

**Abstract**

Fish consumption has become an essential phenomenon due to the increasing appreciation of its health and the economic benefits. The current study aims to identify the pattern of fish consumption and knowledge regarding nutritive values of fish in Benghazi city. As well as, it aims to analyse the heavy metals ~~content of as~~ lead, cadmium and mercury of the top five most consumed fish's species in Benghazi. A cross-sectional study carried out 29<sup>th</sup> December 2022 and extended to 30<sup>th</sup> June 2023. A total of 300 Subjects randomly approached to participate in the study giving a response rate of 85.5 %. Fresh fish's samples were collected from Bankina and analysed ~~in term of the mentioned~~ heavy metals using Atomic Absorption Spectrophotometer. Sparus aurata, Pegellus bogaraveo, Sardina pilchardus, Mullus barbatus and Epinephelus marginatus are the most preferred consumed fishes in Benghazi. Age, female gender and number of family members are the variables that ~~were investigated for the association associated~~ with fish consumption pattern in Benghazi. Lead, cadmium and mercury are the analysed heavy metals in the top five most consumed fishes in Benghazi. All heavy metals results are within the recommended level by (WHO). The results of the current study recommend that increasing fish consumption habit should be considered as an ~~a case of~~ essential fact for having healthier generations. Furthermore, fish consumption should be increased via giving information by educational institutions, government agencies and non-governmental organizations.

**Keywords:** Benghazi, Consumption, Pattern, Fish, Heavy Metals

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**Introduction**

Fishes are approximately 34,000 species of vertebrate animals found in the fresh and salt water globally. Fishes species range from the primitive jawless hagfishes and lampreys through the cartilaginous skates, sharks, rays to the ample and varied bony fishes. Most fish species are cold-blooded; however, the opah (*Lampris guttatus*), is warm-blooded. Pollution of water streams may affect aquatic animals like fishes directly or indirectly. <sup>(1, 2)</sup> Metals are a group of elements with atomic weights ranging from 63.549 to 200,590 Dalton. Metals are characterized by a similar electronic distribution in the outer shell, such as copper, cadmium, and zinc. Metals can be divided into two groups: transition metals and metal-like elements. The transition metals include manganese, iron, copper, and cobalt. This group is essential for metabolism at low concentration levels. However, they can become toxic at higher concentrations. The metal-like elements include arsenic, cadmium, lead, mercury,

selenium, and tin. This group is not important for metabolic function. This group ~~also becomes are~~ toxic at low concentration levels. <sup>(3)</sup> The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic ~~or poisonous~~ at low concentrations. Heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb). Heavy metals cannot be destroyed or degraded. They enter the humans' bodies via food, drinking water and air. ~~As trace elements, some heavy metals such as copper, selenium, and zinc are essential to maintain the human body metabolism. However, at higher concentrations they can lead to poisoning.~~  
**Repeated** The presence of heavy metals in foods is a ~~timely threatening~~ issue as it ~~contaminates, involving contamination of~~ the food chain and harm ~~to the~~ public health. <sup>(3)</sup> There is a wide range of foods contaminated by heavy metals. In particular, fish is one of the products most

affected by heavy metal contamination, because heavy metals are bioaccumulative in the food chain. When heavy metals accumulate in waters, fish ingest them through their diet and accumulate them over the course of their lives.<sup>(9)</sup> The influence of heavy metals from fishes varies between different species and different metals. Fishes accumulate heavy metals to a concentration many times higher than present in water stream. Environmental circumstances such as water hardness, salinity, and pH can play a significant role in heavy metals accumulation in the fish's bodies.<sup>(10, 11)</sup> Aquaculture is a recent activity in the Libya beginning with the culture of a variety freshwater fish species during the 1970s. Success, however, was not forthcoming as a result of a lack of acceptance of farmed fish products by domestic consumers. The culture of marine fish species followed a decade later encouraged through several Government initiatives. In terms of human resources, no historical data is available. The main marine species cultured on a commercial basis in the Libya are gilthead seabream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), and Atlantic bluefin tuna (*Thunnus thynnus thynnus*), common carp (*Cyprinus carpio*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idellus*) and catfish. Nile tilapia (*Oreochromis niloticus*) and red tilapia (Tilapia species.) are the most important freshwater cultured fish. Libya does not have any endemic freshwater species and all freshwater species were introduced in the 1970s and 1990s.<sup>(12, 13)</sup> Many studies have been conducted in different regions in the world to evaluate fish consumption patterns and the parameters affecting it. It was reported that the parameters determining the fish consumption including income level; education level; social status; parents influencing in the pattern of fish consumption within the family; religion

and awareness of the nutritional value of fish. Benghazi is the second biggest city in Libya. However, to the best of our knowledge; there are almost no previous studies on the consumption trend of fish in Benghazi city. According to Food and Agriculture organization (FAO); Libya Gross domestic product (GDP) from fisheries is 0.13 %, while Agricultural GDP from fisheries is 2.69%. Furthermore, fish available for consumption is 14.9 kg/capita. During 2019, imports of fish and fish products ~~makes-account for~~ USD 236 983 550 of Libyan Economy.<sup>(12-15)</sup> Fish is an important food ~~material~~ because of its high protein, vitamins, and minerals, as well as an important source of omega-3 fatty acids. ~~Consuming fishes have protective role against an-activity-against~~ cancer, and heart diseases. Heavy metal toxicity as a result of fish consumption can result in ~~damage-or-reduced deterioration~~ of mental and central nervous system function, lower energy levels, and damage to blood composition, lungs, kidneys, bones, liver and other vital organs. Long term exposure may result in Alzheimer's disease, Parkinson's disease, muscular dystrophy, multiple sclerosis, allergies, and cancer.<sup>(16, 17)</sup> ~~The-presence-of Involving~~ fish in the diet is very important because it is a source of proteins, vitamins, minerals and unsaturated essential fatty acids, especially omega-3 fatty acids.<sup>(18, 19)</sup> Several factors determine the dietary habits of the people in the Arab world. Food consumption pattern has dramatically changed in some Arab countries as a result of sudden increase in income from oil revenue. It is believed that food subsidy policy has adversely affected the food habits in the Arab states by encouraging the intake of fat, sugar, rice, wheat flour and meat. Socio-cultural factors such as changing life style, food preference, education and women's' employment all have a noticeable influence on food consumption patterns in this region. Comprehensive studies on social, cultural and economic factors associated with food

