MINERAL CONTENT OF FLESH OF SOME RED SEA FISHES

By

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SUMMARY

1. The minerals, here examined in flesh of twenty five species of Red Sea fishes, are (mostly) present in the decreasing order : K, P, Na, Mg, Ca and Fe.

2. Sodium ranged from 57.02 to 135 mg% and has an average of 89.03, standard deviation is 22.1 and coefficient of variation is 24.8. Most species have sodium content less than 100 mg %.

3. For potassium, range from 260.12 to 615.45 mg %, average 415.94 mg %, standard deviation 105, coefficient of variation 24.5. A range of K content between 300 and 500 mg % included most species.

4. For calcium, range 18.9 - 43.5 mg %, average 25.21 mg %, standard deviation 5.6, coefficient of variation 22. The range of calcium content between 20 and 30 mg%, included most species.

5. Phosphorus content ranged from 149 to 397.6 mg % and has an average of 239.9 mg %. Most of species belong to range between 200 and 300 mg %. For different species, standard deviation was computed as 58 while the coefficient of variation was 24.

6. For magnesium ; range 18.46 - 56.9 mg %, average 29.4 mg %, standard deviation was computed as 8.5 while the coefficient of variation was 29.

7. For iron : range 0.425 to 2.35 mg %, average 1.03 mg %, standard deviation 0.5, coefficient of variation 48.6. Most species belong to Fe content range between 0.5 to 1 mg %. The high iron content is recorded in active fishes.

8. A direct correlation exists between contents of sodium and potassium. Correlation coefficient computed as 0.92. The relationship between these two minerals can be described by the equation $Y = 4.8\ X - 22.21$ (Y = K content, X = Na content).

9. No correlation exists between phosphorus and calcium or between magnesium and iron.

10. A direct relationship exists between magnesium and calcium and the correlation coefficient was computed as 0.85. The relation is described by the equation :

$Y = 1.29\ X - 3.1$ (Y = Mg content and X = Ca content).

11. The idea of Camara — Besa that high content of ash is associated with low sodium and that high protein paralleled high potassium is apparently not always true.

INTRODUCTION

The nutritional value of fish is not limited by its content in high-quality protein, essential fatty acids, calcium, phosphorus and vitamins. During the last years, evidence has accumulated that fishery products may efficiently contribute also to satisfy the human requirement for essential trace elements including Cu, Mn, Zn, Cr, V, Fe, J, and Se. In general, most workers dealt with fish flesh but our knowledge on the mineral composition of fish offal and that of the whole fish, especially those consumed as such, is still incomplete.

Fish consumption in Egypt is low and for providing the food requirements, fisheries is scheduled to be increased in different fishing territories. However, few investigations dealt with the nutritive value of Egyptian fishes especially those of the Red Sea. For this purpose, the present work was undertaken on some minerals in 25 species from the Red Sea and as a second part of previous issue on moisture, protein, fat and ash of these fishes (Latif and Fouda, 1976).

MATERIAL

The 25 species investigated in the present work are listed in the previous work (Latif & Fouda, 1976)

METHODS

For mineral investigation, flesh samples were dried for 24 hours at 105°C. 3-5 gm. of the dried tissue were ashed. A known quantity of ash was then digested with dilute hydrochdric acid (1:1) for 15 minutes. After cooling, the solution was completed to 50 ml. with distilled water and was used for subsequent estimation of minerals.

(*a*) Determination of Na,K, and Ca.:

The solution under test is atomized and is introduced into a non-luminous flame burning under carefully controlled condition. This flame then becomes coloured and the intensity of the light emitted is measured by means of photo cell. The various regions of the spectrum appropriate to the different elements are isolated

by passing the light emitted through an optical filter. The intensity of the light emitted with a prepared solution of known concentration is recorded.

The test was carried under the following conditions :

Slit opening = 30 microns
Diference in acetylene pressure = 45 mm.
Air pressure = 0.4 atmosphere.

(*b*) **Determination of P :**

Phosphorus was determined spectrophotometrically as molybdenum blue. This method is, although not one of the new methods, still outstanding and is based on the reduction of the yellow phosphate-molybdate complex to molybdenum blue. Transmittance is afterwards examined spectrogaphically. The procedure of Snell and Snell (1961) is here adopted.

