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EFFECT OF COOKING METHODS ON PHYSICO-CHEMICAL CHARACTERISTICS OF FISH

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ABSTRACT : Fish serves as a principal source of dietary protein and usually cooked in different way before consumption. Heat treatment have both beneficial and detrimental effect which depends on temperature, method of heating, time of heating as well as type and nature of the product heated. In the present study three fish species namely Silver carp, Asian sea bass and Croaker were heat treated with different methods i.e. Microwave (T1), Grill (T2), Baked (T3), Fried (T4), Boiled (T5) and steam cooking (T6). It was observed that cooking characteristics of fish differs depending on type of heat treatment. The highest cooking loss ($p<0.05$) was observed during microwave cooking (T1) in Silver carp (64.99±1.87%) and frying (T4) in Asian sea bass (57.99±1.98%) and Croaker (69.50±2.10%) fillets. Highest cooking yield ($p<0.05$) was observed in steamed (T6) followed by boiled (T5) samples. Shrinkage was found highest in microwave cooking (T1) with significantly higher ($p<0.05$) values of 28.33±1.52 and 25.91±2.22% for Silver carp and Croaker fillets. Moisture retention was highest ($p<0.05$) in steamed (T6) Silver carp (89.92±2.43%), and lower in fried (T4) Croaker fillets (21.01±1.58). The highest retention of fat ($p<0.05$) in was observed in fried (T4) Silver carp (523.71±4.57) fillets. Microwave cooked (T1) samples caused highest protein gain. Heat treatment caused significant increase ($p<0.05$) of energy value, where fried (T4) samples showed highest value in Silver carp (291.41±1.21 kcal/100g) and Croaker (273.74±1.62 kcal/100g) fillets and microwave cooking (T1) in Asian sea bass (242.89±1.45 kcal/100g) fillets.

Key words : Cooking yield, Cooking loss, Energy value, Fat retention, Shrinkage

INTRODUCTION

Over the last decade, there has been a great increase in consumer interest in the active role of foods beyond basic nutrition like health benefits (Diplock *et al*, 1999). Educational campaigns undertaken in the last few decades have raised the awareness of the importance of both macro and micro nutrients in food and have made customers adopt as selective approach towards foods, preferring only those having low content of saturated lipid, sugar and sodium (Venugopal, 2006). In these circumstances, fish is fast becoming the major source of dietary animal protein due to the stability, high population growth rate and an increasing national income cost of other sources of animal protein (Adeyeye, 2009).

Fish is rarely eaten raw and usually cooked in different ways before consumption, viz; grilling, frying, steaming, microwave cooking etc. During cooking, chemical and physical reactions take place in food, which improves the flavour and taste, nutritional value, hygienic quality by inactivating pathogenic microorganisms and digestibility by breaking down proteins and carbohydrates which are less digestible in raw condition (Sikorski, 2001 and Alipour *et al*, 2010). Cooking also possesses some detrimental effects to the nutrient content of food. Exposure of food to high temperature may results in leaving water drops, can produce mutagen compounds (Ziabari *et al*, 2002) and some thermo-labile compounds, viz; fat-soluble vitamins or polyunsaturated fatty acids may often reduce (Kocatepe *et al*, 2011). It is in general agreement that the effect of heat treatment depends on temperature of heating, time of heating, method of heating, type of product and also physical and biochemical composition of the product. Keeping view on this, in the present study three fish species, one from freshwater i.e; Silver carp (*Hypophthalmichthys molitrix*), one from brackish water i.e; Asian sea bass (*Lates calcarifer*) and one marine water fish species *i.e.*; Croaker (*Johnius gangeticus*) were selected and heat treated with common house hold cooking methods *i.e.*; microwaved, grilling, baking, frying, boiling and steaming and the cooking characteristics and nutritive values were studied.