consumption patterns in the Arab region are highly recommended. Libya is important part of the African agric-food system. Fish provides 19% of animal protein intake to Africans. The fish consumption pattern in North Africa is 13.5 kg/person / year. Africa lags behind other regions in developing its share in global fish production, consumption, and trade and Libya is no exception. Currently, however, Africans are in the paradoxical position of being highly dependent on fish for animal protein but ranking low in per capita fish consumption. Globally, Africans are second only to Asians in terms of relying on fish as a major share of the total animal protein intake in their diet. Fish represent over 20% of animal protein intake in twenty African countries. No data are available about fish consumption pattern in Libya. To the best of our knowledge, this is the first study regarding fish consumption pattern in Libya. <sup>(12, 20-22)</sup>

Several techniques have been used for determination of metal concentrations in fish species such as flame atomic absorption spectrometry, graphite furnace atomic absorption spectrometer, electrothermal atomic absorption spectrometry, inductive coupled plasma and mass spectrometry. Different digestion methods were used as sample preparation methods for determination of heavy metals in fish samples. <sup>(23- 27 )</sup> In 2017, a study was carried out in Sabratha coastal sediments, Mediterranean Sea, Libya to detect distribution and enrichment of heavy metals. 30 sediment samples were collected for Fe, Cu, Pb, Mn, Cd, Co, Ni and Zn analysis using Atomic Absorption Spectrometry. The analysis indicated that, the Sabratha's coastal sediments were enriched with Cd, Pb, Cu, Ni, Co and Zn (EF = 81.48, 17.26, 12.80, 11.42, 9.85 and 8.56 respectively). The highest levels of Mn, Cu, Ni, Pb and Co were recorded nearby the Mellitah complex oil and gas station in the western Libyan region, while the highest levels of Zn and Cd were recorded at the central

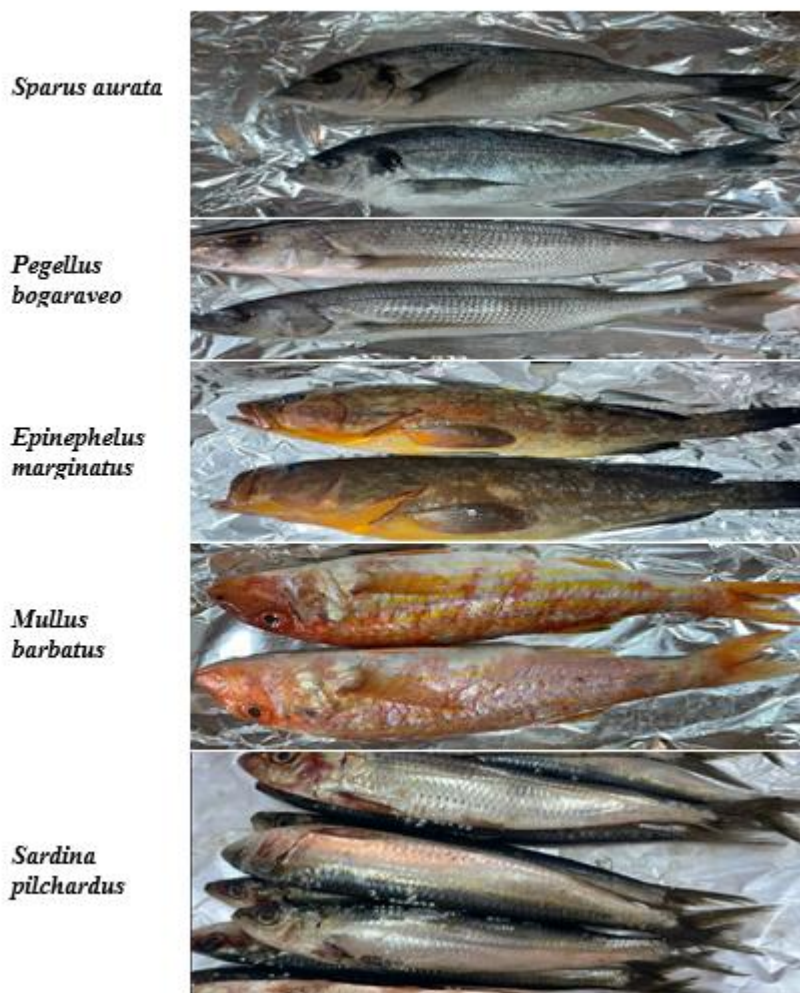
part of the study area nearby fishing port and Sabratha hospital. <sup>(25)</sup> Average values of Cd, Pb and Co were mostly higher than the ones recorded from the Arabian and Oman gulfs, the Red Sea, the Gulf of Aqaba, the Caspian Sea, coast of Tanzania and the background shale and the earth's crust. The high levels of most of the studied heavy metals suggested significant anthropogenic sources along Sabratha coast. <sup>(28)</sup> In 2010, Libyan study determined the concentrations of Co, Cd, Pb, Fe and Cu in different tissues (bone, skin, flesh and tail) of fish species of the Mediterranean Sea (Libyan coastline) using flame atomic absorption spectrometry. The fish Species used in this study were *Sardinella aurita*, *Pagellus erythrinus*, *Balistes capriscus*, *Trachurus trachurus*, *Synodus saurus* and *Dactylopterus volitans*. The concentration of Co was ranged from 0.570 mg/kg to 44.693 mg/kg. These concentrations of Co in all examined tissues were more than the World Health Organization (WHO) recommended level. The results of analysis indicated that the concentrations of the Cd in all examined tissues varied from 0.328 mg/kg to 2.929 mg/kg. These values were greater than the WHO recommended level. The concentration level of Pb in all examined tissues ranged from 0.246 mg/kg to 2.386 mg/kg. These values were higher than the accepted values by WHO. <sup>(29)</sup> During 2008, Another Libyan Study was published. This study aimed to investigate the relationship between concentration of some heavy metals (Lead, Cadmium, Mercury, Copper and Zinc) in water and their bioaccumulation in liver and muscle tissues of some marine fish species at El Khoms area, Libya. ~~The present work-~~ **This work** revealed marked increase of heavy metals concentration in muscles and liver tissues of investigated fish and such increases were positively correlated with a corresponding increase in heavy metals concentration in water. <sup>(30)</sup> The concentration of heavy metals in two tropical fish species from Ogba river ,