(*c*) **Determination of Mg :**

Mangnesium was determined spectrophotometrically by titan yellow. According to this method, the titan yellow changes to orange red or red precipitating magnesium hydroxide by sodium hydroxide. With dilute magnesium solution the lake which is formed remains dispersed for rather long periods, particularly in the presence of protective colloids such as starch, agar or dextrin. The suspension appears clear to the eye. Procedure of Snell and Snell (1961) is applied.

(*d*) **Determination of Fe:**

This method depends on the oxidation of iron to the ferric condition. The density of the colour of the red complex formed by ferric and thiocyanate ions is estimated and is in turn proportional to the amount of iron present. This method is so well recognized as to be standard with the American Society for testing material, Association of Official Agricultural Chemists and the American Public Health Association. The procedure followed is that of Snell and Snell (1961).

RESULTS

1. Content of Minerals

A. Sodium :

Among the species studied, sodium content ranged from 57.02 mg % in Koshar Ads to 135 mg % in Sho'our, with an average of 89.03 mg % (Table 1).

Sodium content is less than 100 mg % is sixteen species but more than 100 mg % in nine species, and of these, this content is less than 110 mg % in 3 fishes, namely, Sigan, Bayadeya and Koshar Abu-Nawara. In general, there is great difference in sodium content between the different species belonging to the same or different families.

On the whole, the standard deviation for the sodium content of the 25 species examined is estimated as 22.1, while coefficient of variation is 24.8.

B. Potassium :

Generally speaking, potassium content is the highest among the different minerals examined. In the species studied, it ranged from 260·12 mg % in Koshar Ads to 605.45 mg % in Sho'our, with an average of 415.95 mg % (Table 1). Potassium content is between 200 and 300 mg % in 4 species, between 300 and 400 mg % in 10 species, between 400 and 500 mg % in 4 species, between 500 and 600 mg % 6 species and above 600 mg % in only one species. The standard deviation for potassium content of the different species is 105 while the coefficient of variation is 24.5.

In turn, there is a difference in potassium content between species of the same or different families

C. Calcium :

The range of the content of this mineral is from 18.9 mg % in Koshar Sherif to 43.5 mg % in Shahfala, with an average of 25.21 mg % (Table 1).

For a calcium content from 20 to 30 mg %, 20 species belong. Only 2 species have calcium content below 20 mg %, and another 2 have this content between 30 and 40 mg %. Only Shahfala has calcium content above 40 mg %.

Among the different species, the calcium content varies from one species to another. This variation is not too high but is somewhat large when compared with the actual calcium content.

The coefficient of variation for values of the calcium content of the flesh of the 25 species is 22 while the standard deviation is 5.6.

D. Phosphorus :

In the species studied, the phosphorus content ranged from 149 mg % in Hebria Mekattata to 397.6 mg % in Mehseny and had an average of 239.9 mg % (Table 1).

Only 2 species, viz. Koshar Kharnaa and Mehsony, have phosphorus content above 300 mg %. This content is less in the remaining species and of which 5 showed phosphorus content between 100 and 200 mg % and 18 species have a content between 200 and 300 mg %. In general, the content varied greatly in the different families,

Standard deviation and the coefficient of variation computed for the phosphorus content of different species are 58 and 24 respectively.

F. Magnesium

Magnesium content of the flesh of the 25 species examined ranged from 18.46 mg % in Drainy to 56.9 mg % in Shahfala. The average for all the species is 29·4 mg %. Of the species studied 2 only have Mg content less than 20 mg %. Thirteen species belonged to range of 3 to 40 mg %, 2 species to range of 40 to 50 mg %, and only one species had magnesium content more than 50 mg %. Thus, it appears that magnesium content varies from one species to another irrespective of the family to which they belong.

For all the species examined, the magnesium content showed a standard deviation of 8.5 while the coefficient of variation is 28.9.

