

EFFECT OF ACETIC ACID AND COOKING PROCESS ON CHEMICAL COMPOSITION AND METAL CONTENTS OF POLLUTED GREY MULLET (*Mugil cephalus*) FISH

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ABSTRACT

Effect of acetic acid and cooking process on chemical composition and mineral contents of polluted grey Mullet (*Mugil cephalus* L.) fish with heavy metals were studied. The fish was immersed in different concentration of acetic acid (1.0%, 3.0% and 5.0%) for different period (1 and 3 min) prior cooking. The results revealed that immersing fish in acetic acid before cooking led to reduce mineral contents including Cd and Pb concentrations in the raw fish fillet. As the concentration of acid increases and extends the immersing period, reduction of metals loads increases. Most of cooking process decreased the moisture and increase protein contents of fish fillet. Also, lipid was dramatically declined by grilling or roasting, while it augment by frying. The best methods for cooking polluted grey Mullet fish is immersing fish in 1.0% acetic acid for 1 minute followed by roasting.

Keywords: heavy metals, cooking methods, chemical composition

INTRODUCTION

Fish is one of the most relevant foods especially to the people of coastline and lakes as well as the cities along the river. Fish also is cheap animal protein with high-nutrition quality and rich in valuable minerals and vitamins (Pieniak *et al.*, 2010). Moreover, fish fat is a significant source of essential polyunsaturated fatty acids (PUFAs), especially omega-3- fatty acids which lowering the risk of coronary heart disease and contributing to normal neurodevelopment in children (Mozaffarian and Wu, 2011; Swanson *et al.*, 2012).

The annually total production of fish in Egypt is about one million ton (FAO, 2011) where more than 60% is produced by farmed fish. Grey Mullet (*Mugil cephalus*) fish is found in coastal marine and brackish waters; consequently it could be successful farmed (Hassanin 2008). It was reported that Mullet fish represented about 30% of the total catch fish. Therefore, it considered as the second category following Tilapia that is consumed by the Egyptians (FAO, 2011).

Minerals and metals are playing an important role in animal body. Calcium and phosphorus are recognized as essential for body functions. Also their constituents of bones and teeth, minerals provide strength and rigidity to skeletal structures. Ca and P are usually discussed together because they occur in the body combined with each other for the most part and because an inadequate supply of either limits the nutritive value of both. They usually found in fish in the ratio of 2:1 (P : Ca). Ca was normally found in fish in two forms. The first one is diffusible Ca which is present as phosphate and

bicarbonate salts and is of significance in calcium and phosphorus nutrition. The second form is the undiffusible Ca where it binds to protein and amino acids (Chow and Schell, 1980). Most of Ca and P are localized in the fish bones, fins and scales. In spite of fish is considered one of the most important foods rich in calcium and phosphorus among animal meats (Stanek and Janicki, 2011; Ravichandran *et al.*, 2012; Stanek *et al.*, 2013).

Polluted fish with heavy metals becomes a very detrimental effect, especially on that category that depends on the fish as a diet. Cd and Pb are the most dangerous aquatic heavy metals due to their levels increase by rise the human activity including industrial, agricultural and mining actions. In addition, capability of such metals to accumulate in living organisms and biological system causing sever disorders (Wafaa *et al.*, 2003; Harris, 2007; Biswas *et al.*, 2011;; Mohammadi *et al.*, 2011).

Most of fish farm in Egypt used drainage waters, especially the private and illegal farms, involving industrial and agricultural discharges as well as sewage and sanitation for the villages that pass by these drains. As a result, the water of these fish farms is heavily polluted with different toxic chemicals such as pesticides, runoff-derived fertilizers and metals (Alne-na-ei, 1998, 2000, 2003; Khallaf *et al.*, 1994, 1995, 1998, 2003; Tayel *et al.*, 2007; Autıman, 2008; Authman *et al.*, 2008, 2012). Consequently, human populations that are dependent on farmed fish in their meals, have the highest potential exposure to Cd and Pb. This is a particularly important issue for children, pregnant women and breast-feeding mothers (Jedrychowski *et al.*, 2007, Ramón *et al.*, 2008 and Ramon *et al.*, 2011).