Nigeria showed varying concentration of Cu, Mn, Zn, Pb, Cr, Ni and Cd in fish tissues. Concentrations of Cu, Mn, Cr and Ni in both fish were higher than the permissible reported by WHO while those of Zn, and Pb were lower than permissible concentrations.<sup>(31)</sup> Limited literatures are found regarding fish consumption pattern in Benghazi as well as heavy metals contents of Benghazi fishes. The current study aims to evaluate the heavy metals contents in the most commonly consumed fishes in Benghazi. ~~Also it addresses the topic—The current study seeks to study methods~~ of fish's meals preparation, knowledge regarding nutritive value of fishes, the association between socio-economic variables and current fish consumption pattern in Benghazi.

### Methodology

This is a cross-sectional study carried out from 29<sup>th</sup> December 2022 and extended to 30<sup>th</sup> June 2023. A total of 300 Subjects (Male and female) randomly approached to participate in the study. The study respondents were people aged 18 years and above, who were fishers, selling, and purchasing fishes from fish local market (Bankina) in Benghazi city giving a response rate of 85.5 %. The sample size was determined by using Richard Jaeger equation. Informed consent was obtained from the subjects who were also assured of the confidentiality of the information collected. The research was approved by the administration of Faculty of Public Health, University of Benghazi. The questionnaire consists of four sections: socioeconomic information, fish's consumption pattern, information regarding Nutritive value and fish cooking methods. Questionnaire was developed by deep reading in similar previous studies. The questionnaire validity was assessed

via pilot study on thirty participants. After determination of all consumed types of fishes in Benghazi, the top five consumed fishes were nominated to analyse for heavy metals content. These fishes include *Sparus aurata*, *Pegellus bogaraveo*, *Sardina pilchardus*, *Mullus barbatus*, and *Epinephelus marginatus*. Three fresh samples were collected from each fish type from the Bankina. Physical inspection was done for all samples. Fishes samples have been collected from Benghazi local fish market (Bankina). Collected samples are illustrated in Figure 2. Samples were analysed in the Food Chemistry Laboratory, Department of Nutrition, Faculty of Public Health, University of Benghazi. **Reagents:** Water: redistilled or deionised, Nitric acid A.R 0.1 M – diluted 7 ml concentrated acid to 1 litre, Nitric acid concentrated (Sp. Grade 1.40), Standard solutions for cadmium, mercury, and lead. Working standard solutions, for flame analysis dilute standard solution with 0.1 M HNO<sub>3</sub> to range of standards that covers the concentration of the elements to be determined.<sup>(32)</sup> The researchers weight accurately 1 gm of each fish type assigned to be analysed. 10 ml of concentrated nitric acid has been added. The dish content is heated with soft flame using Bunsen burner until all the volatile or readily combustible matter has been removed. Then, the sample is leaved to cool. 5 ml of hydrogen peroxide is added and heated for five minutes. The solution is transferred to volumetric flask to volume with water. All the previous steps of sample preparation are repeated with blank. Identical procedures are followed even in heat and time. Samples preparation is illustrated in figure (2).



**Figure (1) Samples of analysed Fishes species**

**Determination**

Set the instrument as per the previously established optimum conditions as per the guide lines given in the Instruction Manual

(provided along with the instrument). Determine absorbance of sample solution(s) and blank. Calculate the heavy metal content from standard curve.

**Preparation of Standard Curve:**

Read the absorbance of a series of standard metal solutions in the Atomic Absorption Spectrophotometer after setting the instrument as per optimum conditions. Plot absorbance is done against  $\mu\text{g}$  of metal/mL solution. <sup>(32)</sup> All data will be coded prior to being entered in a computer. Description and analysis of data was done by *Statistical Package for the Social Sciences*

(SPSS) version 22. Level of significance was set at p value  $< 0.05$ . The researchers of the current study realize that the observational and cross-sectional design, with single measurement in one season is a limitation of the current study. Shortage in laboratory materials limit the nominated ~~analysed~~ selected samples to only five types and analysed heavy metals to only three metals

UNDER PEER REVIEW



**Figure (2) Samples Preparation**

### Results

The percentage of subjects from the age group 18-40 years is the highest percentage, (44%). The percentage of subjects from the age group 41-60 years made up (37.67) %. ~~The—m~~ Males constituted ~~made a percentage of (59.33%)~~ and the while females ~~made a percentage of (were 40.67%)~~ of the total sample of ~~number~~ 300 subjects. The general average ages of males and females mean  $\pm$ SD about  $34\pm 4.6$  as shown in table (1). Socio-economic characteristics details of the respondents were presented in table (2).