TABLE 1.—**Minerals content of the flesh of 25 species**

Fishes	Mineral content in mg/100 tissue					
	Na	K	Ca	P	Mg	Fe
1. Koshar Abu-Loulou	76.2	370.2	20.8	290.0	26.3	1.850
2. Koshar Ads	57.0	260.1	19.7	250.0	22.4	1.375
3. Koshar Kharanaa	94.5	422.5	27.9	378.0	35.1	0.675
4. Koshar Tina	64.4	301.7	24.9	242.6	20.8	0.515
5. Koshar	77.5	378.6	20.2	206.3	18.9	0.650
6. Koshar Abu-Nawara	109.4	560.1	22.1	156.3	26.7	0.725
7. Koshar Sherif	78.7	319.5	18.9	290.0	24.5	0.890
8. Mehseny	73.9	350.4	22.6	397.6	27.2	0.640
9. Sho'our	135.1	605.5	23 3	223.7	31.6	0.770
10. Bonkos	64.1	301.3	29.2	262.5	42.5	0.640
11. Drainy	80.6	381.2	22.4	227.0	18.5	0.650
12. Keneya	63.8	290.6	29.6	213.8	33.7	1.770
13. Nagel	122.3	591.5	20.1	198.7	27.1	1.075
14. Kuscombry	117.9	538.8	24.3	245.0	20.4	2.350
15. Shakk-el-zor	64.7	270.5	32.9	285.0	40.1	1.485
16. Shakhoura	66.3	342.2	36.9	211.3	39.7	2.050
17. Shahfala	113.1	525.5	43.5	176.3	56.9	0.820
18. Bohar	80.0	388.2	21.4	205.0	27.8	1.050
19. Hebria Om-nokta	116.9	543.7	25.3	187.6	32.4	0.750
20. Hebria Mekattata	78.6	362.2	24.3	149.0	21.9	0.640
21. Bayadeya	106.6	498.8	25.6	280.0	34.2	1.260
22. Sigan	102.4	502.4	22.5	228.0	27.6	0.425
23. Gatrin	99.8	475.8	21.0	224.5	23.9	1.205
24. Haffar	111.5	457.7	27.8	228.0	24.6	0.570
25. Moza	70.8	296.8	25.1	232.0	30.9	1.125

F. Iron :

The iron content ranged from 0.425 mg % in Sigan to 2.35 mg % in Kuscombry. The average for iron content for the different fishes is 1.03 mg % (Table 1). In only one fish, viz. Sigan, iron content is less than 0·5 mg %. Most of species have this content between 0.5 to 1 mg % as 13 species came under this range of iron

content. To the range of 1—1.5 mg % only 7 species were related. Two species came under either the third or fourth ranges of iron content, of 1.5 — 2 mg % and 2 — 2.5 mg % respectively.

As was formerly expressed for the other minerals, Fe content differs between the different species belonging to the same or different families. For the values of iron content determined for the 25 species examined, standard deviation was computed as 0.5. The coefficient of variation is high and is 48·6.

2. Relation between Minerals

In this section is attempted to examine the interrelation between duplicates of the six different minerals examined These duplicates are Na and K, P and Ca, Mg and Ca, and Mg and Fe.

A. Sodium and Potassium :

As clear from tables 1 and 2, the potassium content of the flesh of the different species examined is much higher than that of sodium. Thus, in most species, potassium content is more than 4 times that of sodium. In only 2 species, and namely Koshar Abu-Nawara and Shakhoura, the ratio between sodium and potassium content is 1 : 5.11 and 1 : 5.16 respectively.

On plotting the relation between the sodium and potassium content of the 25 species examind it appeared that a direct relationship exists between these two variants. Thus, in general, on increase in potassium content, sodium increases as well. Such a relation can be described by straight line relationship computed by the method of least squares, as

$$Y = 4.8 \times - 22.21$$

(where Y = K content, $\times$ = Na content)

In another trial, the correlation between potassium and sodium cnotent of the 25 species was statistically examined. The correlation coefficient computed for the values of K and Na here is 0.92. This indicated a strong and direct relationship between these two variants.

