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COMPARATIVE STUDY ON THE MAJOR BIOCHEMICAL CONSTITUENTS IN THE MUSCLES OF MUGIL CEPHALUS INHABITING THE MEDITERRANEAN WATER, THE NORTHERN DELTA LAKES AND FISH FARMS OF EGYPT

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ABSTRACT

The major biochemical constituents namely lipids, proteins, water and ash contents were determined in the muscle tissues of one of the most commercial fish species in Manzalah, Borollus, and Edku lakes, Nozha Hydrodrome and Mariut fish farm in Egypt with the aim of evaluating the nutritive value of such fish species.

The present study revealed that these constituents differed significantly from one area to another according to the biological and non-biological conditions in these areas. The percentage contents of the mentioned constituents ranged from 76.18 to 77.93% for moisture, from 56.80 to 76.40% for protein. from 10.92 to 23.23% for lipids and from 12.58 to 20.61% for ash. These percentages were calculated on the dry weight basis.

In the light of the present study it is possible to classify ***Mugil cephalus*** *surviving at the Egyptian waters as fatty fish according to their muscle content of lipids which exceeds 5% in the dry condition at all the fishing areas studied.*

The lipid content of the muscles of the investigated fish species exhibited positive relationships with both the size of fish and its conditions factor. The correlation coefficient (r) between % fat content and condition factor was found to be + 0.8207.

Negative relationship was found between the ash and protein contents in the fish muscles. Another negative correlation was traced between fat and protein while positive correlation existed between the water content and both ash and fat contents in the fish muscles.

INTRODUCTION

The gray mullets are widespread estuarine and coastal fish species and important members of the fresh water communities. These originally marine fish enter the north delta lakes of Egypt as fry, through the various lake- sea connections. Their stock in the lakes is greatly affected by the changes in conditions of such connections. The mullet fry entering the lakes find it suitable habitat to survive feed and grow. When they reach sexual maturity, the fish seek their original habitat. i.e. the sea to perform spawning. It is worth mentioning that the Northern Delta lakes form a very favorable medium for the gray mullets especially ***Mugil cephalus***. The gray mullets contribute about 10% of the annual fish production of these lakes. The ***Mugil cephalus*** represents about 1.5% of such annual fish production (Alsayes and Soliman, 1993). One of the most noticeable features is that mullet are major component in the flow of energy through the ecosystem because they feed on the lowest trophic level (Odum, 1970). These fish are able to utilize either the direct grazing or plant detritus food chains as an energy source and obtain their energy directly from the first trophic level.

Various authors have carried out studies on aspects of food and feeding of certain mugilids and ***Mugil cephalus*** in particular. These authors described the mullet as vegetarian, omnivorous, planktophagous, or as devouring small crustaceans. They have been named mud-eaters by Zenkevich and Zevina (1968), illophagous by Pillay (1953), detritus feeders by Rajan, ***et al*** (1968), algal feeders by Hiatt (1944) and interface feeder by Odum (1970).

In general, mullet ingests whatever organic food of suitable size that may be common in the area in which feeding takes place (Pillay, 1953). It is evident therefore that the feeding habits of ***Mugil cephalus*** varies from area to another, according to the available or common food items in these habitats.

Various authors have also indicated that the biochemical composition of marine organisms is greatly influenced by the food available in the ambient environment. Among those authors. Buchholz and Prado – Fiedler (1987) who pointed out that the major biochemical components (protein and lipid) in the bodies of ***Megayctiphanes norvegica***. clearly correlated to the prevailing supply of food organisms.

Luhman (1953) stated that factors likes temperature, salinity and food are of equal importance on the accumulation and depletion of fat content as sexual maturity. However, it is attempted in the present study to correlate between the water content, protein, lipid and ash in the muscle tissues of ***Mugil cephalus*** surviving at various fishing areas of the Egyptian waters where different environmental factors especially salinity and food items are prevailing in these habitats.

The present study aimed to evaluate the nutritive value of the muscles of ***Mugil cephalus***, which can be considered as one of the most common tasteful and preferable fish species in Egypt. It is hoped that this information be useful for biologists, dietitians and food technologists.

