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Quality evaluation of local Cameroonian mackerel (*Scomber scombrus*) processed by different methods

Mbassi Josiane EG[1*], Tsafack Aristote LS[2], Maboune Abeline S[3], Eyenga Eliane F[4], Sophie Ngono E[5], Bongse Kari P[6]
[1-6] Food Technology Laboratory, Institute of Agricultural Research for Development (IRAD), Yaounde, Cameroon

Abstract
A research was carried out to study the influence of processing methods which are boiling, frying and roasting on the physicochemical and organoleptic properties of mackerel (*Scomber scombrus).* The aim of this study was to propose which method in terms of nutrients conservation for a healthy diet and shelf life is the best. Fishes were purchased from a local market, processing steps such as evisceration, brining and spicing were carried out before different cooking methods. Physical, color and sensory tests were performed on the processed fish. AOAC official methods were used for the proximate composition analysis of the fish samples. All processing methods revealed significant difference ($p<0.05$) in the various physical, color nutritional composition of fish. The results obtained for percentage of weight losses showed that after evisceration, there was a significant change (about 14% of losses) of the fish samples. Boiled and roasted samples showed lowest results of percentage losses 31.27 %, 36.64 % respectively compared to fry ones 43.59 %. Roasted fish had the highest scores in terms of global acceptability. The raw sample had the highest moisture content of 75.65 %, followed by fried and boiled 31.65 % and 32.1 % respectively and roasted fish sample with 35.6 %. In this study, the percentage protein of the various fish samples was observed to be highest in cooked fish sample compared to fresh fish. The boiled sample (55.22%) and roasted sample (55.93%) have a statically significant ($p<0.05$) lower proteins content than the fried sample (65.00%). The fried sample had a drastically increased on the fat content 35.52 % followed by the roasted with a fat content of 30.92 %, the raw and boiled with the lowest 12.20 % and 10.34 % respectively. These results show that, boiling is the best method in terms of conservation and frying the best for a healthy diet due to high values of the proximate composition.

Keywords: preservation, *Scomber scombrus,* cooking, nutrients, quality, sensory

1. Introduction

Foods of animal origin represent an important share in the diet of Cameroonian populations. The second Cameroonian Household Budget Survey (HBS/ECAM II) in 2001 demonstrated that consumption of animal products covered up to 8.1% of the total diet including fish (52 g/day), beef, poultry and eggs (17 g/day), and milk and dairy products (10 g/day) (Gimou *et al.*, 2014) [1]. Fishes are a rich source of protein commonly consumed as an alternative source of protein due to the higher cost of meat and other sources of animal protein. Fish is widely acceptable because of its high palatability, low cholesterol, tender flesh, cheapness and its aroma in cooking (Eyo, 2001; Sadiku, *et al*., 1991) [2-3]. The major constituents of fish are moisture, protein and fat with minerals occurring in trace amount. Generally, fish contains very little carbohydrate while the moisture content is very high. In most fish species, the moisture content is between 60-80 %, protein between 15-26% and 2-13% of fat (Murray *et al*., 1991) [4]. Due to the fact that the main constituent of fish flesh is water, which usually accounts for about 80 % of the weight of a fresh white fish fillet, it is an extremely perishable food commodity. It has been estimated that 10 % by weight of world fish catch is lost by poor handling, processing, storage and distribution. However, losses in small-scale fish processing are said to be particularly high and figures as high as 40 % are sometimes reported (FAO, 1984; Moes, 1980) [5-6]. These losses have a profound adverse impact on fishing communities whose status and income often depend on post-harvest activities. Such losses also have a detrimental impact on the socio-economic life of the fishing communities and reduce the amount of animal protein available to large segment of the population.

Since fish could not be eaten raw, various processing methods are employed in preparing them for consumption. Food processing and preservation is a set of physical, chemical and biological processes that are performed to prolong the shelf life of foods and at the same time retain the features that determine their quality, like color, texture, flavor and especially nutritional value (FAO, 2011) [7]. According to Nout *et al*., (2003) [8], food security cannot be guaranteed by only increasing agricultural production. Fish processing in Cameroon is mostly dominated by smoking and drying but nowadays, the demand for grilled, fried and boiled fish in restaurants, alongside streets and homes is increasing.

Due to the fact that fish is one of the most complete foods, provides nutrient and also it has low cholesterol contents compared to other meat such as beef and pork (Harris, 1979) [9], deeper understanding of the effect of processing methods on the nutrient composition of fish is highly recommended. The aim of this study was a preliminary investigation of the effect of some common cooking methods such as boiling, frying, and roasting on the macronutrient contents and organoleptic properties on some marine fishes (mackerel) in Cameroon.