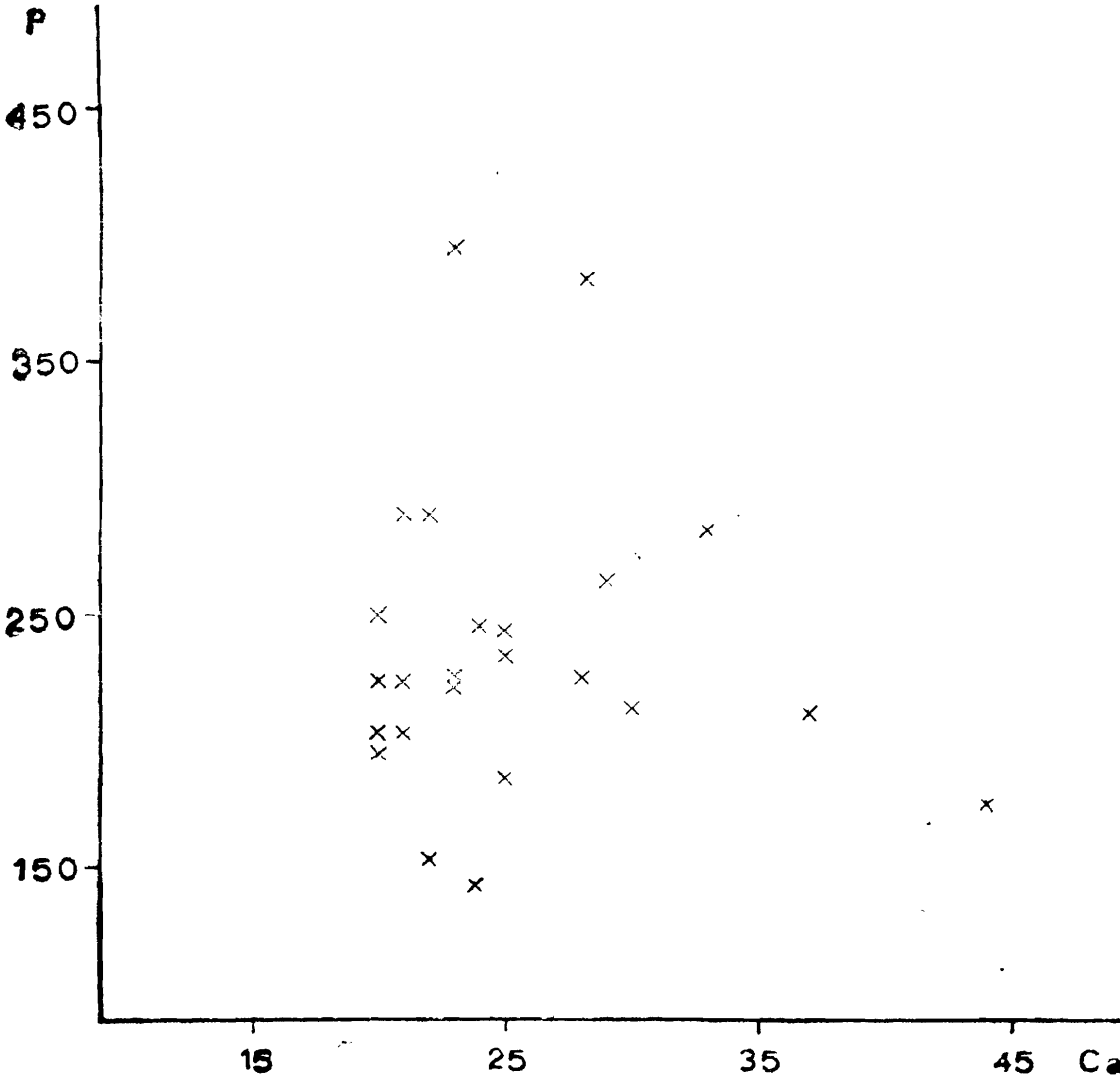

Figure 1. Relation between calciuw (mg/100g.) and potassium (mg./100g) in flesh of Red Se2 Fishes

B. Phosphorus and Calcium :

In all the species examined the phosphorus content is much higher than that of calcium. Thus, in 8 species calcium content is less than one tenth of phosphorus content. Besides in 14 species, the calcium content is from 10% to less than 15% of phosphorus content (table 2).

Apparently, no correlation exists between the contents of calcium and phosphorus in the flesh of the 25 species examined. Such a conclusion can be withdrawn from the scatter diagram of the calcium and phosphorus contents (Fig. 1).

Table 2. **Ratios of the contents of different minerals**

Fishes	K/Na	Ca/P	Ca/Mg	Fe/Mg
1. Koshar Abu-loulou	4.85	0.07	0.79	0.070
2. Koshar Ads	4.56	0.08	0.87	0.061
3. Koshar Kharnaa	4.47	0.07	0.79	0.019
4. Koshar Tina	4.68	0.10	1.19	0.024
5. Koshar	4.88	0.10	1.06	0.034
6. Koshar Abu-nawara	5.11	0.14	0.82	0.027
7. Koshar Sherif	4.05	0.07	0.77	0.036
8. Mehseny	4.74	0.06	0.83	0.023
9. Sho'our	4.48	0.10	0.73	0.024
10. Bonkos	4.70	0.11	0.68	0.015
11. Drainy	4.72	0.09	1.10	0.035
12. Keneya	4.55	0.14	0.87	0.050
13. Nagel.	4.83	0.10	0.74	0.039
14. Kuscombry	4.57	0.10	1.19	0.115
15. Shakk-el-zor	4.18	0.12	0.82	0.037
16. Shakhoura	5.16	0.17	0.92	0.051
17. Shahfala	4.64	0.25	0.76	0.014
18. Bohar	4.85	0.10	0.77	0.037
19. Hebria Om-nokta	4.64	0.13	0.79	0.023
20. Hebria Mekattata	4.60	0.16	1.11	0.029
21. Bayadeya	4.68	0.09	0.74	0.036
22. Sigan	4.90	0.10	0.81	0.015
23. Gatrin	4.76	0.09	0.87	0.050
24. Haffar	4.10	0.12	1.13	0.023
25. Moza	4.19	0.11	0.81	0.036
Average	4.64	0.11	0.88	0.036