Areas of Sampling:

A- Northern delta lakes:

The Northern Delta lakes from which ***Mugil cephalus*** samples were taken are Manzalah Lake, Borollus Lake, and Edku Lake.

I- Manzalah Lake:

Manzalah Lake is bordered by the Mediterranean Sea to the north, the Suez Canal to the east and Damiatta branch of the Nile to the west. The lake covers an areas of about 160.000 hectares with an average depth of about 1.20 m. Cholorosity varies according to locality and season, from 0.77 to 11.67 g I/L. (Unesco report, 1986)

The lake is connected to the Mediterranean Sea through a main opening at El-Gameel. It is also connected to the Suez Canal by several drains open into the lake. The water level of the lake is often subjected to variations, which may expose or cover extensive areas along its shores.

II- Borollus Lake:

Borollus Lake occupies a central position between Rosetta branch in the west and Damietta branch in the east. Its area amounts to about 130.000 feddans. The lakes are connected to the sea through Boughaz El-Borollus. It receives fresh water supply from Brembal canal. The water depth in the lake varies between 0.50 to 2.0 m Extensive turbulence of water reduce its transparency due to the swirling up of bottom sediments. The Cholorosity values of the lake water vary from place to another. According to Alsayes (1976), the eastern part of the lake is characterized by higher Cholorosity (6.5 to 20.9 g/l) if compared with the central part (0.7 to 6.5 g/l) and the western part which is characterized by the minimum range of Cholorosity (0.20 to 3.80 g/l)

III- Edku Lake:

Edku Lake, situated at about 30 Km to the north east of Alexandria, has an area of about 28,560,000 feddans and a water depth ranging from 0.5 to 1.5 m. The Cholorosity values give a wide range of variation, fluctuating between 0.44 and 23.24 g/l (Unesco report, 1986).

Its water supply is derived from three main drains. Drainage water causes a rise in the lake level above sea level inducing a lake–sea current. Exchange of water between the lake and sea occurs through a narrow channel, Boughaz El-Maadia.

B- Investigated fish farms:

I- Nozha Hydrodrome:

Nozha Hydrodrome, a small land – locked basin, was completely isolated by an embankment from its mother lake, Lake Mariut, in 1939. The Hydrodrome occupies an area of about 1140 feddans. Nile water reaches this lake through Mahmoudiah Canal. Its average bottom depth is 3.65 m below mean sea level, and the average water depth reaches about 3 m. Its Cholorosity ranges from 0.1 to 0.4 g/l (Unesco report, 1986).

The Hydrodrome is used as a fish farm, and yields a good Production. Stocking of this Hydrodrome with mullets is carried out annually by transplanting the mullet fry to it from the adjacent nursery grounds.

II. Mariut fish farm:

Maruit fish farm is located 30 Km west of Alexandria. The area of this farm is 5200 feddans. 3200 feddans of this area comprise 6 farms each containing 84 ponds, Tilapia and prawn hatcheries and an intensive fish farm. The other2000 feddans constitute a feed mill, fry collecting pond and marine fish-hatchery. This farm was put into operation after reducing the water salinity from 200 mg/l to 20 mg/l. Gray mullets comprise about 50% of the annual yield of this farm (Report of Mariut fish farming company – 1997).

C- Mediterranean Coast of Alexandria:

Samples of ***Mugil cephalus*** were collected from the Mediterranean Sea, Alexandria coast that extends for 40 Km between Agamy headland and Abu Qir Bey. This area is affected by domestic and industrial discharge. The water temperature ranges from 15 to 28°C the Salinity fluctuates between 37.2 to 39.8 ‰. (El-Rayis ***et al*** 1997).

MATERIAL AND METHODS

Sampling:

Seasonal samples of ***Mugil cephalus*** were collected from the commercial fish landed at lake Manzalah, Lake Borollus, Lake Edku, Nozha Hydrodrome, Mariut fish farm and Anfoushy fish center during 1996. Freshly caught fish were transported immediately into iced boxes, to the laboratory. Investigations were carried out shortly after capture. The total length of each specimen was measured to the nearest mm. The total and gutted weighed were determined to the nearest gm. The number of fish sampled, ranges and averages of lengths and weights are given in table (1). From each fish, samples were taken from the anterior part of the dorsal muscle in both sides, and weighted to the nearest 0.001 g. Samples were dried at 105°C for about 6-8 hours to a constant weight.