MATERIALS AND METHODS

Preparation of fish fillet

Silver carp (*Hypophthalmichthys molitrix*), Asian sea bass (*Lates calcarifer*) and Croaker (*Johnius gangeticus*) were purchased from the landing centre and transferred to the laboratory in iced box and were processed immediately after reaching the laboratory. Head and viscera of fish were removed, then fish were washed and fillets were cut in uniform size from middle part of fish (average weight of 50±20 gm). Fillets were divided in to 7 groups randomly. One group was kept raw and used as reference (R), other 6 groups were subjected to different cooking methods:

1. Microwave cooked in oven at 2450 MHz for 2 minutes (T1)
2. Grill cooked in oven at 180°C for 20 minutes (T2)
3. Baked in oven at 170°C for 15 minutes (T3)
4. Fried in sunflower refined oil at 160^{0}C for 4 minutes (T4)
5. Boiled in water at 100°C for 4 minutes (T5)
6. Steam cooked in water vapour for 5 minutes (T6)

Estimation of cooking characteristics of fish fillets

Cooking loss was measured according to the method of Niamnuy *et al* (2008) and was calculated from the difference in the mass of fish steaks before and after each cooking method.

$$\text{Cooking loss (\%)} = \frac{\text{(Mass before cooking} - \text{Mass after cooking)}}{\text{Uncooked weight}} \times 100$$

Cooking yield, fat and moisture retention were determined as described by Alesson-Carbonell *et al* (2005). Fish steaks were weighed before and after each cooking method. Cooking characteristics are calculated as follows:

$$\text{Cooking yield (\%)} = \frac{\text{Cooked weight}}{\text{Uncooked weight}} \times 100$$

$$\text{Fat retention (\%)} = \frac{\text{Cooked weight} \times \text{\% fat in cooked fish steaks}}{\text{Uncooked weight} \times \text{\% fat in uncooked fish fillets}} \times 100$$

$$\text{Moisture retention (\%)} \frac{\text{Cooked weight} \times \text{\% moisture in cooked fish steaks}}{\text{Uncooked weight} \times \text{\% fat in uncooked fish fillets}} \times 100$$

Shrinkage (%) was calculated as described by A.M.S.A. (1995) with modifications as follows:

Shrinkage (%) = {(a-b) + (c-d)}/ (a+c) × 100

Where, a = Thickness of uncooked steaks

b = Thickness of cooked steaks

c = Diameter of uncooked steaks

d = Diameter of cooked steaks

Protein loss was calculated from the difference in the protein content of fish steaks before and after each cooking method as described by Alipour *et al* (2010).

% Protein loss (w.b) = % Protein before cooking (w.b.) – % Protein after cooking (w.b.).

Energy value of fish steaks

Energy value was determined using Atwater factors as given below:

E = (9 × Fat content) + (4 × Protein content) + (4 × Carbohydrate content) (Neiva, 2010).

RESULTS AND DISCUSSION

Estimation of cooking characteristics

Cooking characteristics of food products includes several parameters like cooking yield, cooking loss, fat retention, moisture retention, shrinkage, protein loss and energy value. Different cooking methods are known to affect the cooking characteristics of food material (Garsia-Segovia *et al*, 2007).

Cooking loss

Cooking led to a significant loss of solid matter (Alipour *et al*, 2010). The cooking loss in the present study was significantly different ($p<0.05$) depending on the cooking process except between T3 (45.89±1.76%) and T4 (36.36±0.72%) ($p>0.05$) in Silver carp and T1 (56.02±1.42), T3 (54.88±1.78%) and T4 (57.99±1.98%) ($p>0.05$) in Asian sea bass. The changes in cooking losses tended to have a linear relationship with the time and temperature of cooking (Garsia-Segovia *et al*, 2007). The amount of loss is probably related to the composition of muscle, denaturation of proteins by the ionic strength of the extra cellular fluid and oxidation of lipids, which decreases the solubility of proteins (Alipour *et al*, 2010). The highest cooking loss ($p<0.05$) was observed during microwave cooking (T1) about 64.99±1.87% for silver carp and frying (T4) for Asian sea bass and Croaker fillets with figures of 57.99±1.98% and 69.50±2.10% respectively. The least cooking loss was observed during steaming (T6) with values of 9.90±0.65%, 10.90±0.97% and 9.14±0.83% recorded for fillets of Silver carp, Asian sea bass and Croaker respectively (Fig. 1). Hakimeh *et al* (2010) while working on cooked Silver carp (*Hypophthalmichthys molitrix*) fillets reported highest cooking loss in grilled samples (52.34%) followed by fried (31.95%) and steamed (33.66%). Similar observations were also made by Oduro *et al* (2011) in chub mackerel (*Scomber japonicas*) and Farag (2013) in cooked Sardin. Ghelichpour and Shabanpour (2011) suggested that aggregation and denaturation of protein in golden grey mullet muscles were induced by heating, leading to the loss in water holding capacity of proteins as a result, drastic cooking loss was observed.

