increase in fat content of the fried fish fillets is also related to oil absorption during

the cooking process. Similar results were found for sardines fried in sunflower oil (Garcia-Arias *et al.*, 2003). Increasing in fat content can be due to the oil penetration in the food after water is partially lost by evaporation (Sam Saguy and Dana, 2003).

Cooking loss in silver carp muscle was measured after each cooking treatment. The cooking loss was different depending on the cooking process. The significant increase rate was found in grilled samples by 52.34%, compared to fried and steamed samples which were 31.95 and 33.66%, respectively. Aggregation and denaturation of protein in silver carp muscle were induced by heating, leading to the loss in water holding capacity of proteins. As a result, drastic cooking loss was observed. Niamnuy *et al.* (2008) reported occurrence of drip loss in shrimp muscle throughout the boiling in salt solution.

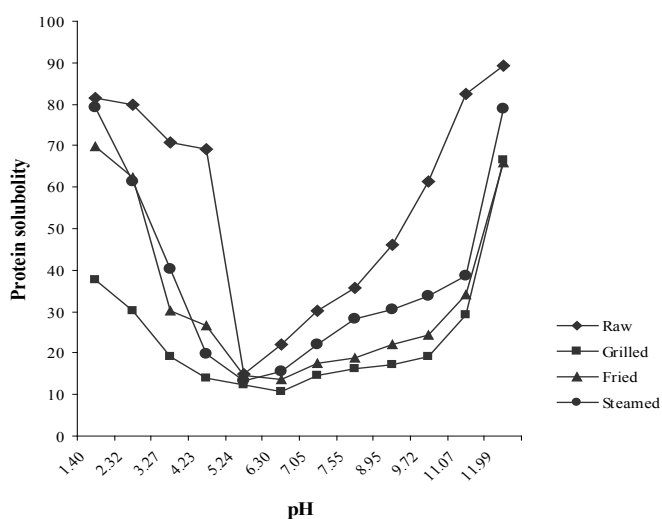
Table1. Proximate composition (g/100 g wet matter and g/100 g dry matter) for raw, grilled, fried, and steamed silver carp fillets. A, B

	Raw	Grilled	Fried	Steamed
Moisture g/100g wet mater	78.71±0.07 ^a	69.34±0.25 ^c	62.23±0.04 ^d	75.97±0.05 ^b
Protein g/100g wet mater	18.28±0.09 ^b	27.31±0.37 ^a	28.14±0.18 ^a	20.81±1.09 ^b
Fat g/100g wet mater	0.99±0.07 ^c	1.72±0.08 ^b	7.88±0.09 ^a	1.68±0.01 ^b
Ash g/100g wet mater	1.04±0.07 ^b	1.62±0.09 ^a	1.73±0.02 ^a	1.20±0.003 ^b

^A Results are Means ± standard deviation of triplicates.

^B Means with the same letter in each row are not significantly different (P<0.05).

Figure 1. Protein solubility profile of raw and cooked silver carp fillets at different pH values.



Protein solubility

Figure 1 shows the Protein solubility profile of raw and cooked silver carp fillets at different pH values. Protein solubility of all samples versus pH showed a specific behavior as the most solubility observed at acidic and alkaline and the least at isoelectric points. Heat processing affected the solubility of proteins. In general, raw samples possess higher protein solubility than that of cooked ones.

Signs of denaturation of protein are reflected in changes in solubility. Method of processing affects the solubility of protein especially if they are exposed to heat (Kilara and Harwalkar, 1996). As it can be seen in figure 1, steamed samples as received minimum heat during steaming, showed higher solubility compare to two other processing methods. It is conducted that this method has less negative effect on the nutritional parameters. Solubilities of grilled and fried samples were near to each other with a little difference at acidic values (fried samples had higher solubility at acidic values) that were not significantly difference. Reduction in protein solubility due to heat processing has been reported (Romero *et al.*, 2009; Bourtoom *et al.*, 2009).

In isoelectric point and in neutral condition, electrostatic absorbance takes place between two neighbor ions which lead to orientation and also aggregation of molecules. On the other hand, hydrogen-bonding result in more adjacency of molecules to each other. Nevertheless, because of numerous hydrogen-bonding and electrostatic linkages in isoelectric point, there could be the most stability and minimum solubility. Data of this study on isoelectric point were in agreement with Fatemi (2000). At both side of isoelectric point, the same net charges and negative force will increase; protein unfolding occurs and as it can be seen in figure 1, resulted in increased solubility.