Fish is usually cooked by different method, such as boiling, grilling, baking, and frying, before consumption. However, in some population fish is eaten raw. The effects of different cooking methods on gross chemical composition of several fish species have been reported (Gokoglu *et al.*, 2004; Ersoy *et al.*, 2006; Kucukgulmez *et al.*, 2006; Rosa *et al.*, 2007; Weber *et al.*, 2008; Stephen *et al.*; 2010). Therefore, scientists and researchers are paid more attention concerning decrease the level of heavy metals concentrations in fish via different transactions before the cooking process and choose the best cooking methods so that does not effect on the physical, chemical and organoleptic characteristics for cooked fish (Atta *et al.*, 1997; Elnimr, 2011). Mullet fish is cooked in many ways such as grilling, frying and baking, or processed such as dried and pickled to make fessek (Arias *et al.*, 2003). During processing chemical composition of fish is deteriorated depending on cooking method (Atta *et al.*, 1997; Eves and Brown, 1993; Tao and Linehun, 2008; Eyo, 2001). Therefore, it is important to determine the retention of nutrients including minerals in the farmed fish cooked using several common domestic practices, namely roasting, grilling and frying. Consequently, the amount of mineral intake by consumers could be estimated (Cid *et al.*, 2001). Many studies have been published on the determination of heavy metals in raw fish (Yazkan *et al.*, 2002), but these studies are inadequate for estimating the intake of metals by humans after different cooking methods. Atta *et al.*, (1997); Ersoy *et al.*, (2006); Diaconescu *et al.*, (2013) pointed out that cooking methods reducing heavy metals concentration and the reduction depends on cooking condition. While, Elnimr (2011)

concluded that addition of acetic acid to raw fish before cooking could be reduced the level of heavy metals.

This work was carried out in order to evaluate the effect of acetic acid treatment in different concentrations for different times on fish chemical composition including the content of some minerals in grey Mullet fish fillets. The effect of cooking method on farmed Mullet fish followed acid treatment was also investigated.

MATERIALS AND METHODS

Sampling:

Polluted grey Mullet (*Mugil cephalus*) or Bouri (as a local name) fish was collected from private fish farm at Al-Hamol, Kafer El-Sheikh Governorate, Egypt in the spring season of the years 2013 and 2014. This farm is supplied from heavy metals polluted drainage waters. The length of the fish was ranged from 20-35 cm while the weight was ranged from 370 to 530g.

Fish Transportation:

Fish was transported directly in an insulated ice box at 4°C to the laboratory of Food Science and Technology Department, Faculty of Agriculture, Tanta University for analysis.

Determination of fish freshness:

Fish freshness tests including the cohesion of scales to skin, skin with flesh, eye brightness and gills color were performed according to Sikorski (2001).

Fish treatment:

Fish was washed thoroughly with tap water followed by distilled water before they subjected to physical and chemical analysis. Thereafter, fish was beheaded and eviscerated.

Organic acid treatment:

Fish was divided into six groups. The first and second groups were immersed in 1.0% acetic acid solution for 1 and 3 min, respectively. The third and fourth groups were immersed in 3.0% acetic acid solution for 1 and 3 min, respectively. The same treatment was repeated with the fifth and sixth groups using 5.0% acetic acid solution instated of 3.0%. After the appropriate period fish was washed with distilled water and subjected to the cooking process.

Cooking methods:

Fish was subjected to different types of technological process including deep frying in sunflower oil, fish roasting and fish grill as common household methods according to Ganbi (2010) as follows:

- **Frying:** Fish fillets were powdered with wheat flour 72% extraction using frying pan made of aluminum. Fillets immersed in sunflower oil as the medium for deep-frying which heated to 180 °C for 5-10 min and removed when a golden brown color appeared on surface.

- **Roasting:** Fish was placed in pans containing a little quantity of refined sunflower oil using gas oven at nearly 160°C for 20 minutes till complete cooking.

- **Grilling:** Fish was grilled as common household method according Hasanin (2008) as follows: Fish was powdered with wheat bran then grilled at 180°C for 10 min on each side using a grilling plate made of tin.