The marital status shows that, (50.33%) are married and (49, 67%) are not married. Regarding education level of the subjects; the percentage of subjects with a basic education was (6%), and the percentage of people with a secondary education was (18%), while the highest percentage of subjects with a university level (72.33%). Regarding occupation; (5.33%) of the subjects were student, the house wife, employee, freelance made (40.33%) and (36%), and (3.3%) respectively of the total sample. The percentage of subjects whose

income was less than 500 Libyan Diner (LD) was about (3.67%), the percentage of subjects whose average income was between 500-1000 LD was (42.33 %) which is the highest percentage of earned income. The subjects whose average income was 1000-1500 LD were

(23.33%). The percentage of subjects whose income was more than 1500 LD was about (30.67%). Families with less than five members made (40%), while families with more than five members made (60 %) of the total sample.

**Table (1) Subject characteristics**

Age (Years)		Total		Total
		Male	Female	
<b>20-40</b>	<b>No. (%)</b>	82(27.33)	50(16.67)	132(44)
<b>41-60</b>	<b>No. (%)</b>	78(26)	35(11.67)	113(37.67)
<b>61-80</b>	<b>No. (%)</b>	18(6)	37(12.33)	55(18.33)
<b>Total</b>	<b>No. (%)</b>	178(59.33)	122(40.67)	<b>300(100)</b>
<b>Age (Years)Mean ± SD</b>		35±3	33±6.2	34±4.6

**Table (2): Socioeconomic Characteristics of the Subjects**

Socioeconomic Characteristics	No.	%
<b>Marital status</b>		
<b>Married</b>	151	50.33
<b>Not Married</b>	149	49.67
<b>Education Level</b>		
<b>Basic</b>	18	6
<b>Secondary</b>	54	18
<b>University</b>	217	72.33
<b>Higher Education</b>	11	3.67
<b>Occupation</b>		
<b>Student</b>	16	5.33
<b>House wife</b>	121	40.33
<b>Employee</b>	108	36
<b>Freelance</b>	10	3.3
<b>Retired</b>	45	15
<b>Income level</b>		
<b>&lt;500</b>	11	3.67
<b>500-1000</b>	127	42.33
<b>1000-1500</b>	70	23.33
<b>&gt;1500</b>	92	30.67
<b>Family members</b>		
<b>&lt;5</b>	120	40
<b>≥5</b>	180	60

### Fish Consumption Pattern

The percentage of subjects who consume fish is (88%). The reasons for not eating fishes varied between tastes and smell (33.33%) bone (30.56%). Subjects who consume fish from once to twice a weekly make about (42.33%). It is the highest percentage. (8.67%) of subjects consumes fish three to four times a week. (33%) of subjects who do not eat fish on weekly

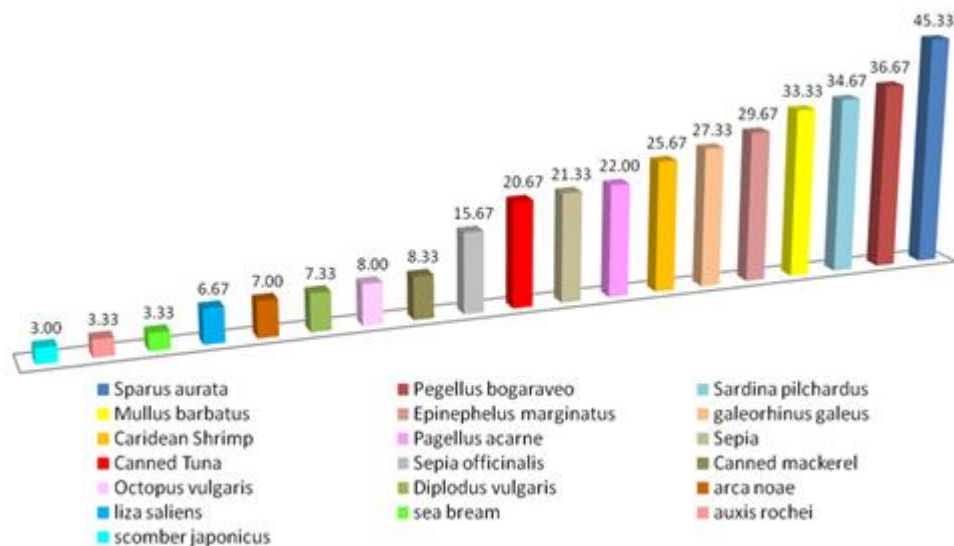
bases—basis. (42.67%) of the subjects consume once to twice a month which is the highest percentage. (25.33%) of the subjects consume fish three to four times a month. Furthermore, subjects who consumed fresh fish made (72%) of the total sample; which is the highest percentage. (7.3%) of subjects preferred canned fish. frozen fish , salted fish and

smoked fish were preferred by (10%), (6.7%) and (4%) of the subjects respectively. Figure (3) shows the frequency of the most consumed fishes in Benghazi. The top five consumed fishes were *Sparus aurata* (45.33%), *Pegellus*

*bogaraveo* (36.67%) *Sardine pilchardus* (34.67%), *Mullus barbatus* (33.33%), and *Epinephelus marginatus* (29.67%).