C. Magnesium and Calcium :

In 19 species the magnesium content is lower than that of calcium. The reserve is the case in only 6 species but on the whole, the difference between the content of these two minerals is small. Thus, the average of the ratio of the contents of Ca and Mg for all the species examined is 0.88 : 1 (Table 2).

A simple glance to the scatter diagram for the content of Mg and Ca shows tendency for a direct relationship (Fig. 2), which is described by, $Y=1.29\ X-3.1$ (where Y=Mg content and X = Ca content).

Besides, correlation coefficient computed statistically for the contents of Ca and Mg of the species dealt with is 0.85. This points to the positive correlation between these two variants.

D. Magnesium and Iron :

On considering table 1, it becomes clear that magnesium content is much higher than that of iron. Thus, in 20 species the iron content is less than 5% that of magnesium. The highest percentage was only about 11% and recorded in Kuscombry.

The scatter diagram (Fig. 3) of the magnesium and iron content for the flesh analysed for the 25 species revealed that no relation exists between these two variants.

Discussion

According to Causeret (1962), the mineral constituents are studied much less than nitrogenous compounds, lipids or vitamins. Only few elements have been subjected to thorough analyses, particularly phosphorus, calcium, iron and iodine. The first non-comprehensive study on the mineral composition of fish was published in 1892 by Atwater. Spectrographic analysis on a broad front covering most mineral elements was made by Newell and McCollum (1931) on fish meal. Later papers of a general nature were those published by Nilson and Coulson (1939), Stansby (1953), etc. The most comprehensive investigations were those of Vinogradov (1935. 1937). A treatise was published by Vinogradov and Odum (1953).