The moisture content was calculated according to the formula:

$$\% \text{ Moisture content} = \frac{\text{Difference in weight}}{\text{Weight of sample}} \times 100$$

The dry samples of the muscles were crushed and kept in a dissector for analysis of fat, protein and ash contents.

The amount of each biochemical component is expressed as a percentage on the dry weight basis. This avoids any error caused by variation in water content.

Table (1) : length, weight and condition factor of ***Mugil cephalus*** eaught from various fishing areas.

Fishing Area	No of Samples	Length (Cm.)				Weight (gm)				Condition Factor
		Min.	Max.	Av.	S.D.	Min.	Max.	Av.	S.D.	
Mediterranean	21	22.0	31.2	26.57	± 2.71	100	300	193.81	± 63.97	0.9981
Lake Manzalah	24	19.4	37.0	25.33	± 3.99	75	450	154.17	± 85.83	0.8713
Lake Borollus	17	22.8	30.5	25.50	± 1.91	125	300	168.23	± 45.48	0.9935
Lake Edku	13	22.0	29.5	25.15	± 2.07	110	260	166.92	± 54.94	1.0262
Nozha Hydrodrome	10	23.3	25.8	24.35	± 0.93	105	155	124.5	± 18.33	0.8550
Mruit fish farm	6	22.5	25.4	23.23	± 1.09	105	140	112.5	± 13.69	0.8933

(S.D.) : Standard deviation

Determination of crude fat:

The crude fat was determined by Soxhlet method using petroleum ether at 60-80°C for 12–16 hours. Sample residue was dried at 85°C till a constant weight was maintained. The difference is the weight of sample due to fat extraction was determined as $W_1 - W_2$ where:

W_1 = Weight of sample before fat extraction

W_2 = Weight of sample after fat extraction

Therefore

$$\% \text{ Crude fat content} = \frac{W_1 - W_2}{W_1} \times 100$$

It may be interesting to indicate here that Wassef and Shehata (1991) in their study on the biochemical composition of ***Sparus aurata*** determined the lipid content in the flesh of fish using the above mentioned procedure as well as the producer of Bligh and Dyer (1959) and its modification by Smith ***et al*** (1964) with the aim of comparing accuracy of the two procedures for lipid determinations. They concluded that both the two procedures gave similar results.

Determination of protein:

The protein content of the muscle tissues samples was determined according to the method adopted by Wrong (1923), Alexander, (1956) and Abu. El Wafa ***et al*** (1994). The estimation of protein is based on determining the total nitrogen by the use of microkjeldahl. Total crude protein can be determined according to the formula.

$$\% \text{ Crude Protein content} = \% \text{ Nitrogen} \times 6.25.$$

Determination of ash

The ash was determined by heating samples in a muffle furnace at 200°C for two hours, then the temperature was raised gradually every two hours to reach 550-600°C. The samples were left in the furnace at this temperature for 6 hours. The weight of the residue represents the ash content.

It is important to point out that all the subsequent results shown in the present investigation are the mean of at least three determinations with further repeats if necessary.

Calculation of condition factor (C.F.):

The condition factor was calculated according to the formula given by Bagenal (1978)

$$C.F. = \frac{W}{L^3} \times 100$$

Where W = total weight of fish in g.
L = total length in cm.

Statistical methods:

Mean values (X), standard deviation (S.D.), t-test (t) and correlation coefficient (r) were calculated according to Snedecor (1962); Shukla and Gulshan (1971).

RESULT AND DISCUSSION

The four major biochemical constituents of the muscle tissues of Mugil ***cephalus*** namely protein, lipid, ash & moisture contents are given in Table (2).

The percentage contents of these constituents in the fish muscles are usually affected by several factors such as type of food organisms and their availability, water salinity, fish size and stage of maturity.