Cooking yield

The trends in cooking yield are complimentary to that of cooking loss with highest ($p<0.05$) yield observed for steamed (T6) followed by boiled (T5) samples (Fig. 2). The lowest yield about35.00±1.02% was observed for silver carp fillets during microwave treatment (T1). In case of Asian sea bass and Croaker the lowest yield 42.00±2.72 and 30.40±2.02% were encountered respectively in fried (T4) samples which is in agreement with the results of Gall *et al* (1983), who suggested that the weight yield is related to the type and the dimension of food.

Shrinkage

The highest shrinkage was found in microwave cooking (T1) with significantly higher values of 28.33±1.52 and 25.91±2.22% for Silver carp and Croaker fillets, respectively. In case of Asian sea bass fillets highest shrinkage of 29.15±2.09% was observed after frying treatment (T4) (Fig. 3). Many cooking conditions above 60°C are reported to cause shrinkage in fish protein with concomitant loss of liquid containing water soluble components (Tarr, 1962). It was observed that the shrinkage was proportionately increased with increasing temperature during microwave heating and frying process. A probable correlation is also observed among moisture retention, cooking yield and shrinkage.

Moisture retention

Moisture retention was highest ($p<0.05$) in steamed fillets (T6) Silver carp (89.92±2.43%), Asian sea bass (87.72±2.51%) and Croaker (88.22±1.12%). The lower moisture retentions were observed in frying (T4) in Silver carp (22.09±0.93%) and Croaker fillets (21.01±1.58) and microwave cooked samples of Asian sea bass (25.99±0.49) (Fig. 4). Similarly, Kocatepe *et al* (2011) reported that after cooking, moisture content decreased in grilled, baked, fried, microwave cooked anchovy ($p<0.05$). Most water in muscle is held within the myofibrils, in the space between the thick filaments (myosin) and thin filaments (actin) and some water is located in the connective tissue (Offer *et al*, 1989). As cooking proceeded, heat induced protein denaturation and aggregation leading to shrinkage of both the filament lattice and the collagen and also to exposition of hydrophobic areas of the myofibrillar structure, which allow new intra and inter - protein interactions that resulted in a more dense protein structure (Straadt *et al*, 2007). Hence, water was pressed out of the muscle cells leading to water loss.

Fat retention

Bognar (1998) suggested water loss and fat absorption occurred in potatoes, meat and low fat fish (< 5% fat) as well as breaded meat and fish by deep frying and shallow frying. In the present study the fat content (%) of the raw fillets of all the three species were found to be below 5% with values of 2.10, 1.41 and 1.14% recorded for Silver carp, Asian sea bass and Croaker respectively. Fat absorption occurred in all the species with consequent high fat retention figures (Fig. 5). The highest retention of fat ($p<0.05$) in Silver carp (523.71±4.57), Asian sea bass (317.49±2.78) and Croaker (429.61±2.98) fillets were observed in fried (T4) samples. The high fat retention during frying treatments may be due to apparent increase in fat coupled with gain in fat due to absorption (García-Arias *et al*, 2003). In Croaker fillets, however, no significant influence ($p>0.05$) of cooking methods was observed on fat retention except fried (T4) samples. Significant amounts of fat was absorbed from frying fat by the chops of lean pork, chicken and turkey breast and by the fillets of fish with low fat content (grouper, red snapper and pompano) (Bognar, 1998). The gain or loss of lipid from meat and fish is related to the lipid content in raw food and to the quantity of the coating flour or bread crumbs on the food surface. Deep fried, breaded meat, poultry and fish usually absorb less fat than meat, poultry and fish fried in pan. The kind of fat had no essential influence on fat uptake (Bognar, 1998).

Protein loss

All the cooking methods showed significant increase ($p\leq0.05$) in protein content. The highest protein gain was observed in microwaved (T1) samples with the amount of -20.58±1.32, -25.63±1.28 and -23.41±0.71% in Silver carp, Asian sea bass and Croaker fillets respectively, whereas steamed (T6) samples showed lowest protein gain (Table 1). Bognar (1998) investigated the effects of certain cooking methods on the protein content of selected foods. The retention of protein in the investigated cooked food varied from 90% in boiled meat and 96% to 100% in deep fried potatoes, meat and fish. The gain in protein due to heat treatment may be due to proportionate decrease in moisture content. The lower retention of protein after steaming and boiling of meat and fish occurred mainly due to leaching and dripping (Bognar, 1998).