After the previous cooking methods fishes allowed to cool at room temperature prior further analysis.

Chemical analysis:

Moisture using an electric oven at 105°C, crude protein (N×6.25) by micro-kjeldahl method, ether extracts by petroleum ether (bp 60-80°C) in a Soxhlet apparatus and ash using an electric muffle at 450-550°C, of fish samples were carried out according to AOAC (2000). While, total carbohydrates were calculated by difference according to Egan *et al.*, (1981).

Determination of metals:

Metals namely calcium (Ca) cadmium (Cd) and Lead (Pb) in the fish flesh were determined by Atomic Absorption Spectroscopy (ICP = inductively couple plasma unit: optima 7000 DV) following wet digestion with HNO₃: H₂O₂ (1:1v/v) mixture as described by Olaifa *et al.*, (2004). Results are expressed as mg metal/ kg fish fillet sample based on wet weight bases.

Determination of phosphorus:

Phosphorus in fish fillet was determined calorimetrically using spectrophotometer (UV1901PC Phenix UV-VIS Spectrophotometer) at 650 nm by using ammonium molybdate solution (Cupisti *et al.*, 2006).

Statistical analysis:

Data were analyzed using Analysis of Variance (ANOVA) and means were separated by Duncan at a probability level of < 0.05 (SAS, 2000).

RESULTS AND DISCUSSION

Effect of acid treatment on sensory characteristics of fish freshness

The color, flavor and texture of fish are important factors affecting the suitability of fish for different methods of culinary preparation and use in the food industry. Therefore, freshness of raw fish must be done to ensure high quality of fish products. Although there is a different methods were applied to evaluate the raw fish quality using various instruments, but sensory methods are still the most satisfactorily way of assessing fish freshness and quality deterioration (Ólafsdóttir *et al.*, 1997). According to Sikorski (2001) fish quality divided into four grades: the first grade is (extra) which means that raw fish in an excellent quality. The second grade is (a) and the third is (b) which means that quality of raw fish is gradually decreased but still accepted by the consumers. Then the quality decreases to get (not admitted) grade which means that raw fish is not accepted by the consumers.

The results of Table (1) show that raw (untreated) fish has the best quality which was gradually deteriorated due to acid treatment.

Table (1): Freshness characteristics of grey Mullet (*Mugil cephalus*) fish as affected by acetic acid treatments.

Acetic acid Treatments		Skin color	Flesh	Skin cohesion	Gills	Eye
Concentration (%)	Time (min)					
Raw	0	bright, iridescent, pigment opalescent(extra)	firm and elastic, smooth surface(extra)	smooth, bright, difficult to detach from flesh(extra)	bright color, no mucus(extra)	convex, bulging; black bright pupil, transparent cornea(extra)
1%	1	pigmentation bright but not lustrous(a)	less elastic(a)	slightly dull can be detached from flesh(a)	less colored, transparent mucus(a)	convex and slightly sunken, black dull pupil, grey cornea(a)
1%	3	pigmentation in the process of becoming discolored or dull(b)	slightly soft (flaccid), less elastic, waxy and dull surface(b)	slightly dull can be detached from flesh(a)	less colored, transparent mucus(a)	flat, grey cornea, opaque pupil(b)
3%	1	pigmentation in the process of becoming discolored or dull(b)	slightly soft (flaccid), less elastic, waxy and dull surface(b)	speckled: comes away easily from flesh(b)	brown, grey becoming discolored, thick opaque mucus(b)	flat, grey cornea, opaque pupil(b)
3%	3	pigmentation in the process of becoming discolored or dull(b)	slightly soft (flaccid), less elastic, waxy and dull surface(b)	speckled: comes away easily from flesh(b)	brown, grey becoming discolored, thick opaque mucus(b)	flat, grey cornea, opaque pupil(b)
5%	1	pigmentation in the process of becoming discolored or dull(b)	slightly soft (flaccid), less elastic, waxy and dull surface(b)	slightly dull can be detached from flesh(a)	brown, grey becoming discolored, thick opaque mucus(b)	convex and slightly sunken, black dull pupil, grey cornea(a)
5%	3	dull pigmentation (not admitted)	Soft scales easily detached from skin(not admitted)	does not stick (not admitted)	brown, grey discolored, thick opaque mucus (b)	concave in the center, grey pupil (not admitted)

Where the skin pigmentation of the fish slightly decrease and became bright but not lustrous with grade (a) due to treatment the with 1.0% acetic acid for 1 min. The skin became discolored or dull with grade (b) when the acid concentration increased to 3.0% for 1 or 3 min. But the quality of fish skin is not accepted when the fish was treated with 5.0%. The same trend is also seen for flesh, skin cohesion, gills and eye characteristics.