Therefore it has been taken in consideration to carry out the present study on fish samples collected from fish populations surviving at the Mediterranean coast, three of the northern delta lakes as well as two fish farms. It is expected that the biotic and abiotic conditions in these different habitats may have played an important role in affecting the percentage contents of the four major constituents in the fish body.

It can be indicated from the data given in Table (2) that:

(1) The moisture content in the fish muscles ranged from 76.18% in the fish sampled from Mariut fish farm to 77.93% in the fish collected from the Mediterranean coast.

(2) The protein content in the muscle tissues of ***Mugil cephalus*** had its lowest percentage (56.80 %) in the fish sampled from the Nozha Hydrodrome. The highest protein content was found in the muscles of fish collected from Lake Manzalah with a percentage of 76.40%.

Table (2) : Percentage of the main biochemical constituents in the dry muscles of fish caught from different fishing localities in Egypt .

	Water content		Protein*		Fat*		Ash*	
	%	S.d.	%*	S.d.	%*	S.d.	%*	S.d.
Mediterranean	77.93	± 0.7264	61.92	± 1.5164	20.76	± 1.5608	17.53	± 0.7223
Lake Manzalah	76.50	± 0.9152	76.40	± 2.3676	10.92	± 2..1510	12.58	± 2.2676
Lake Borollus	76.53	± 0.2779	71.78	± 3.2608	13.77	± 2.1929	14.45	± 1.1426
Lake Edku	77.42	± 0.4483	59.93	± 1.1886	22.04	± 1.2575	18.03	± 0.6428
Nozha Hydrodrome	76.50	± 0.6936	56.80	± 1.1348	23.23	± 0.2609	20.61	± 2.0815
Mruit fish farm	76.18	± 0.8109	58.95	± 0.8109	21.93	± 0.1889	18.84	± 0.6338

(S.D.) : Standard deviation
* Calculated on dry weight basis:

To indicate the level of significance of the differences between the percentages of protein contents in fish collected from the various fishing areas, the statistical student test (t-test) was applied on the data obtained in the present investigation. The calculated (t) values are given in Table (3).

It can be observed from the calculated high values of (t) in such table that the differences between the percentages of protein content in the muscle tissues of fish are significant at high levels with the exception of one case, where the comparison was undertaken between fish collected from lake Manzalah and Maruit fish farm (t = 1.7027).

(3) The fat content had its minimum percentage of 10.92% in the muscles of fish collected from Lake Manzalah. The maximum percentage of fat content was found to be 23.23% in the fish taken from the Nozha Hydrodrome.

In their study on the caloric value and fat content in gray mullet in the Egyptian lakes. Libosvarsky ***et al*** (1971), indicated that, beside being tasteful, the gray mullet also show high nutritive (caloric) value, amounting to over 1600 K cal per Kg wet matter on the average; higher caloric value is due to the high fat content

Table (4) shows the values of (t), which have been calculated to indicate the level of significance of the differences between the percentage fat contents in the fish collected from various areas. It can be indicated from this table that these differences were significant at high levels in all the cases of comparison with the exception of the non-significant level of difference between the fat content of fish collected from the Mediterranean coast when compared with those collected from Lake Edku.

(4) The percentages content of ash in the muscle tissues of fish collected from different fishing areas had a minimum of 12.58 % in fish collected from lake Manzalah and a maximum of 20.61% in fish taken from the Nozha Hydrodrome.

(5) Various authors classified fish in two large groups, concerning fat storing. These two groups are fatty fish and lean fish. Fatty fish are those which store their fat in the muscles, while lean fishes are those which store their fat in the liver (Love ***et al*** 1975).