Energy value

Consequent upon the increase in various nutrients due to cooking it is obvious that the energy value of the cooked fillets will increase irrespective of the fish species. Figure 6 portrays the significant increase ($p<0.05$) in

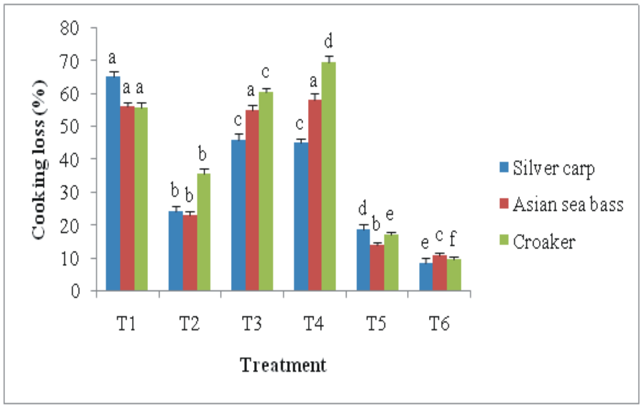


Fig. 1 : Cooking loss (%) in cooked fish fillets.

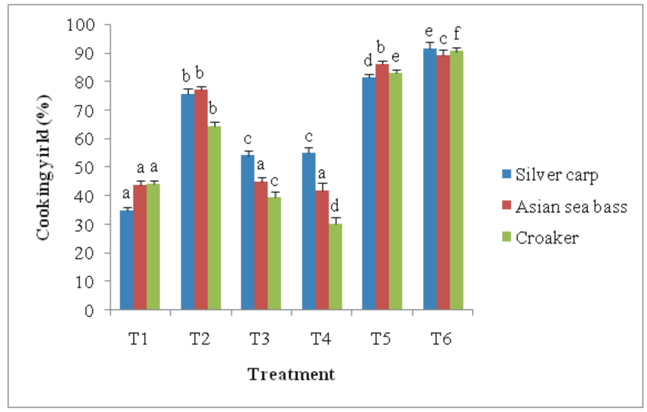


Fig. 2 : Cooking yield (%) in cooked fish fillets.

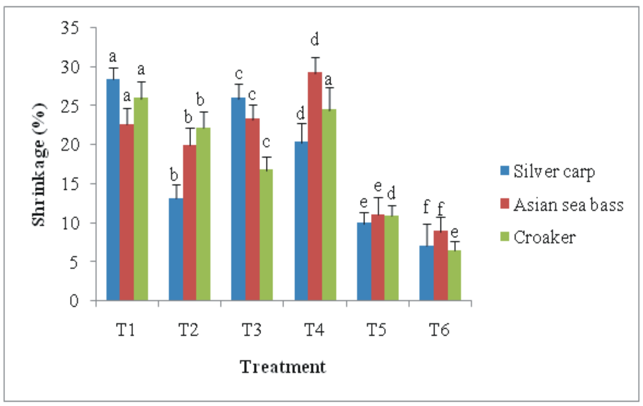


Fig. 3 : Shrinkage (%) in cooked fish fillets.

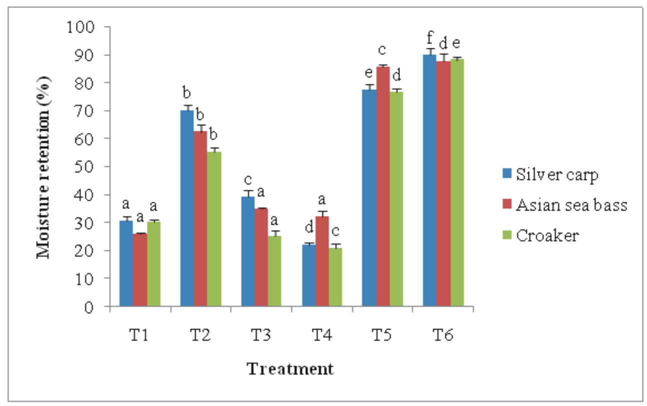
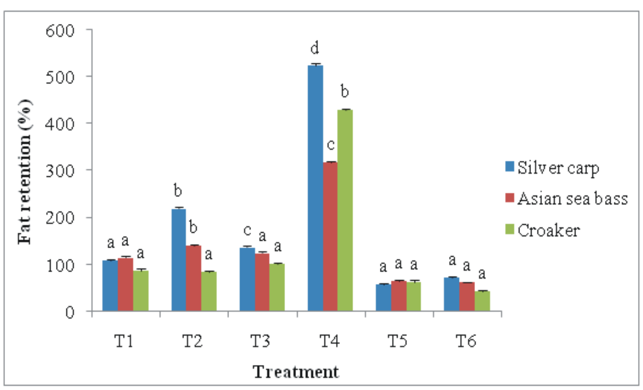
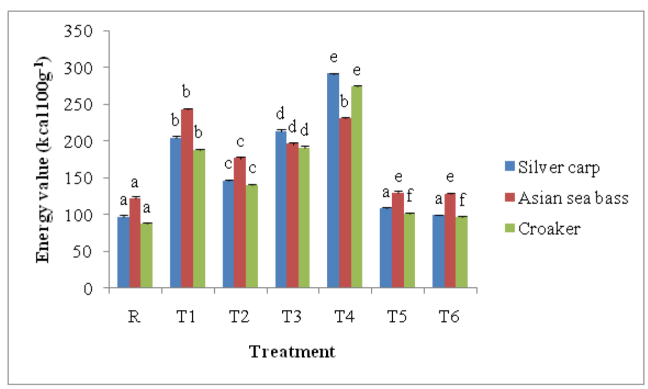