In conclusion, treatment of fresh grey Mullet fish with 1.0% acetic acid for 1 min is satisfactory treatment followed by 1.0% acetic acid for 3 min or 3% acetic acid for 1 min. The previous treatments did not altered the fish quality, where treatment fish with 3% acetic acid for 3 min or 5% acetic cause severe deterioration in the fish quality so that fish is not accepted.

Effect of acid treatment on gross chemical composition of fish:

The results of Table (2) show that the treatment of grey Mullet fish with acetic acid has a marked effect on the gross chemical composition. Where, moisture content of fish slightly increases. The amounts of water absorbed by fish body is significantly ($P \geq 0.05$) increased as the concentration of acid is raised and/or time of immersing is prolonged. The increment in moisture content of fresh fish may be related to the change protein properties and decrease of ether extract. Since, increase of moisture content is a sign of reduction of water holding capacity due to denaturing of proteins (Suvanich *et al.*, 2000). Myofibril proteins denaturation in fish muscle has been reported to be the reduction of water holding capacity (WHC) of the fish protein (Suvanich *et al.*, 2000; Pourashouri *et al.*, 2009). This phenomenon leads to reduction of flavor agents and nutrition value (Rostamzad *et al.*, 2011). Similar results were reported by Pourashouri *et al.*, (2009) and Rostamzad *et al.*, (2011) for Wels catfish.

It is interesting to note that crude protein content of fresh grey Mullet fish did not significantly ($p < 0.05$) affected by acid treatment at different concentrations and various immersing periods.

On the other hand, ether extract of raw grey Mullet fish is significantly ($P \geq 0.05$) decreased due to acid treatment. This depression in ether extract could be related to the effect of acetic acid on lipid hydrolysis. Where the amount of free fatty acids separated from fat are increased (Tahiri *et al.*, 2011).

Ash content of fresh fish seems to be not significantly ($P \geq 0.05$) influenced by acid treatment at 1.0% for 1 min immersing. Whereas, it is significantly ($P \geq 0.05$) decrement as the acid concentration increased in the immersing water or extended the period of soaking rather than 1 min. The reduction in ash content in fish may be due to reactions between acetic acid and some organic salts in the fish tissues forming water soluble acetate compounds that released in the immersing water. It was reported that most of acetate salts are water soluble especially at room temperature (20°C) (Anon, 2015).

Table (2): Gross chemical composition (g/100g) of polluted grey Mullet (*Mugil cephalus*) fish as affected by immersing fish in different concentrations of acetic acid for various periods.

Acetic acid Treatments		Moisture	Protein	Ether extract	Ash	Total carbohydrates
Concentration (%)	Time (min)					
Raw	0	75.08± 0.52d	76.00± 0.06a	14.44± 0.15a	7.79± 0.02a	1.76± 0.08d
1%	1	76.38± 0.20c	76.02± 0.25a	14.16± 0.06a	7.72± 0.05ab	2.08± 0.33dc
1%	3	77.51± 0.27a	75.93± 0.12a	13.61± 0.06ab	7.65± 0.06c	2.80± 0.02ab
3%	1	76.52± 0.09c	75.99± 0.02a	14.14± 0.07a	7.71± 0.02ab	2.15± 0.07dc
3%	3	77.63± 0.22a	75.97± 0.10a	13.65± 0.15bc	7.46± 0.11c	2.90± 0.10ab
5%	1	77.27± 0.23ac	75.96± 0.08a	13.81± 0.08a	7.70± 0.06bc	2.51± 0.20bc
5%	3	78.32± 0.54a	75.96± 0.06a	13.43± 0.23c	7.26± 0.10c	3.33± 0.187a