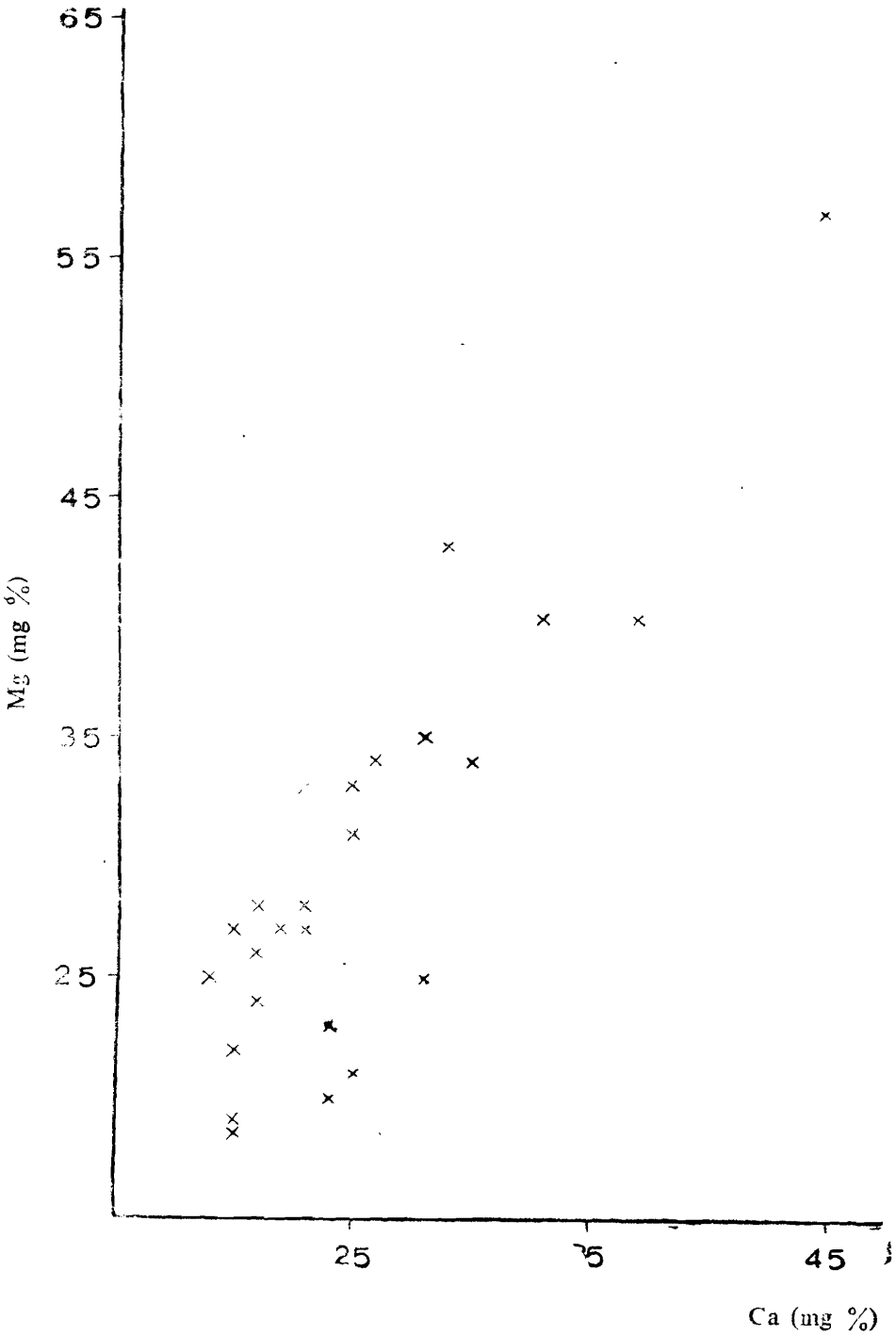

Figure 2 : Relation between calcium and magnesium.

