MINISTRY OF COMMERCE AND INDUSTRY, EGyP’\*

HYDROBIOLOGY AND FISHERIES DIRECTORATE

NOTES AND MEMOIRS No. 29

A CHEMICAL STUDY OF THE

EGYPTIAN SARDINELLA

1.—VARIATION IN THE FAT CONTENT

OF WHOLE FISH, FLESH, AND GONADS

By

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INTRODUCTION

Save what is recorded in the Fisheries reports issued since 1920

by the Fisheries Research of Egypt, there is no published account

concerned with a description of the Egyptian Sardine Fishery, and

for this reason it appears to me to be desirable to write a short note

on this fishery as regards composition, locality, season, annual total

production, importance, ctc., before proceeding to discuss the chemical

aspect of the subject.

Three species of the genus Sardinella compose our Sardine Fishery,

of which the S. aurita (allache) constitutes about 80 per cent of the

total production ; the remainder consists of 8. eba save for the neg-

ligible percentage of less than 0°50 per cent of 8. granigera,

S. aurita (Allache).

Migratory, travels in big shoals, appears in considerable quantities

about two to five weeks time after the flow of the Nile flood reaches

the Mediterranean. At the time of its first appearance the fish is

lean and exhausted after spawnmg during the summer months.

Some of the fish are still full, but these form a very small percentage

of the total. The fish start to feed vigorously on the Nile mud con-

tents of phytoplankton and on the swarms of the marine diatoms

and perydinians and other phytoplanktonic forms, which flourish

abundantly at that time due to the effect of the vast quantities of

fresh water discharging inte the sea.

—?—

The fish rapidly fatten and the catches increase in size until

they reach a maximum by November. :

With the fall of the Nile flood the fishery begins to slacken gradually

until it practically ceases by the end of January. Thus the season,

in some years, extends from mid-August to the end of January,

while in others it fluctuates by starting a little later and ending a

little earlier. The season seems to depend mostly on the height of

the flood and also on the prevailing physical and chemical conditions.

After the season is ended, the fish leave the inshore waters and

migrate into deeper waters probably in an easterly direction.

Average individual size of the fish during season 18 cms.

Average individual fresh weight of the fish during season.70 grains.

S. eba.

This species seems to be more local than 8S. aurita and lives

along the shores in the shallower waters.

During season October—January it mixes up with S. aurita and

travels in big shoals.

The fishermen’s catch is often a mixture of the two species ;

sometimes composed entirely of 8. aurita while at others it consists

exclusively of 8. eba.

Average individual size of this fish during season 14 cms.

Average individual weight of this fish during season 35 grams.

After the season is ended, this fish disappears for 3 to 4 mouths

until it again re-appears during the very limited summer inshore

Sardine Fishery, localised so far at Alexandria Eastern Harbour.

The summer fishery ground extends only from Alexandria to Abou

Kir in the inshore waters of not more than 20 fathoms.

The number of boats engaged in this fishery does not exceed 20,

The quality of the fish is poor and their gonads are approaching

ripening and maturation aud the fish are ready to move to deeper

waters to spawn.

The quantities, produced from this summer fishery, are compara-

tively small and are consumed fresh locally. 8. eba is generally

the predominant fish in the catches, S. aurita being rather rare

during this fishery.

Average individual size of §. cba during summer fishery 14°5 cnis.

Average individual weight of 8. eba during summer fishery 28 grms.

Average individual size of 8. aurita during summer fishery 17 cms.

Average individual weight of 8. aurita during summer fishery

52 grams.

S. granigera.

This is a rare fish, compared with the other two species and

does not play anv signifieant part in the economics of the Sardine

fishery. It generally appears carly during the summer fishery men-

tioned above. Its presence in the catches does not occur later than

May-July. This fish ts caught in small quantities at Alexandria

Harbour in a westerly direction. It seen to prefer life in waters

deeper than 20 fathoms. (V.B.-—The deepest waters in which the

fisherman can work on is bounded by the depth of his net, which in

Kevpt does not exceed 20 fathoms).

This species does not make more than 10 per cent of the summer

fishery, which in its turn does not exceed 5 per cent of the total pro-

duction of the Sardine fishery all the vear round.

Average individual size of this fish during May-July 18 crus.

Average individual weight of this fish during May-July 48 grams.

The Sardine fishery is centered along the Northern coast of

Keypt at Abou Kir, Rosetta. Broullos, Damietta and Port Said,

Table T shows that the average annual landing returns of this

fishery during the last ten years are estimated at 4,880°3 metric tons,

while in the same period the total production of our sea fisheries,

practiced along the Mediterranean coast, Red Sea coast and along

the Suez Canal with its Jakes amounts to an annual average of 9,218°7

metric tons.

Tapre L--AMoUNTS oF SaRDInk CatCHES, COMPARED TO THE TotaL

PRODUCTION OF ALL THE SEA FISHERIES AND ESTIMATED VALUE OF THE

SARDINE (1926-1935).

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\_ Amounts of Metal prone: ae Ea Annual Total

Year were in | WPisheries in FI ® 53 Miners

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W929 eI 2,938 6 626 14°3 —\_

Ls S| ve 7,867 13,708 57°4 167,731

TP I 3,826 10,152 37°6 52 003

W322 5,042 10,144 49°7 61 , 966

W833 | 6,190 11 ,407 54:2 107,579

4 12,055 16,657 72°3 224 ,422

35 195 9 ,668 53:7 67 ,527

Mean 2.0.00... os 41,880°3 9,21R°7 484 113,538

—4—

The annual sardine catches exceed by far those taken of any

other marine fish in Egypt and as shown above make up 48°4 per cent

of the total landings of our Sea Fisheries. It is thus obvious that

any attempt to develop the Sea Fisheries industry should deal first

with the development of the sardine fishery.