- Total carbohydrates are calculated by differences
- Values are mean standard ± deviation (M±SD) of three successful trails
- In a column, means followed by the same letters are not significantly different at 5% level

Effect of acid treatment on some metal contents of raw grey Mullet fish:

Table (3) display that both Ca and P in raw fish fillet gradually decreased by increasing the concentration of acetic acid or extended the immersion period. Therefore, the highest Ca (87.33mg/100g) and P (307.66mg/100g) concentration are found in the raw fish fillet. On the other side, the significantly ($P \geq 0.05$) lowest concentrations (63.30 and 289.66mg/100g) are found in the fish fillet immersed in 5.0% acetic solution for 3 min. This may be related to the ability of acetic acid to break down the linkage between Ca and P of fish protein or organic calcium and phosphorus compounds in the fish fluids forming water soluble acetate salts that release into the immersing solution. Moreover, minerals could be leached out into the water during immersing the fish leading to significant reduction (Wang *et al.*, 2008; Bayram *et al.*, 2004; karkle and Beleia 2010; Huma *et al.*, 2008).

The same Table displays that Cd concentration in the raw grey Mullet fish fillet is 0.36 mg/kg. This value is higher than those of the permissible level recommended by Egyptian Organization of Standard (EOS, 2005) (0.10mg/kg) and (FAO/WHO 1992) (0.05mg/kg) or European Commission Regulation (2011) (0.05 to 0.30mg/kg). Also, Pb concentration in fish fillet, it is (5.21mg/kg) which considered as extremely higher than those recommended by different authorities (EOS, 2005 1.0mg/kg); (FAO/WHO 1992, 0.5mg/kg). Likewise, it is higher than that of European Commission Regulation (2011) for fish flesh where Cd must be ranged between 0.05 to 0.5mg/kg. This may be related to the water quality of the fish farm, where it is supplied with drainage waters which include industrial, agricultural and municipal waters (Atta *et al.*, 1997).

Table (3): Metal contents of polluted grey Mullet (*Mugil cephalus*) fish as affected by immersing fish in different concentrations of acetic acid for various periods.

Acetic acid Treatments		Essential minerals (mg/100g)		Heavy metals (mg/kg)	
Concentration (%)	Time (min)	Calcium (Ca)	Phosphorus (P)	Cadmium (Cd)	Lead (Pb)
Raw	0	87.33±1.45a	307.66±1.20a	0.36±0.003a	5.21±0.08a
1%	1	79.66±1.20b	304.0±1.00a	0.34±0.003b	5.10±0.08a
1%	3	74.66±0.88c	297.00±1.15b	0.32±0.008c	4.77±0.07b
3%	1	74.00±0.57c	303.66±0.88a	0.34±0.003b	4.79±0.02b
3%	3	69.00±1.00d	297.33±1.45b	0.31±0.003d	5.91±0.05c
5%	1	72.00±1.52e	305.33±0.88a	0.33±0.003b	4.90±0.05b
5%	3	63.30±0.88e	289.66±2.02c	0.27±0.003e	3.57±0.04d

- Values are mean standard \pm deviation (M \pm SD) of three successful trails

- In a column, means having the same letters are not significantly different at 5% level

It is clear that immersion of raw grey Mullet fish in acetic acid solutions has a positive effect on reducing Cd and Pb concentration in fish fillet. For example, concentration of Cd in raw fish fillet is 0.36mg/kg which is significantly decreased to 0.34mg/kg after 1 min immersing in 1.0% acetic acid. This effect is more pronounced in the case of increased the acid concentration and/or prolongs the duration of immersion. The lowest concentration of Cd and Pb is found in fish which immersed in 5.0% acetic for 3 min. However, this advantage offset by a large defect in fish flesh as the increase the acid concentration or prolonged immersion duration lead to the existence the acid aroma. In addition to decrease coherence of fish flesh as well as cut the degree cohesion between skin and muscle. As a result, it becomes handling fish after immersion and before cooking difficult process, which reduces the quality of the fish.