**Table (3): Fish Consumption Pattern**

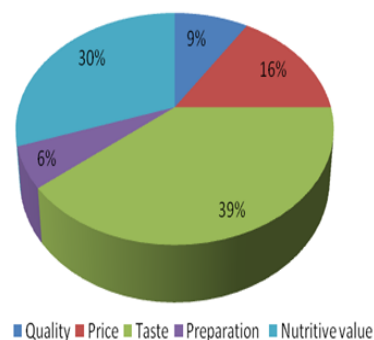
<b>Socioeconomic Characteristics</b>	<b>No.</b>	<b>%</b>
<b>Fish Consumption</b>		
Yes	264	88
No	36	12
<b>Reasons for Not eating fishes</b>		
Taste and Smell	12	33.33
bones	11	30.56
Taste, Smell and Bones	13	36.11
<b>Weekly fish consumption</b>		
No	99	33
1-2	127	42.33
3-4	26	8.67
5-6	4	1.33
≥ 7	8	2.67
<b>Monthly fish consumption</b>		
No	20	6.67
1-2	128	42.67
3-4	76	25.33
5-6	26	8.67
≥ 7	14	4.67
<b>Types of preferred Fishes</b>		
Fresh	216	72
Canned	22	22
Frozen	30	30
Salted	20	20
Smoked	12	12



**Figure (3): Frequency of Different fishes Consumption in Benghazi**

Figure (4) present reasons for selected the preferred fishes. The fish quality was (9%); it is the lowest percentage. The price of the fish (16%), the taste was (39%); it is the highest percentage, the nutritive value was (30%). Figure (5) shown the sources of consumed fishes. The highest percentage comes from local market "Bankina" with (46%). Supermarket, fish restaurants, fishers, and fishing make (24%), (11%), (12%) and (7%) respectively. Figure (6) shows the reasons of selecting fish's sources. The highest percentage (51%) was for available fishes types, (30%) for place close to home and (19 %) for price. Figure (7) presents factors affecting fish selection. The highest percentage was for there is no special reason (44.3%), (14.7%) for gills color, and (12%) for eyes status. The lowest percentages were (10.3%), (10%), and (8.7%) for tenderness, smell, and color

respectively. Figure (8) shows the most preferred cooking methods of fishes in Benghazi. Grilling on charcoal is the preferred preparation method of fish in Benghazi with (35.2%). (20.9%) of the subjects prefer eating fried fish. Libyan traditional Tagin and oven roasting are coming after that with percentage of (12.36%) and (11.11%) respectively.



**Figure (4): Reasons for selected the preferred fishes**

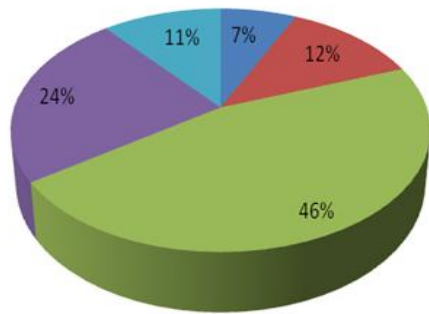


Figure (5): Sources of Consumed Fishes

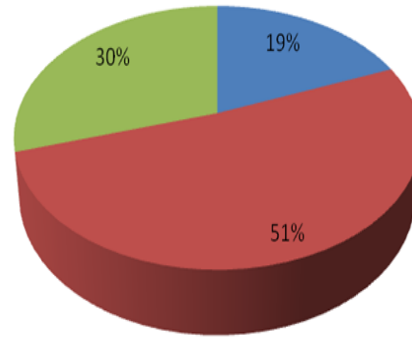


Figure (6): Reasons of Selecting Fishes Sources

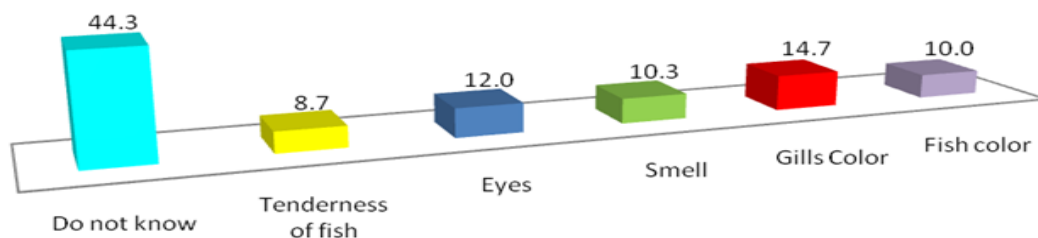


Figure (7): Factors affecting fish Selection

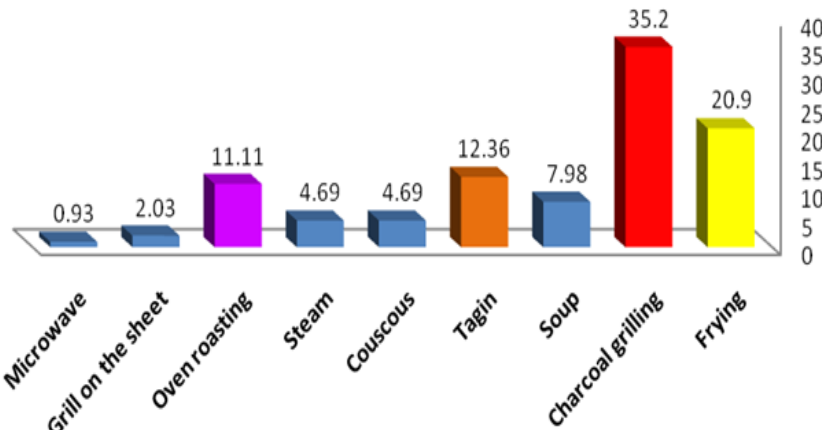


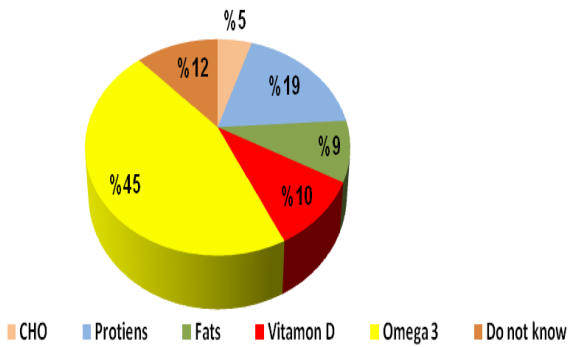
Figure (8): Fish Preferring Cooking Methods