2. Material and Methods

2.1 *Collection of Samples*

Ten kilograms (10 kg) of raw Frozen fish of mackerel species (*Scomber scombrus*), were purchased from Mokolo market, the biggest market of Yaoundé town in Cameroun. The cooking condiments which comprised of garlic cloves, ginger, curry powder, thyme, white pepper, common salt (sodium chloride), parsley and seasoning cubes were also gotten from the same local market.

2.2 *Samples preparation*

The fishes were defrosted in a refrigerator for 24h at 4 ± 1ºC. The raw fish was gutted, cleaned and made into four (4) portions. One portion considered as control was left without further treatment and stored at -20°C in a refrigerator (Haier Thermocool, Port-Harcourt) prior to analysis. Three (3) other portions were immersed in a NaCl 25% (w/v) solution at a ratio of 1:2, fish and brine, respectively, for a period of 1hour. After brining, those portions were seasoned. The seasoning was done by mixing the crushed spice mixture (garlic cloves, ginger, curry powder, thyme, white pepper, common salt (sodium chloride), parsley and seasoning cubes) with the fish. The seasoned fish is allowed to rest for 15 minutes to permit the spices to penetrate to the heart of the fish flesh.

2.3 Cooking operations

From the three (3) portions, one was boiled, another one roasted, and the last one fried. The boiling was done in a pot without adding water and with firewood as fuel. The pieces of fish were cooked and tender with water contained in its mussels and grounded condiments. It was kept boiling for about 45 minutes. For the roasting operation, fish was placed over a wire gauze that was on burning charcoal. The mackerel was allowed to cook for 35 min on both sides. During frying, fish was put in a fryer that already contained as much as 4 L of heated oil at a temperature of 170 °C. Samples of fish were fried for 15 minutes. After different cooking processes, the samples were allowed to cool down at room temperature sufficiently before packaging. The fish products were each wrapped with a layer of aluminum foil before packing in transparent polyethylene and stored at a temperature of 4 ± 1°C and -25 ± 1°C prior to sensory and physicochemical analyses respectively.

2.4 *Physical and color analysis*

Before and after each cooking method (boiling, frying, roasting), length and weight of the control and cooked fish samples were taken using calibrated weighing balance and ruler. The percentage cooking loss was calculated as follows:

$$\%\text{Cooking Loss} = ((W_0 - W_1)/W_0)*100$$

Where W0 and W1 are the weights before and after process respectively.

For the color, data collected was obtained by color Reader analyzer (Color reader CR-10,MADE IN JAPAN). The parameters of surface color were measured on three different points of the fish. The average value of the three measurements was recorded. Color readings were displayed as L* a* b* values where L* represents the lightness/darkness dimension. The positive and negative a* values indicate redness and greenness, respectively, and b* indicates yellowness for a positive value and blueness for a negative value. The standard white plate was used to calibrate the colorimeter (Kim *et al*., 2002) [10].

2.5 Sensory assessment

Sensory evaluations of cooked fish samples, conserved in a fridge at 4°C during about 16 hours, were carried out with twenty trained individuals. The samples were coded using letters and randomly presented to the panelists. The panelists evaluated each of the cooked fish its color, flavor, tenderness, juiciness, texture and overall acceptability. A five-point hedonic scale (Clucas, 1981) [11] describing the score of attributes of the fish samples. Parameters were scored (Table 1) using a scale from 0 (absent) to 5 (very pronounced) for color, flavor, tenderness, juiciness, texture, and for the overall acceptability from 0 (very disagreeable) to 5 (very pleasant). All data were collected with three replications.

Table 1: Scores and descriptors for sensory attributes

Scores	Sensory attributes of cooked fish	
	Color, flavor, smoke odor, tenderness, juiciness, texture	Overall acceptability
0	Absent	Very disagreeable
1	Very weak	Unpleasant
2	low	Rather unpleasant
3	Net	Rather pleasant
4	Pronounced	Pleasant
5	Very pronounced	Very pleasant

2.6 *Proximate analysis*

All four (4) portions (raw, boiled, fried and roasted) of the mackerel were separately dried to a constant weight in the oven at 60°C and allowed to cool in a desiccator. The cooled samples were pulverized using a ball grinder, further sifted through a 0.5mm mesh to a fine particle size for exhaustive extraction. The proximate components of fish samples were carried out in triplicates.