Fig. 4 : Moisture retention (%) in cooked fish fillets.





Results are mean of six determinations with SD. Values with different superscripts are significantly different at p<0.05 within the species.

Fig. 5 : Fat retention (%) in cooked fish fillets.

Fig. 6 : Energy value (kcal/100g) of raw and cooked fish fillets.

energy values due to heat treatment with the highest value calculated for fried fillets of Silver carp (291.41±1.21 kcal/100g) and Croaker (273.74±1.62 kcal/100g) fillets. Microwave cooking resulted in significantly higher energy value in Asian sea bass (242.89±1.45 kcal/100g) as compared to raw fillets, which may be due to the concentration of nutrients. Microwave cooking resulted in water drip and resultant higher lipid values (Domiszewski *et al*, 2011). This probably explains the high energy values for microwave fillets. Kocatepe *et al* (2011) reported similar findings and concluded that all cooking methods were significantly different in terms of calorie value (P<0.05). Abdulrahman *et al* (2008) also reported that energy content increased as a result of frying as evident by the fried *Scomberomorus commerson* (894.2 KJ/100g). Neiva *et al* (2011) was of the view that the consumption of high-calorie food was a risk factor for obesity among children and young adults. The consumption of and/or development of products that are not deep fried can be considered an adjuvant strategy to reduce the increasing rate of obesity and associated pathologies. In this context, boiling (T5) with energy

Table 1 : Protein loss (%) in cooked fish fillets.

Treatments	Silver carp	Asian sea bass	Croaker
T1	-20.58±1.32[a]	-25.63±1.28[a]	-23.41±0.71[a]
T2	-8.62±1.67[b]	-11.26±0.98[b]	-12.87±1.21[b]
T3	-14.35±1.21[c]	-13.58±2.14[c]	-22.46±2.32[c]
T4	-12.75±2.32[d]	-8.61±1.61[b]	-16.57±0.94[d]
T5	-4.71±0.56[e]	-3.09±0.99[d]	-4.38±0.42[e]
T6	-2.73±1.52[f]	-2.87±0.23[d]	-3.84±0.51[f]

Results are mean of six determinations with SD
Values with different superscripts are significantly different at P<0.05 within the species.

values of 108.45±1.87 kcal/100g, 129.35±3.28 kcal/100g and 101.81±0.67 kcal/100g for fillets of Silver carp, Asian sea bass and Croaker respectively and steaming (T6) with energy values of 99.41±0.87 kcal/100g, 128.23±1.89 kcal/100g and 96.38±1.54 kcal/100g for fillets of Silver carp, Asian ea bass and Croaker respectively may be considered as a viable alternative. However, such cooking methods like steaming and boiling did not have a good acceptability compared to other cooking methods.

CONCLUSION

Increasing population and industrialization of cities tend to growing of tendency to ready to eat products. Among the various methods of fish processing, application of heat is one of the most important methods available for fish preservation, quality improvement and consumer convenience and/or to increase their market value. From the present study, it can be concluded that cooking processes has influence on the physico-chemical characteristics of fish products, which depends on the method of cooking and nature of cooking. Boil and steam cooked fish with low energy value may become good alternative as nutrient rich healthy food product.

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