Figure (9) shows the subjects' knowledge regarding the nutritive value of fish. The highest percentage of the subjects (45%) know that fish are good sources of omega 3. Only (19%) of the subjects know that fish are good sources of protein. Furthermore, only (9%) of the subjects know that fish are good sources of healthy types of fats. (10%) and (5%) of the subjects know that fish are good sources of vitamin D and carbohydrate respectively.

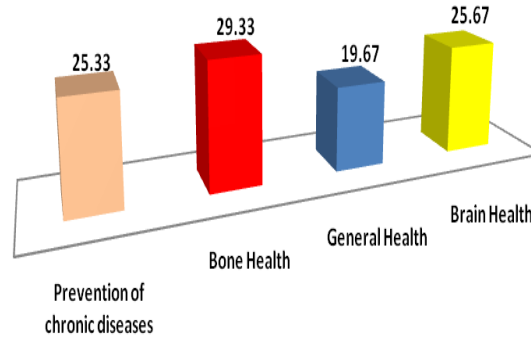
(12%) of the subjects state that they do not have any information regarding the nutritive value of the fish. Figure (10) shows the subjects' knowledge regarding adult health benefits of fish. (29.33%) of the subjects know that fish is **important significant** for bone health. Prevention of chronic diseases and brain health as benefits of fish has response by the subjects (25.33%) and (25.67%) respectively. Only (19.67%) of the

subjects think that fish are important for general health. Figure (11) shows the sources of information regarding fish. The internet was the biggest source of information with a percentage of (42%).

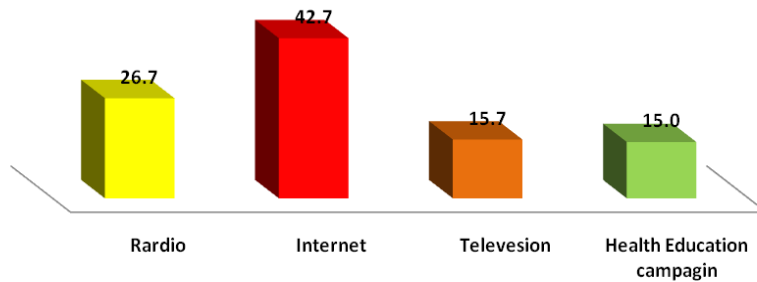
The radio was the second source of information with a percentage of (26.7%). Television, and health education programs have similar effects with percentage of (15.7%) and (15%) respectively.



**Figure (9): Subjects Knowledge regarding adult health benefits of fish**



**Figure (10): Subjects Knowledge Nutritive value of fish**



**Figure (11): Sources of Information regarding Fish**

In Sparus aurata and Epinephelus marginatus lead is higher in muscles than guts and grills respectively. In Pegellus bogaraveo, Sardina pilchardus and Mullus barbatus lead is higher in guts than muscles and grills. Regarding, cadmium is higher in gills than muscles and guts in all samples of the five fishes. Looking at

mercury, all sample provide < 0.01 ppm except in Epinephelus marginatus. Epinephelus marginatus contains 0.03 ppm of mercury in guts, which is the highest comparing to gills and muscles. Muscles and gills of Epinephelus marginatus contain 0.027 and 0.016 ppm of mercury respectively as illustrated in table (4) .

**Table (4): Heavy metals Contents in the most consumed fishes in Bnghazi**

Fishes Samples	Gills			Guts			Muscles		
	Pb	Cd	Hg	Pb	Cd	Hg	Pb	Cd	Hg
Sparus aurata	0.010	0.012	<0.01	0.015	<0.005	<0.01	0.018	<0.005	<0.01
Pegellus bogaraveo	0.014	0.010	<0.01	0.024	<0.005	0.013	0.020	<0.005	0.011
Sardina pilchardus	<0.005	0.007	<0.01	0.008	<0.005	<0.01	<0.005	<0.005	<0.01
Mullus barbatus	0.008	0.017	<0.01	0.011	0.006	<0.01	0.010	<0.005	<0.01
Epinephelus marginatus	0.019	0.025	0.016	0.027	0.009	0.030	0.032	0.006	0.027

The results of Logit model are shown in Table (5). The age variable has been found significant at 5% level statistically. As the age increases a unit, fish consumption amount probability increases 1.643. In this

study, females consume more fish in 0.489 rates more than males. Also, of family members increase; the probability of consumers' consumption increases at 1.40.