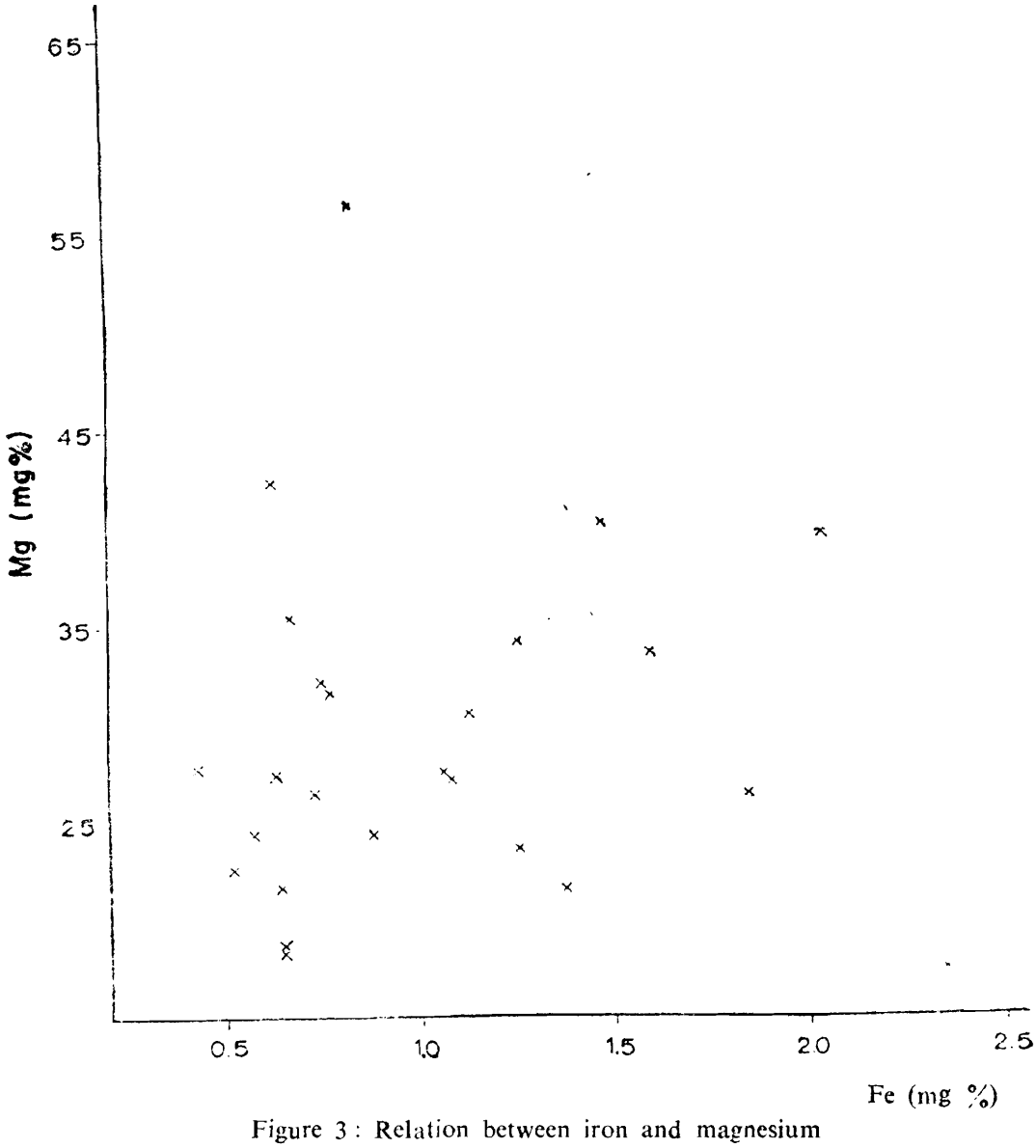

Figure 3 : Relation between iron and magnesium

Authors dealing with the minerals found that P content is higher than that of Ca and this is in turn higher than Fe content (Setna et al 1944 : Airan. 1950 ; Eisa and Zaki, 1955 ; etc. According to Shanovi (1944), the minerals he examined are found in the decreasing order of P, K, Na, Ca, Mg, and Fe. Similarly, Eisa and

Zaki (1959) and Kasinova (1961) recorded the decreasing order of P, Ca, Mg and Fe. The content of minerals examined in the present work has the decreasing order K, P, Na, Mg, Ca, and Fe in 17 species and this is quite different from Shanovi's conclusions who found P to be more than K. This is found the case in only 2 species, viz. *Lethrinus mahena and Scomber japonicus.* Furthemore ; in 6 species, viz. *Epinephelus mebachi, Cephalopholis argus*, *Lethrinus latifrons, Rastrelliger kanagurta, Lutianus kasmira,* and *Chrysophrys haffara,* Ca content is higher than that of Mg.

For Na, K, Ca, P, Mg, Fe, the ranges are 57.02 — 135, 260.12 — 605.45, 18.9 — 43·5, 149 — 397, 18·46 — 56.9, 0.425 — 2.35 mg %, and the averages are 89.03, 415.94, 25.21, 239.9, 29.4, 1.03 mg % respetcively. Standard deviation for these elements is 22·1, 105, 5·6, 58, 8.5 and 0.5 respectively. Although these values are quite different yet the coefficient of variation is comparable for Na, K, Ca, P. and Mg, and is computed as 24.8, 24.5, 22, 24 and 28.9 respectively. The highest coefficient of variation is 48·6 and recorded for iron.

Comparing sodium and potassium content of the flesh of fish, Shanovi (1944), Solita and Minerva (1950) and Camara-Besa (1954) found that potassium content is about 3, 4 and 5 times to that of sodium respectively. According to Causeret (1962), the ratio of sodium content to that of potassium is quite similar in both fresh water and marine fishes and roughly one part by weight of sodium to five parts of potassium (Thurston, 1958 ; Thurston et al., 1959) Among the present studied species, 23 species have the ratio of potassium and sodium between 4 : 1 to 5 : 1 and only in 2 species this relation is more but close to five parts of potassium to one part of sodium.

According to Causeret (1962), the contents of phosphorus, calcium and magnesium have ranges 100-400, 5-200 and 10-66 mg% and averages 220, 30, and 30 mg% respectively. Higher contents were recorded· Thus, De Clercq (1932) found that meat from fish belonging to family Pleuronectidae exceeds 100 mg per 100 g in phosphorus content. The meat of *Ethmidium chilcae* contained on the average 186 mg of Ca per 100 g. (Costa Saenz, 1952). Concerning the present studied species, 18 species lie in the phosphorus

content range between 200 and 300 mg% and only two species and namely *Epinephelus summana* and *Lethrinus mahsena* have phosphorus more than 300 mg%. For magnesium, two species have its content less than 20 mg%, 13 species belonged to magnesium content range between 20 and 30 mg%, 7 species to range 30-40 mg%, 2 species to range 40-50 mg% and only one species viz· *Lutianus argentimaculatus,* has magnesium content more than 50 mg %. In turn, 20 species belonged to range of calcium between 20 and 30 mg %, 2 species have lower calcium content and another 2 have calcium content between 30 and 40 mg % and only one species has calcium content more than 40 mg %.