Changes in color

Color is an important indicator of food quality. The consumer associates food color with good processing and safety. However, color cannot be studied without considering the human sensory system. Although seafood color is a parameter normally not used by many consumers in their buying decision, it is very important when seafood is consumed. The influences of different cooking methods on the values of lightness (L^*), redness (a^*) and yellowness (b^*) are shown in table 2. There was significant changes after cooking treatments compared to the control sample ($P < 0.05$). The b^* values increased in all cooked samples, while L^* values showed a decrease. Steam cooking method had higher L^* and lower a^* and b^* values compared to the other cooking methods. These results are in agreement with Moradi *et al.* (2009). The mechanisms of those changes are not entirely clear. However, Sikorski *et al.* (1994) stated that denaturation and oxidation of proteins, as well as the formation of colored compounds with involvement of H_2S released from amino acids and in Maillard-type reactions could be the reasons of color changes in cooked samples.

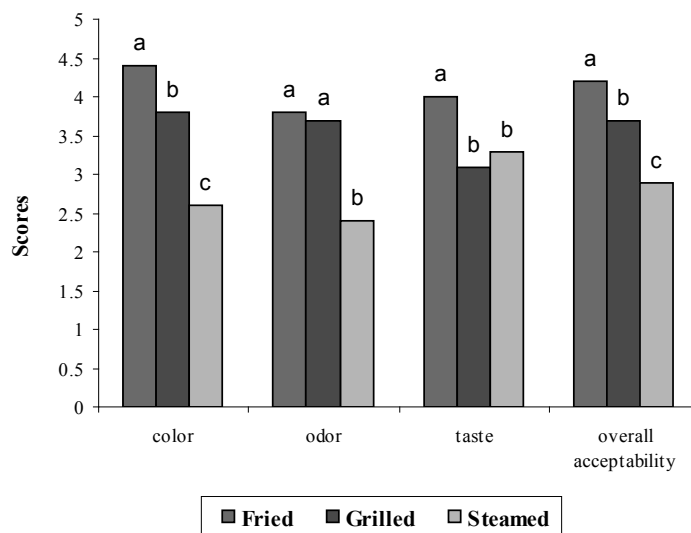
Sensory evaluation

The results of sensory evaluation of cooked silver carp fillets are shown in Figure 2. From the panelist's viewpoint, fried samples were most acceptable in taste, color, odor and in overall acceptability. Significant difference observed in odor and color of cooked samples as steamed samples had the least score compared to other cooked samples. Nonetheless, compared to grilled sample, steamed sample showed high taste score. There were significant differences ($P < 50.0$) between all samples in color and overall acceptability but no significant differences were observed in odor of fried and grilled samples and also in taste of grilled and steamed samples, which can be used to select proper procedure for cooking foods.

Table 2. Effects of different cooking methods on the color of silver carp fillets

Samples	L^* -values	b^* -values	a^* -values
Raw	66.43±4.29 ^a	0.93±0.26 ^c	6.71±0.01 ^c
Grilled	52.56±3.38 ^{ab}	7.16±2.15 ^{ab}	10.60±0.92 ^b
Fried	42.46±3.41 ^b	9.80±1.45 ^a	15.03±1.16 ^a
Steamed	63.90±8.49 ^a	2.73±1.18 ^{bc}	4.83±0.26 ^c

Means with the same letter in each column are not significantly different ($P < 0.05$).

Figure 2. Sensory evaluation of fried, grilled and steamed silver carp fillets

Columns with the same letters in each parameters are not significantly different ($P < 0.05$).

Conclusion

Cooking of silver carp fillets caused significant changes in proximate composition, protein solubility, color and sensory analysis. Steaming of fillets had minimum effect on protein solubility of samples and because in food systems, existence of protein in soluble form is necessary, thus indicates on a positive effect of using this method. In general and according to sensory analysis, it can be said that although steamed samples didn't have a good acceptability compared to other methods, They showed the least undesirable effects of heating such as protein denaturation and resulted in maintaining nutritional value of fish, can be selected as the best.

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