The recommended methods of the Association of Official Analytical Chemists (AOC) were adopted for the analyses of the samples. Moisture content was determined by heating 5.0 g of each sample to a constant weight in a crucible placed in an oven maintained at 105ºC. Crude protein content was calculated by converting the nitrogen content determined by the Kjeldahl method (Nx6.25). Ash was determined by the incineration of 1.0 g samples placed in a muffle furnace maintained at 550 ºC for 5 hours. Crude lipid content was determined by acid digestion prior to continuous extraction using petroleum ether. Crude fiber content was determined by extraction with petroleum ether and diethyl ether. The extraction method was similar to that of the fat. All the proximate values were reported in g/100g of the fish sample.

2.7 *Statistical Analyses*

Results are expressed as mean of triplicate trials. The data obtained from physicochemical and sensory analysis were subjected to analysis of variance (ANOVA) with EXCEL. Duncan Multiple Range Test (DMRT) for mean comparison was used to determine a significant difference between the various samples that was set at 5% (P <0.05).

3. Results and Discussion

3.1 Physical parameters of fish samples

3.1.1 Losses along operations of cooking methods

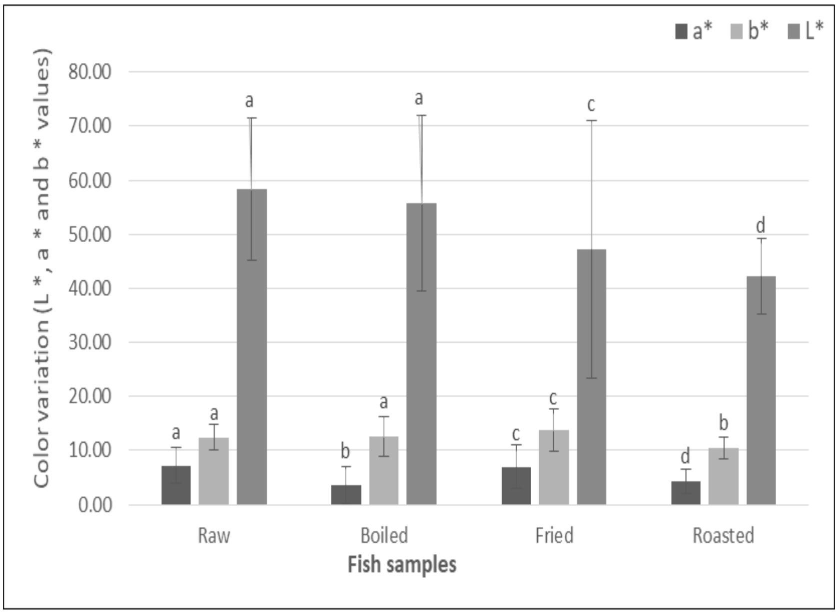
Table 2 below shows variation in weight and length of fish. It can be seen from the results that length of fish does not change before, after evisceration and after processing unlike weight that vary during the process. The results obtained for percentage of weight losses showed that after evisceration, there was a significant change (about 14% of losses) of the fish samples. This is due to the fact that eviscerated organs such as gills, intestines, stomach, and blood were removed. Different processing methods led to decrease in weight. Losses of 31.27 %, 43.59 %, and 36.64 % respectively of boiled, fried and roasted fish samples were recorded. This was due to the fact that they were performed at very high temperatures thereby drying up water molecules in the fish muscles. Frying had the highest rate of losses. This could be explain by the fact that during frying, fish is heated in oil above the boiling point of water (170 °C), therefore is basically a dehydration process in which oil acts as transfer medium for heat (Ngadi *et al*., 1997) [13].

Table 2: Variation of Length and weight of fish after evisceration and after processing

Methods	Weight Loss (%)		ΔL (cm)	
	Evisceration	Process	Evisceration	Process
Boiling	14.36 ± 1.52	31.27 ± 8.99	0.00	0.00
Frying	13.88 ± 2.57	43.59 ± 5.50	0.00	0.00
Roasting	14.83 ± 1.22	36.64 ± 8.11	0.00	0.00

3.1.2. Color analysis

Figure 1 below shows variation in color for the four different samples following the L*, a*, and b* system of color. The results demonstrate that there is a significant difference in color for each fish sample. It is observed that raw and boiled fish L* values (58.33% and 55.70 %), which represents the lightness/darkness dimension, are slightly but not significantly different (p<0.05), but significantly different from fried (47.27 %) and roasted (42.23%) samples. These values indicate that roasted fish samples are the darkest and raw fish the lightest. However, boiled fish is lighter than fried fish which is lighter than roasted fish. This color difference could be the non-enzymatic browning reactions on the processed fish samples engendered by the high heat. In other words, during cooking, discoloration occurs due to the oxidization of the pigment heme groups (Kinsman *et al*., 1994) [14].