Table (3): (t) Value which shows the significance of differences between the Concentration of protein in the muscle tissues of ***M. Cephalus*** caught from different areas

Area of Fishing	Medit	Lake Manzalah	Lake Borollus	Lake Edku	Nozha Hyd.
Lake Manzalah	24.0270	-			
Lake Borollus	22.8040	7.2989	-		
Lake Edku	4.5000	23.4299	28.2380	-	
Nozha Hyd.	9.4580	36.2050	33.9330	6.3797	-
Mariut Fish farm	5.7420	1.7027	34.6560	2.3755	5.1830

Table (4): t -values which shows the significance of differences between the Concentrations of fat in the muscle tissues of ***M. cephalus*** caught from different areas

Area of Fishing	Medit	Lake Manzalah	Lake Borollus	Lake Edku	Nozha Hyd.
Lake Manzalah	17.3213	-			
Lake Borollus	17.8166	4.1892	-		
Lake Edku	1.5938	17.0504	32.9889	-	
Nozha Hyd.	4.9579	39.2669	44.1141	2.9584	-
Mariut Fish farm	2.1525	16.0234	11.7637	0.2000	2.8790

Stansby (1962) divided fish into different categories according to their lipid contents. The fatty fish contain more than 5% fat content in their muscles.

The present study reveals therefore that ***Mugil cephalus***, which is surviving in the water. can be classified under the category of fatty-fishes.

Percentage contents of the biochemical constituents in fish muscles in relation to its size

Various authors have discussed the relationships between the muscle tissue contents of the major biochemical constituents and the size of fish. Mikhail ***et al*** (1982) who pointed out that the fat content in the muscles of the young fish is higher than that in the adults of ***Epinephalus aeneus*** and ***Epinephalus alexandrinus.*** Moreover the water content is generally higher in the young fish than in the adults.

Bogucki and Trzesinski (1949); Krvaric and Muzinic (1950); Love (1957); Mussacchia (1959); Rao (1957); and Stirling, (1972) indicated that in various fish species, fat content possessed individual variations and young fish usually contains lower fat than adult ones.

Hashem and El-Tabakh (1977) in their study on fat content in the flesh of some Cyprinids in Egypt, found that the amount of fat in the flesh of both investigated species increased with the increase of fish length. The same authors (1981) found that the fat content in the muscles of ***Bargrus bayad*** caught from the Nozha Hydrodrome increases with the increase of fish size.

Wassef and Shehata (1991), in their study on the biochemical composition of ***Sparus aurata*** from lake Bardawil (Egypt), pointed out that percentage protein of juveniles and young fish were slightly lower than that of adults. Likewise, lipids content was found to increase with fish size. Percent moisture showed a tendency to decrease with further increase in fish size. Moisture showed a tendency to decrease with further increase in fish size. Ash had more or less a constant value for all sizes. However it is attempted in the present study to compare between the size of ***Mugil Cephalus*** and its muscle contents of the major biochemical constituents.

The samples of fish examined were classified into two or three – if possible – size classes. The first class (medium size) ranged in length from 20.0 to 24.5 cm., while the second class (average size) ranged in its length from 25.0 to 29.5 cm., and the third class are fish larger than 30.0 cm. Table (5) shows the average percentages of fat content in the muscles of such size classes for ***Mugil cephalus*** collected from the various fishing areas.

It can be indicated from the data given in Table (5) that the fat content was slightly higher in the muscles of the large size fish than its corresponding the medium ones

Table (6) gives the average percentage of protein content in the three classes of fish analyzed. It was not possible to describe the relationship between size of fish and the percentage of protein content in their muscles by a general trend. It can be detected that the protein content increased with the increase of size in some cases. Inverse relationsnips were traced in other cases.

On the other hand it has been attempted to correlate between the size of fish collected from the four fishing areas and their muscles contents of the four major biochemical constitute. Table (7) shows the correlation coefficient between the fish length and the percentages of, protein, fat, moisture and ash contents in the fish muscles.

It can be indicated from Table (7) that the fat content exhibited positive relationships with fish length in most of the cases. This emphasizes again that fat content in the muscles of ***Mugil Cephalus*** increases with size increase.

As for the other three biochemical constituents, it is difficult to recognize a general trend that may describe the relationships between these constituents and fish size.

However the data given in the present study agree to large extent with the conclusions achieved by other authors with special reference to their observations and conclusions concerning relationship between size of fish and their muscle content of fat.