Based on the above, we have found that the best treatment for polluted fish is the immersion in 1.0% acetic acid solution for 1 min, which gave a noticeable impact on the lack of heavy metals while retaining the natural properties of the fish and the strength of the smell.

The decrement in the Cd and Pb concentration may be related to the reaction between the metals in fish body and acetic acid leading to forming some water soluble salt which release in the immersing solution.

Effect of cooking methods on gross chemical composition of fish:

Gross chemical composition of raw and cooked grey Mullet fish fillets are given in Table (4). The moisture content in raw grey Mullet fillets is 75.10%. Similar results were reported in the literature (Hassanin 2008; Kumaran *et al.*, 2012; Udo and Arazu, 2012; Mostafa and Khalil, 2014). The moisture content of fish flesh in all cooking methods was significantly ($P \geq 0.05$) decreased. The decrement in moisture depends mainly on the cooking type, where the lowest moisture content is (63.98 %) found in the fried fish. In contrast, grilled cooked fish fillets have the highest moisture content (68.06 %) among other cooked fish fillets. No significant ($P \geq 0.05$) differences in moisture content are found between grilled and roasted fish fillet.

As for crude protein, it is clear that grilling or roasting processes lead to significantly ($P \geq 0.05$) increment in the protein content of fish fillet, while frying has no significantly ($P \geq 0.05$) effect. On the other hand, ether extract is significantly ($P \geq 0.05$) increased in the fried fish fillet and decreased in grilled or roasted fish fillet. These may be related to the release of lipids due to melting fat by direct dry heat during grilling or roasting processes and its diffusion with the drip separated. The amounts of loss lipids are depended on the temperature and time of cooking. Contrary to grilling or roasting, frying of fish in oil led to increase the fat content in fish fillet. This may be explained by absorption of oil from the frying environment by fish fillet and as water is lost by evaporation during the frying process (Saldanha and Bragagnolo, 2008). The gain or loss of fat during frying is closely related to the initial lipid content in raw fish (Varela and Ruiz-Roso 1992). These results are in agreement with those reported by Echarte *et al.*, (2001); Saguy and Dana (2003); Rosa *et al.*, (2007); Türkkan *et al.*, (2008); Devi and Sarojnalinech (2012).

Table (4): Effect of different cooking methods on gross chemical composition (g/100g) of polluted grey Mullet (*Mugil cephalus*) fish.

Cooking methods	Raw	Frying	Roasting	Grilling
Moisture	75.10±0.88a	63.98±0.33c	66.99±0.34b	68.06±0.84b
Protein	75.01±0.50b	75.29±0.79b	80.50±0.53a	81.17±0.30a
Ether extract	15.04±0.16b	15.70±0.20a	11.02±0.09c	11.05±0.50c
Ash	7.78±0.05a	5.74±0.29b	5.77±0.09b	5.72±0.04b
Total Carbohydrates	2.17±0.39a	3.27±0.68a	2.71±0.611a	2.06±0.43a

- Total carbohydrates are calculated by differences
- Values are mean standard \pm deviation (M \pm SD) of three successful trails
- In a row, means followed by the same letters are not significantly different at 5% level

Also, ash content in raw fish fillet is significantly ($P \geq 0.05$) decreased due to cooking process. There are no significant ($P \geq 0.05$) differences among ash contents of fried, grilled and roasted fish fillet. The depression in ash content could be due to some minerals diffusion from fish tissues (El Shehawey *et al.*, 2012). These results are in agreement with those reported by (Kocatepe *et al.*, 2011) and contradictory with Hassanin (2008) and Weber *et al.*, (2008). While Alipour *et al.*, (2010) stated that the increase of ash content after cooking process was not statistically significant. It is interesting to note that no significant ($P \geq 0.05$) effect on the carbohydrates contents due to cooking process.

Effect of cooking methods on minerals content of fish

The results obtained from Table (5) show a decrement in Ca and P content in raw fish fillet due to cooking process. This decrement is not significant ($P \geq 0.05$), in exception of frying. Where the concentration of Ca and P are significantly ($P \geq 0.05$) decreased to reach 64.66mg/100g and 267.48mg/100g, respectively. These results are in agreement with Musaiger and D'Souza (2008).