**Table (5): Association of Socioeconomic Variables with Fish Consumption**

Variables	B (Coefficient of explanatory variables)	Standard Error	Z-statistics	Severity Rating	Betting odds
Age	0.497	0.193	2.568	0.010	1.643
Gender	- 0.715	0.357	-2.003	0.045	0.489
family members	0.337	0.139	2.425	0.015	1.401

### Discussion

Worldwide, fish consumption and marketing has become an essential phenomenon due to the increasing appreciation of its health and the economic benefits. Given this, the current study sought to identify the pattern of fish consumption and knowledge regarding nutritive values of fish in Benghazi city. Consequently, The top five most consumed fish's species in Benghazi have been analyzed in term of heavy metals content of lead, cadmium and mercury. Data obtained have been analyzed using the Statistical Package for Social Sciences (SPSS). *Sparus aurata*, *Pegellus bogaraveo*, *Sardina pilchardus*, *Mullus barbatus* and *Epinephelus marginatus* are the most preferred consumed fishes in Benghazi. <sup>(1, 17)</sup> Fish consumption preferences are affected by individuals' socioeconomic characteristics. The percentage of subjects from the age group from 20-40 years is the highest percentage and they constituted about (44%). It is followed by subjects from the age group 41-60 years made up (37.67) %. The mean ages of male's  $\pm$ SD about  $35\pm 3$  and the mean  $\pm$ SD for females was about  $33\pm 6.2$ . The general average ages of males and females mean  $\pm$ SD about  $34\pm 4.6$ . This mean is almost close to the mean age of a similar study 31 years done by Rhoda Foil's 2020. <sup>(33)</sup> In Tripoli similar study, the age category (36-45) was the highest age (34%) among the study sample. The age variable has been found significant at

5% level statistically. <sup>(34)</sup> The coefficient of age variable took positive value. When the age increases a unit, fish consumption amount probability increases 1.643. This result is similar to previous studies by Ahmad NI 2016 and Burger J 2002. <sup>(35, 36)</sup>

~~The m~~Males constituted made a percentage of (59.33%) and the while females made a percentage of (were 40.67%) of the total sample of number 300 subjects. This result is opposite to Tripoli study of fish consumption pattern. In Tripoli, it was that nearly 60% of respondents were females while 40% were males. The coefficient of gender variable takes negative value. ~~In this case, it has been determined~~ denoting that females consume fish more than males. Females consume more fish in 0.489 rates more than males. The findings of this study are similar to Turkish study that was carried out during 2013. <sup>(34, 37)</sup> The marital status shows that (50.33%) are married. In the current study as well as in previous studies statistical tests did not show significant difference relating to the fish consumption and marital status of respondents. <sup>(34)</sup> Regarding education level of the subjects; the percentage of subjects with a basic education was (6%), and the percentage of people with a secondary education was (18%), while the highest percentage of subjects with a university level (72.33%). Comparing to literature, most of the respondents (36%) indicated that the terminal educational level was Junior High

School, while a minority (8%) indicated that primary as their last level of education. Only 8% of the respondents reported ~~not~~ having ~~a~~ no formal education. Statistical tests did not show a significant difference relating to the fish consumption and the level of education. <sup>(34, 37)</sup> Regarding occupation; (5.33%) of the subjects were student, the house wife, employee, freelance made (40.33%) and (36%), and (3.3%) respectively of the total sample. In previous study, 17.4% of them are civil servants, 20.3% are workers, 23.2% are homemakers, 19.2% are other, 10.7% are self-employed, and 9.2% are unemployed. ~~There is no Statistical tests did not show a significant relation between difference relating to the~~ fish consumption and the occupation. <sup>(33-37)</sup> The percentage of subjects whose income was less than 500 Libyan Diner (LD) is about (3.67%), the percentage of subjects whose average income between 500-1000 is (42.33 %) which is the highest percentage of earned income. When considering exchange rate, the results of this study is similar to Turkish study. <sup>(37)</sup> Families with less than five members make (40%), while families with more than five members make (60 %) of the total sample. In this study, the variable of the individual number in the family takes positive value. A unit increases in the number of family members; increases the probability of consumers' consumption at 1.401. This result is similar to results by previous study done by E. Onurlubas during 2013. <sup>(37)</sup> The current study reveals that the percentage of subjects who consume fish was (88%), while ~~Accordingly~~, (12%) of the subjects do not consume fish. The consumption rate in Benghazi is higher than previous African rate in sub-Saharan where the majority of the respondents (72%) consumed fishes while (28%) indicated that they do not consume fishes. The consumption rate in Benghazi is lower than in Tripoli. Tripoli results showed that 98% of the respondents consume fish. <sup>(33, 34)</sup> The reasons for not eating fishes in the

current study vary between tastes and smell (33.33%) and bone content (30.56%). In previous study, ~~not consuming fish is attributed to either dislike of fish (16.7% ) or that fish are very expensive to them 16.7% .-subjects do not like fish and very expensive were the main reasons for non-consumption of fish with a percentage of 16.7% and 16.7%, respectively.~~ It is noteworthy that 44.4% of the respondents did not give a reason for not consuming fish. <sup>(34)</sup> Subjects who consume fish from once to twice a weekly make about (42.33%) of the total sample. It is the highest percentage (8.67%) of subjects consumes fish three to four times a week. (33%) of subjects who do not eat fish on weekly bases. Regarding monthly fish consumption; (6.67%) of the subjects don't consume, (42.67%) of the subjects consume once to twice a month which is the highest percentage. (25.33%) of the subjects consume fish three to four times a month. Tripoli study results show that the largest percentage of respondents 66% consume fresh fish one to two times per month, 27% consume fish once to twice a week and 5% of respondents consume fresh fish daily. Furthermore, subjects who consumed fresh fish made (72%) of the total sample; which is the highest percentage. (7.3%) of subjects preferred canned fish. frozen fish , salted fish and for smoked fish were preferred (10%), (6.7%) and (4%) respectively. In previous study, the categories of fish consumed are in descending order include fresh, canned, frozen and salted and smoked with percentages of 96.7, 94.7, 21.8 and 0.98% respectively. <sup>(33-37)</sup> Nine teen fish types are consumed in Benghazi. The top five consumed fishes were *Sparus aurata* (45.33%), *Pegellus bogaraveo* (36.67%) *Sardine pilchardus* (34.67%), *Mullus barbatus* (33.33%), and *Epinephelus marginatus* (29.67%). In previous Libyan study ~~date~~, more than one-third of the respondents frequently buy and consume sardine, sea bream and mackerel with a percentage of 57.6, 47.0 and 37.2%,