In addition, according to Causeret (1962), the calcium/phosphorus ratio varies between 0.05 and 0.6 with an average of 0.2. The range of this ratio in the species studied is between 0.06 and and 0.25, being less than 0.1 in 8 species, between 0.1 and 0.15 in 14 species and more than 0.15 in only 2 species. For Ca/Mg ratio, it is less than 1 in 19 species and more but close to 1 in 6 species. For the Fe/Mg ratio, it is less than 0.05 in 19 species and in only one species, viz. *Rastrelligar kanagurta,* this ratio is more than 0.1.

Furthermore, Rose (1933) reported calcium content of 22 mg/100 g. in the meat of lean fish and 19 mg/100 g. in fatty fishes. Apparently, such a difference is of low magnitude which does not allow to draw down any conclusion. Again, in the lean fishes studied in the present work (Latif and Fouda, previous work), calcium content of more than 22 mg/100 g. is recorded in 17 species Furthermore, the variation in the calcium content apparently does not bear any relationship with the variation in the fat content among these lean fishes.

Besides, Camara-Besa (1954) assumed that high protein paralleled high potassium. Such a conclusion is inapplicable to our species. Thus, in the fishes *Cephalopholis argus, Plectropomus maculatus, Lutianus argentimaculatus, Lutianus fulviflamma* having protein content less than 20 %, the potassium content is about 560, 590, 525, 544 mg % respectively. On the other hand, in *Rastrelliger kanagurta, Scomber japoncius, Decapterus sanctaehelenae* and *Clupea leiogaster* in which the protein content was more than 20%, the potassium content is about 539,342 and 297 mg % respectively.

Concerning iron, fish flesh contains from 0.4 to 5 mg. of iron per 100 g. (Park and Rose 1933 ; Ranganathan 193; Nilson and Coulson 1939; Airan, 1950; McCance and Widdowson 1960, etc.) On an average, iron content comes close to one mg %. In general salt-water fish contain more iron than fresh-water fish. Dark meat is almost twice as rich in iron as white meat (Parks and Rose, 1933; Namiki, 1934). In the present work, 14 species have iron content less than 1 mg. per 100 g of fish flesh and in 9 species this content is more, but less than 2. Besides, in only 2 species the iron content is more than 2 mg %.

From the present work, the variation in the mineral content, in general, cannot be attributed to the behaviour of fish or the type of food ingested. The only conclusion which can be offered concerns only iron. Thus, all the pelagic species, viz. *Rastrelliger kanagurta, Scomber japonicus, Decapterus sanctaehelenae* and *Clupea leiogaster*, which feed on plankton have iron content more than 1 mg %. The pelagic and carnivorous barracuda, *Sphyraena kenie*, behaved similarly. Of the 18 species of the carnivorus fishes of less activity, only 4 species have iron content more than 1 mg %. On the whole, the highest iron content is recorded in the 2 pelagic fishes, namely, *Rastrelliger kanagurta* (2·35 mg %) and *Decapterus sanctaehelenae* (2.05 mg %). Such a high content of iron meets the requirements of the comparatively high haemoglobin content of the active fishes. In this connection, it is worthmentioning that slow-moving and relatively sedentary fishes have relative heart weights of less than 1 part per thousand of the total body weight whereas the value in fast swimmers such as mackerels and tunas is 1.2 per thousands and the heart of flying fishes has a relative weight of 2.1 parts per thousand. Furthermore, the oxygen carrying capacity, iron content of the blood and the number of the red blood cells in fishes often go hand in hand with life habits and activity levels (Lagler et al., 1962). Furthermore, Parks and Rose (1935) dealing with Cu, Mg and Fe in some fresh water and marine fishes concluded that fishes with dark coloured tissue contain approximately 75% more Fe than species with light coloured tissue. As well known, scombroid fishes as the tuna are active swimmers and have dark muscles.

Trying to find out any correlation between the different minerals analysed, a graphical represenatation was drawn for the pairs Fe/Mg, Ca/P Na/K. and Ca/Mg and a relation was found

only with the last two pairs. Such a relation is
the increase of one component, the other also i
relation was described by the equation Y=4.8X-22.2
content and X is the sodium content, or Y = 1.29 X
is the Mg content and X is the Ca content. The scat
the diagrams representing relations between Fe
Ca and P allows one to conclude that no correlation

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