Table (5): Effect of different cooking methods on metals content of grey Mullet (*Mugil cephalus*) fish.

Cooking method	Raw	Frying	Roasting	Grilling
Calcium (mg/100g)	86.21±3.17a	64.66±2.08b	84.39±1.52a	86.21±1.20a
Phosphorus (mg/100g)	307.01±2.02a	267.48±4.33b	296.79±1.85a	315.19±2.33a
Cadmium (mg/kg)	0.32±0.004a	0.22±0.002b	0.26±0.004b	0.28±0.008ab
Lead (mg/kg)	5.01±0.050a	3.68±0.040b	3.71±0.090b	3.96±0.290b

- Values are mean standard \pm deviation (M \pm SD) of three successful trails

- In a row, means having the same letters are not significantly different at 5% level

5.15±0.04b

As for Cd concentration in the fish fillet, it is significantly ($P \geq 0.05$) decreased from 0.32mg/kg in control to 0.26 and 0.28mg/kg in roasting and grilling. While the decrement of Pb content markedly noticed after frying compared with the raw fillets.

The reduction in metals concentrations as affected by cooking methods may be due to the release of these metals with the loss of drip as free salts, possibly in association with soluble amino acids and un-coagulated proteins bounded with metals (Atta *et al.*, 1997; Ersoy *et al.*, 2006; Ganbi, 2010).

Metals under study in the edible parts of the investigated fish are in comparable with permissible levels for human use. Fish preparation (trimming, eviscerating, beheading, filleting and washing) with cooking procedures (frying, grilling and roasting) can modify the amount of metals ingested by fish consumers. Grilling and roasting or cooking, may reduce the levels of these metals.

Effect of roasting on the chemical characteristics of raw polluted grey Mullet fish after immersing the fish in 1.0% acetic acid for 1 min:

Moisture content reduces from 74.99% in raw fish fillet to 67.09% in fish treated with acid followed by cooking. This reduction may be related to cooking heat. Protein content increased because of loss in moisture. Ether extract is reduced from 14.50% in raw fish fillet to 10.54% due to treatment process. Ash decreased significantly from 7.51% to 5.20% after this treatment. This may be explained by significant loss in these compounds within fish drip during the processing. There are no significant differences between carbohydrate in raw and acid treated fish following by roasting.

Fig. (2,3) revealed that significant decrease in heavy metals and minerals except phosphorus. This reduction may be related to their loss in fish drip due to acid treatment.

In conclusion, immersing of raw grey Mullet fish in 1.0% (w/v) acetic acid for 1 min as well 3.0% acetic acid for one min could be satisfactory method to reduce heavy metals content for polluted semi-fatty fish types. But the best is using 1.0% acetic acid for 1 min to reduce pollutant metals such as Cd and Pb content of fish body burden with minimum fish fillet deterioration either in the sensory characteristics and gross chemical composition. Moreover, appropriate organic acid with the optimal concentration followed roasting could improve the quality and safety of fish.

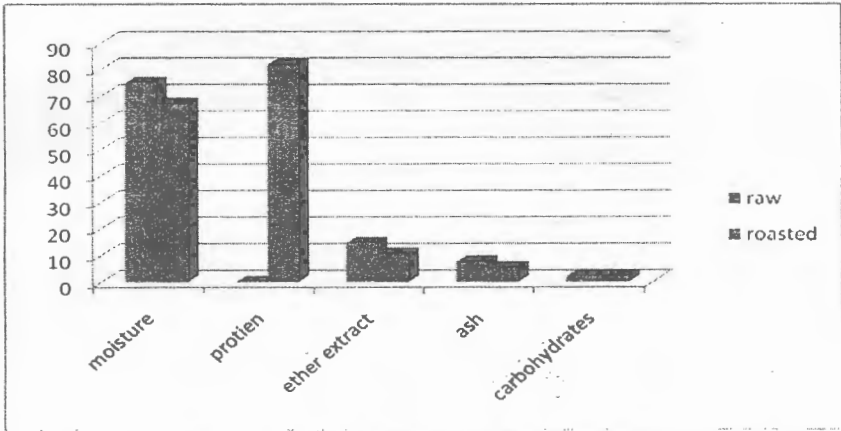


Fig. (1): Effect of roasting after immersing the fish in 1% acetic acid for 1 min on gross chemical composition (g/100g) of farmed grey Mullet fish.