respectively. The reasons of selection of these types include fish quality; price, taste, and nutritive value (9%) (16%) (39%), (30%) respectively. In previous study, the reasons behind respondents' choice toward a certain fish include that 61% of the respondents buy certain type of fish because of their taste while 38 % of them their choice is based on their belief that this type of fish is good for health, meanwhile, 22, 21 and 8% of the respondents buy certain kind of fish because their prices are affordable and fit to budget, high quality and easy to prepare respectively. <sup>(34)</sup> The highest percentage of consumed fish comes from local market "Bankina" with (46%). Supermarket, fishers, and fish restaurants, and fishing make (24%), (11%), (12%) and (7%) respectively. Literature showed that fish market at seaport is the most popular market for respondents (75%) to buy fish from, followed by the fish store (13.3%), directly from of fishermen (11%), fish and meat market (6%), supermarket (5%) and vehicles for selling fish (3%). <sup>(33-37)</sup> Reasons behind selection of these place are varies in the current study. The highest percentage (51%) was for available fishes types, (30%) for place close to home and (19 %) for price. In previous study, the reasons behind the chosen of certain place for buying fish by respondents are varied. The majority of the respondents (82.2%) choose a place of buying fish because of the availability of fresh fish in the chosen place followed by reasons of near my house and cheap with the percentage of 23.6% and 14.3%, respectively. <sup>(34)</sup> Grilling on charcoal is the preferred preparation method of fish in Benghazi with (35.2%). (20.9%) of the subjects prefer eating fried fish. Libyan traditional Tagine (mixed fish and different types of vegetables such as potato, zucchini, carrot, eggplant and garlic) and oven roasting are coming after that with percentage of (12.36%) and (11.11%) respectively. The most popular methods of fish cooking include frying, grilling, with soup, Tagine,

and couscous. The results from the Tripoli Study revealed that frying is the most frequent method of cooking fish (71.1%) by the respondents in this study followed by grilling (61.7%). <sup>(34)</sup> The highest percentage of the subjects (45%) knows that fish are good sources of omega 3. Only (19%) of the subjects know that fish are good sources of protein. Furthermore, only (9%) of the subjects know that fish are good sources of healthy types of fats. (10%) and (5%) of the subjects know that fish are good sources of vitamin D and carbohydrates respectively. (12%) of the subjects state that they do not have any information regarding the nutritive value of the fish. In previous study, the subjects have better knowledge than Benghazi subjects regarding fish content of omega 3. In previous study, lower percentage of the subjects (32%) of the participants in the study was able to identify omega 3 fatty acids as essential fat. <sup>(36, 37)</sup> In the current study, (29.33%) of the subjects know that fish is **significant beneficial** for bone health, **however (25.33%) stated that they know that consuming fish is important for prevention of chronic diseases and (25.67% believe its important for brain health. ).—Prevention of chronic diseases and brain health as a benefits of fish have response by the subjects (25.33%) and (25.67%) respectively.** Only (19.67%) of the subjects think that fish are important for general health. In previous study, majority of the respondents (85.6%) agreed that eating fish is good for health. Again, literature indicates that knowledge is much lower in Benghazi regarding health benefits of fish comparing to other regions. <sup>(34)</sup> The internet was the biggest source of information with a percentage of (42%). The radio was the second source of information with a percentage of (26.7%). Television, and health education programs have similar effects with percentage of (15.7%) and (15%) respectively. In previous study, the majority of the respondents (83%) chosen television as the most effective medium for getting

information about the benefits and use of fish. Whilst 12%, 4% and 1% of the respondents chosen radio, internet, and newspapers as an effective medium for obtaining information about the benefits and use of fish. Different sources of information justify the differences in knowledge level comparing to other regions. <sup>(34, 35)</sup> Lead (Pb), cadmium (Cd) and mercury (Hg) are the analysed heavy metals in the top five most consumed fishes in Benghazi in Part Per Million (PPM) in the current study using Atomic Absorption, Spectrophotometer inside the Food Chemistry and Analysis Laboratory of Department of Nutrition, Faculty of Public Health, University of Benghazi. In *Sparus aurata* and *Epinephelus marginatus* lead is higher in muscles than guts and grills respectively. In *Pegellus bogaraveo*, *Sardina pilchardus* and *Mullus*

*barbatus* lead is higher in guts than muscles and grills. All these values are higher than previous Libyan studies published by researchers from Tripoli, Alkhomse, and Sebha. However, all these levels are still within the recommended levels by WHO. Regarding, cadmium is higher in gills than muscles and guts in all samples of the five fishes. Moreover, these all results for cadmium are still within the recommended levels by WHO. Looking at mercury, all sample provide < 0.01 ppm except in *Epinephelus marginatus*. *Epinephelus marginatus* contains 0,03 ppm of mercury in guts, which is the highest comparing to gills and muscles. Muscles and gills of *Epinephelus marginatus* contain 0.027 and 0.016 ppm of mercury respectively. All these results are within the recommended level by WHO. (34, 37, 38)

## Conclusion

*Sparus aurata*, *Pegellus bogaraveo*, *Sardina pilchardus*, *Mullus barbatus* and *Epinephelus marginatus* are the most preferred consumed fishes in Benghazi. Age, female gender and number of family members are the variables that associated with fish consumption pattern in Benghazi. The current study reveals that the percentage of subjects who consume fish in Benghazi was (88%). Accordingly, (12%) of the subjects do not consume fish. Lead (Pb), cadmium (Cd) and mercury (Hg) are the analyzed heavy metals in the top five most consumed fishes in Benghazi. All these results are within the recommended level by WHO.

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