Table (5): % Fat content in the muscle tissues of the medium and large size fish caught from different areas

Fishing area	% Fat at different size classes of fish		
	Medium (20.0 – 24.5 cm.)	Large (25.0 – 29.5 cm.)	< 30.0 cm.
Mediterranean	20.71	20.87	
Lake Manzalah	10.13	11.28	15.37
Lake Borollus	13.08	14.18	
Lake Edku	21.27	22.69	
Nozha Hyd.	23.25	23.17	
Mariut Fish farm	21.89	22.14	

Table (6): % Protein content in the muscle tissues of the medium and large size fish caught from different areas

Fishing area	% Fat at different size classes of fish		
	Medium (20.0 – 24.5 cm.)	Large (25.0 – 29.5 cm.)	< 30.0 cm.
Mediterranean	61.42	62.10	63.72
Lake Manzalah	77.06	76.48	72.34
Lake Borollus	72.66	72.55	
Lake Edku	59.38	60.57	
Nozha Hyd.	56.25	58.08	
Mariut Fish farm	59.18	57.84	

Table (7): Correlation coefficient between length of fish and biochemical Constituents of ***Mugil Cephalus*** caught from different areas.

Area of Fishing	Correlation coefficient between length and			
	% protein	% Fat	% Moisture	% Ash
Mediterranean	+ 0.1955	+ 0.0228	- 0.2768	- 0.4892
Lake Manzalah	- 0.3360	+ 0.5695	- 0.1152	- 0.1720
Lake Borollus	- 0.3094	+ 0.2669	+ 0.1854	- 0.0952
Lake Edku	+ 0.6084	- 0.5021	- 0.5180	- 0.1417
Nozha Hyd.	+ 0.5876	- 0.2000	+ 0.0432	+ 0.4047
Mariut Fish farm	- 0.7572	+ 0.4390	+ 0.4850	+ 0.9010

Correlation between fats content in the muscle tissues and condition factor of fish:

The values of the condition factor have been used widely by the fishery investigators to express the relative robustness of fishes. Cooper and Benson (1951) pointed out that the condition factor indicates the suitability of an environment for a fish species and to measure the effects of environmental improvements. Bagenal (1978) mentioned that the condition factors are used to compare the condition, fatness and well being of fish and are based on the hypothesis that the heavier fish of a given length are in a better condition.

It is believed therefore that a relation between fat content in the muscles of fish and its condition factors may be occurred. However it is attempted in the present investigation to correlate between the fat content in the muscles of ***Mugil Cephalus*** surviving at different fishing areas and their condition factors.

The condition factors of fish are calculated as given in Table (1). Such a factor had its minimum value of 0.8550 at the Nozha Hydrodrome. The highest value of this factor was 1.0262 at Lake Edku. This may indicate that the most favorable environmental conditions for the survival and growth of ***Mugil Cephalus*** were prevailing at Lake Edku in comparison with the other investigated fishing area.

The correlation coefficient between the fat content in the muscle tissues of ***M. Cephalus*** surviving at the various areas and their condition factors was found to be + 0.8207. From the statistical point of view, it has been indicated by Shukla and Gulshan (1971) that if the correlation coefficient (r) is greater than 0.75 but less than 0.85 there is probably a decided amount of association between the two variables, and one of the variables may be estimated from a known value of the other.

In our case the positive sign of the calculated value of (r) indicates that the increase of fat content in the muscles of ***M. Cephalus*** leads to an increase in the condition factor of fish. This agrees with the data of Bagenal (1978) that the condition factor is related to the fatness of fish. On the other hand a relationship between the condition factors and the fat content of ***M. Cephalus*** was derived. Such relationship can be expressed by the following linear equation

$$(C.F.) = 0.6673 + 0.0167\ (\%F)$$

Where: (C.F.) is the condition factor,
(%F) is the percentage fat content in the fish muscle.

Interrelation between the major biochemical constituents:

The interrelation between the biochemical constituents of the fish muscles has been observed and discussed by some investigators. Stirling (1972) pointed out that, in the muscle tissues of fatty fish, a reverse relationship between lipid and water exists, an increase in the proportion of one leads to a decrease in the other, so the summation will approximately be constant. The muscles of non-fatty fish behave differently in that a time lag occurs before this reverse relationship is listed.