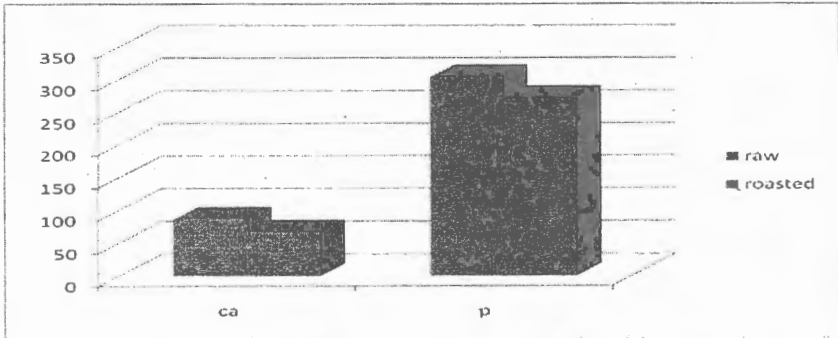


Fig. (2): Effect of roasting after immersing the fish in 1% acetic acid for 1 min on mineral content (mg/100 g) of farmed grey Mullet fish.

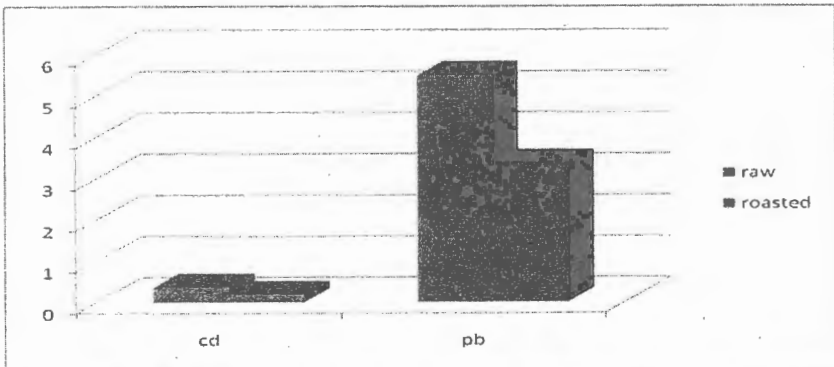


Fig. (3): Effect of roasting after immersing the fish in 1% acetic acid for 1 min on heavy metals concentration (mg/kg) of farmed grey Mullet fish

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تأثير المعاملة بحمض الخليك وطرق الطبخ علي التركيب الكيماوي والمحتوي المعدني لسماك البوري

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أجريت هذه الدراسة بهدف معرفة تأثير المعاملة بحمض الخليك وطرق الطبخ علي التركيب الكيماوي والمحتوي المعدني لسماك البوري الملوّث. تم الحصول علي السمك الملوّث من مزرعة اهلية بمركز الحامول بمحافظة كفر الشيخ والتي تستخدم مياه الصرف الزراعي الملوّث بالمعادن الثقيلة. تم نقع السمك في تركيزات مختلفة من حمض الخليك وهي 1%، 3%، 5% وذلك لفترات مختلفة (1 دقيقة، 3 دقيقة) وذلك قبل طرق الطبخ. وأوضحت النتائج ان النقع بحمض الخليك قبل الطبخ أدى الي تقليل محتوى السمك من المعادن حيث بزيادة تركيز الحامض وزيادة مدة النقع أدى الي زيادة نسبة الخفض في المحتوى المعدني . اما بالنسبة لطرق الطبخ ادت الي خفض نسبة الرطوبة وزيادة نسبة البروتين في لحم السمك. بالنسبة للدهون فهي انخفضت في طريقتي grilling و roasting بعكس طريقة القلي التي زادت من نسبتها. في النهاية كانت افضل المعاملات هي المعاملة بحمض الخليك بتركيز 1% لمدة دقيقة واحدة متبوعة بالطبخ بطريقة roasting.