Means with similar letters are not significantly (P<0.05) different.

Fig 1: Color variation (L *, a * and b * values) of fish samples.

3.2. *Organoleptic characterization*

Results obtained from sensory analyses on figure 2 show that the roasted fish have the highest scores on the different parameters that were determined by the panelist. Such parameters were color (2.75), aroma (3.50), sugar taste (3.06), salty taste (2.69), tenderness (3), juiciness (2.44) and global quality (3.63). This is to say that roasted fish is the best. The boiled fish sample with 3.063 for the global quality is the less appreciated by panelists.

Generally color/ appearance is one of the quality parameters that consumers use in accepting or rejecting products, hence this is crucial in quality evaluation.Concerning color and aroma attributes, fried (3.95 and 3.38) and roasted (2.75 and 3.5) fish samples have the highest scores compare to boiled samples (2.56 and 2.56). According to this results, frying and roasting methods give the fish product attractive color and enhance the aroma (Bereket *et al*., 2018) [15]. But even more, the charcoal used during roasting contributed by its smoke, which contains chemicals like formaldehydes and phenols, to improve the flavor of the fish sample (Longwe P *et al*., 2016) [16].

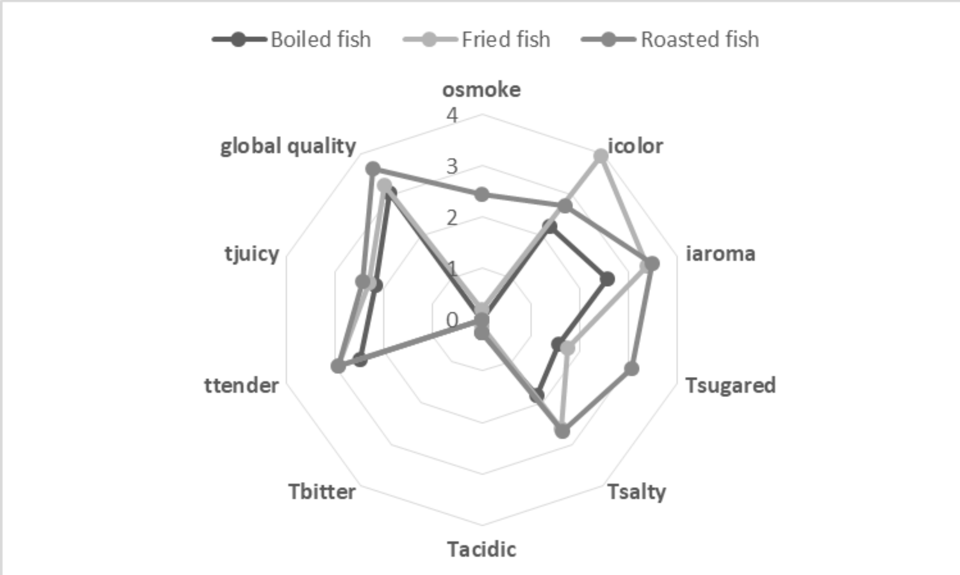


Fig 2: Sensory analyses of processed fish samples

3.3. *Proximate composition*

Results of proximate composition analyses of raw boiled, fried and roasted fish samples were given in Table 3. From these data, in a general point of view, we can say that all the cooking methods affect the nutritional values of fish.

Moisture content varied for the different fish samples. Percentage moisture revealed that fresh fish samples had the highest moisture level of 75.6%, followed by roasted and boiled samples with 35.6 % and 34.90 % respectively. The fried sample had the lowest moisture content and 31.65% respectively. Highly significant difference ($P<0.05$) was noted in moisture level among the fish samples. This results was similar to those of (Ali M. *et al*., 2014) [17], though not same values as on his study which could due to the different variety of fish. These significant change in moisture of the different samples when compared to the raw samples is due to the fact that after evisceration, the fishes were submitted to high temperatures, therefore led to dehydration of fish muscles. Oduro *et al*., investigated in their work that cooking fish contributed in reducing of moisture. Also, the low moisture of the fried sample was due to the fact that, it was done under very high temperature (160℃) and at such temperature, there was a reaction between water and oil that caused the oil to replace the water molecules from the fish muscles. The boiled sample also had a lower. The reason being that, after adding spices on the fish, water was not added for the boiling and during the process, liquid was instead going out from the fish muscles to the surface. Thus reduction in moisture content in both will improve the quality of the fishes for longer preservation time, because low moisture levels in fish reduces the fishes' susceptibility to microbial spoilage and oxidative degradation of polyunsaturated fatty acids (Allen, 1987; Frankel, 1991; Oparaku, 2013) [19-21].