Mikhail ***et al*** (1982) in their study on the fluctuation in fat and water contents of two species of Serranid fishes in Egypt found an inverse relationship between fat and water for both species under study in both liver and muscle of fish. They pointed out to the fact that although the amount of fat in immature fish muscles is higher than in the adult, yet the amount of water is still higher in the young than the adult.

Various authors found that there is a protein – water relationship in lean fish (Love, 1957; Dambergs, 1964).

Wassef and Shehata (1991) found that a strongly negative relationship existed between lipid and moisture in the muscles of sea bream. Positive relationship existed between lipid and protein contents in the muscles of this fish species while a negative relationship was found between the protein and moisture contents.

In the present study, it is attempted to correlate between the biochemical constituents of the muscle tissues of ***Mugil. Cephalus*** surviving at different fishing areas in Egypt. Correlation coefficient (r) was calculated to show the direction and degree of significance of such correlation. The calculated values of (r) are given in Table (8). It can be observed from the data given in this Table that:

(1) Highly or fairly significant negative relationship existed between the fat and protein contents of the muscles of the investigated fish species caught from Mediterranean water, Lake Borollus and Lake Manzalah.

(2) Negative correlation existed between the protein and ash contents of the muscles in all the fishing areas investigated.

(3) The water content showed positive correlation with both the ash and fat content in four fishing areas. Reverse relationships were existing in the two areas.

(4) It was difficult to find out correlation at high level of significance between the other biochemical constituents of the muscle tissues of the investigated fish species.

Table (8): Correlation coefficients between the biochemical constituents *Mugil Cephalus* caught from various fishing areas.

Fishing area	Biochemical Constituent	Correlation coefficient with		
		Protein cont.	Fat cont.	Water Cont.
Mediterranean	Fat content	- 0.7959		
	Water content	- 0.3140	+ 0.1217	
	Ash	- 0.2107	+ 0.0360	+ 0.4940
Lake Manzalah	Fat content	- 0.5280		
	Water content	+ 0.3450	- 0.3559	
	Ash	- 0.4970	- 0.3758	+ 0.0636
Lake Borollus	Fat content	- 0.7645		
	Water content	+ 0.1357	- 0.1994	
	Ash	- 0.3217	- 0.2960	+ 0.0916
Lake Edku	Fat content	- 0.8636		
	Water content	- 0.2137	+ 0.2150	
	Ash	- 0.1590	+ 0.3554	- 0.1166
Nozha Hyd	Fat content	+ 0.0800		
	Water content	+ 0.1430	+ 0.3299	
	Ash	- 0.4100	- 0.1978	- 0.4267
Mariut fish farm	Fat content	- 0.1407		
	Water content	- 0.2646	+ 0.6090	
	Ash	- 0.5526	+ 0.4360	+ 0.1880

CONCLUSIONS

It can be concluded from the present investigation that:

(1) The major biochemical constituents of the muscles of ***Mugil Cephalus*** namely protein, lipid, ash and moisture content differed significantly from one fishing area to another. Such variations can be attributed to the biotic and abiotic conditions, which are prevailing in these areas.

(2) The present study reveals that ***M. Cephalus***, which is surviving in the Egyptian fishing areas, can be classified under the category of fatty fishes.

The muscle tissues of such fish species contained more 5% lipid in all the areas investigated.

(3) The fat content of the muscle tissues of fish exhibited positive relationship with fish length. As for other biochemical constituents, it is difficult to recognize a general trend that may describe the relationship between these constituents and size of fish.

(4) It was possible to find out that a positive relationship between the % fat content in the muscle tissues of fish and the condition factors was existing. The correlation coefficient between these two variables was found to be + 0.8207. This indicates that the correlation is significant at high levels. It was possible also to derive an equation that can describe the relationship between the two variables as.

$$C.F. = 0.6673 + 0.0167 (\% F)$$ where

(C.F.) is the conditions factor and
(% F) is the percentage fat content.

(5) The interrelation between the major biochemical constituents indicated that negative relationship in the fish muscles. Another negative correlation was found between the lipid and protein contents. Positive relationship was existing between the water content and both the ash and fat contents of the fish muscles.

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