The crude protein of boiled, fried and roasted fish samples were higher (55.22%, 65% and 55.93% respectively) than the corresponding values for raw fish samples. This could be attributed to the extent of drying which lowered moisture and concentrated proteins. Similar results were obtained by Thot and Pothast (1984) [22]. In this study, the percentage protein of the various fish samples was observed to be highest in cooked fish sample compared to fresh fish. The boiled sample (55.22%) and roasted sample (65%) have a statically significant ($p<0.05$) lower proteins content than the fried sample (65.00%). Oduro *et al*., demonstrated in their work that cooking fish via grilling, microwave, steaming and frying contributed in increasing protein content.

Cooking methods significantly affected fat level of fish. The highest fat level (35.52%) was found in fried samples. Depending on the fat content fish are classified as: lean (below 2% of fat), medium (2-7% of fat), oily (7-15% of fat), and very oily above 15% of fat). The total fat content in fish is associated mainly with the fish species, their nutritional status, fishing seasons, the life cycle of the fish, and the technological processes used. Absorption of frying oil by the fish caused high fat levels in fish muscle. Similar results related to fat levels in fish cooked by different methods have been reported (Steiner-Asiedu *et al*., 1991 [23]; Gokoglu *et al*., 2004 [24]; Salawu *et al*.; 2005 [25]; Marimuthu *et al*., 2011) [26] who reported significantly higher lipid content in fried fish than in raw fish.

Crude fibre level also revealed that fresh fish samples had the highest crude fibre of 0.66% and was significantly difference ($P<0.05$) from boiled fish (0.55%), fried fish (0.42%) and roasted fish (0.40%). Although fried fish had the least fibre content. Okpanachi *et al*., reported the same results.

After cooking process using three methods, ash contents of fish significantly ($p<0.05$) increased. The lowest ash content (0.99 %) was also found in fried samples. Similar results were found in a previous study for anchovy (*Engraulis encrasicholus*) carried out by Harun Uran & Nalan Gokoglu (2014) [28].

Table 3: Proximate composition (%) of raw and cooked fish samples

Fish samples	Proximate composition				
	% Moisture	**% Protein**	**%fats**	**%fibre**	**%ash**
Raw	75.55 ± 0.20^{a}	42.50 ± 2.12^{a}	16.20 ± 0.14^{a}	0.66 ± 0.03^{a}	0.70 ± 0.01^{a}
Boiled	34.90 ± 0.99^{b}	55.22 ± 0.11^{b}	12.43 ± 0.13^{b}	0.55 ± 0.14^{b}	1.50 ± 0.00^{b}
Fried	31.65 ± 4.03^{c}	65.00 ± 0.70^{c}	35.52 ± 0.28^{d}	0.42 ± 0.01^{c}	0.99 ± 0.01^{c}
Roasted	35.6 ± 2.68^{b}	55.93 ± 0.99^{b}	30.92 ± 0.16^{c}	0.40 ± 0.00^{c}	1.14 ± 0.12^{d}

Data are given as mean in triplicate ± SD. Values with the same superscript letter within the same column are statistically significant ($p<0.05$).

4. Conclusion

The study was carried out to study the effects of processing methods on the organoleptic and physicochemical properties of *Scomber scombrus*. It was concluded that cooking methods had influence on nutritional and quality characteristics of the mackerel. Proximate, color, and sensory properties of mackerel were affected by cooking methods. These values indicated that roasted fish samples are the darkest and raw fish the lightest. However, boiled fish is lighter than fried fish which is lighter than roasted fish. Based on the results obtained from the sensory analyses, the roasted fish was the best in terms of global acceptance followed by the fried. Results obtained on the nutritional analyses shows that, the fried fish had the highest protein (65.00%), fats (35.52%), and ash (0.70%) contents and also the lowest moisture content. it could be concluded that of all processing methods examined for the preparation of fish for human consumption, although was the most appreciated, frying is the best when preservation of the fish is the priority, because of its low moisture content, but when nutrient conservation is the focus, boiling is the best. Therefore, because of its higher fats content, frying cannot be recommended for people who would like to limit their dietary intake of fat due to diet and health concerns. Health organizations all over the world have promoted lower intake of total dietary fat and cholesterol as a means of preventing cardiovascular heart disease. This study clearly indicates that the proximate values obtained could be of help when choosing fish processing methods based on nutritional values and needs of each individual. These results will be useful for the fish product industries, nutritionists, families and fellow researchers to improve fish processing and marketing.

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