With the importance of the sardine fishery in view, the writer

started the biological and chemical investigations on the sardine

in the hope that these investigations might help its economic deve-

lopment.

The complexity of the problem has become increasingly apparent

and has necessitated careful consideration from different aspects.

As a result it was found convenient to deal with the chemical and

biological aspects separately.

In a previous paper by the writer on the “ Dietetic Value of

certain Egyptian Food Fishes ” 22 species including the sardine were

considered. The chemical analyses for the determination of the

percentages of Protein, Fat, Ash, and Water in the flesh of 21 species

were carried out, while in one further species the Karous (Morone

Labraz) a study of the gross chemical changes, which occur in the

different tissues during the process of maturation and reproduction

was made.

As the protein constitutes to a large extent the protoplasm of

the living tissue, its percentage in the flesh of fishes does not greatly

vary between individual fish, between different species, or between

fish from different localities.

In contrast with the protein-content, the fat-content in the so

called fat-rich-fishes such as herring, pilchard, sardine, makerel, ete..

varies greatly between individual fish, between species in different

localities and at different seasons of the year.

Fish fats and oils are of great value as foodstuffs because of their

high caloric value. They have also further importance as foods

because of their more lor less intimate association with three very.

valuable accessory food substances, namely, Vitamins A, D and KE.

The presence of the three vitamins in the dict 1s of prime imfpor-

tance for the proper economy of the body.

The industrial importance of fish oils, extracted from whole

fishes or from the offal of the canneries in the case of herring. pil-

chard. sardines, salmon, ete., 18 increasing as their particular properties

are becoming known. Fish oils are now-a-days considered a relatively

valuable raw material in the general factory consumption of fats and

oils, required by various industries.

From a table, given by the U.S. Department of Commerce for

the year 1929 and recorded by Brocklesby and Denstedt (1933), the total

consuniption by factories of fish oils is estimated at 188,102 thousand

pounds, consumed in the varions industries as follows :-—

U\s.A. Facrory Consunerion oF Fisa Oris By ALL INDUSTRIES FOR

THE YEAR 1929 (QUANTITIES IN THOUSANDS OF Pounpy).

Total of all Shorten- ' Paint and: Printers’ Linoleum - . Miscella-

: : : Soap : . and Textiles neous

industries ings Varnish Ink : :

“ oil-cloth Industries

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188,102 | 14,921 [130,634 | 10,602 50 | 10,141 — 21,753

The oil of the miscellaneous industries are mainly consumed in

the leather tanning industry, of which the annual consumption 1s

estimated at 8,000 tons and also in the manufacture of greases and

lubricants ; and sometimes for general purposes one class of mineral

oils is blended with another class of fish oils.

Besides the importance of fish oils and fats in the foods and m

the different industries mentioned above, the success of canned sar-

dine as regards quality and flavour depends to a certaim extent on

the degree of its oiliness. Rich fatty sardines generally make a good

quality canned food stuff, while the poor weak fish produce a low grade

of canned sardine.

As the economic value of the sardine increases with the increase

of the degree of tts fatness, the study of the fat-content of sardine

and its properties throughout the year in order to establish the dif-

ference between individual fish ; between different sexes ; between

species ; between localities, and above all between the different

seasons of the year, is essential for the development of the Sardine.

Fishing Industry on sound and scientific basis. This paper is a pre-

luminary survey of the fat metabolism of our sardine,

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COLLECTION OF SAMPLES

Biological and chemical investigations on sardinella were carried

on during the seasons of 1933-1934 and 1935-1936. The reason of

the break in 1934-1935 season was due to the absence of the writer on

board R.R.S. ~ Mabahiss ” on her trip to the Red Sea (December 1934

to February 1935) for biological and hydrograpbical investigations.

Samples of fish were, whenever possible, collected from the

marketable catches, landed at various fishing centres, After the

count of the sample and its analysis tnto the three species of sardinella—

S. aurita, S. eba and §. granigcra--the biometrical and biological

investigations of Jength; sex: age; state of maturity ; condition

of intestinal fat and examunation of the food-contents of stomach

were recorded on every Individual fish. These observations will be

published later on.

Length was measured from the tip of the snout to the end of the

longest caudal fin ray in the dorsal fluke of the tail.

Several scales from the anterior region near the tip of the pectoral

fin were removed and prepared in the same way described by Channon

and Saby (19382) for the count of winter rings under a projector or a

binocular microscope according to the method of Lea (1910).

It was found convenient to record the state of maturity, according

to the classification of Hjort’s scale. The adopted classes of this

scale actually encountered were :-—

.—lImmature virgin or spent fish not yet recovered ;

T].-—Maturing virgins or recovering spents ;

HIT. Gonads filling one-half of the body-cavity ;

1V.—Gonads filling more than two-thirds of the cavity ;

V.—Gouads full, fillmg the body cavity.

The quantity of fat round the alimentary tract was observed

and is recorded as the “mesenteric” fat in the terms, “no fat” ;

“Tittle fat’; “some fat“) “ verv fat.”

Throughout this work on the biological and the biometrical data

on the three species of sardinella, samples of a few fishes for the che-

mical analyses were selected to represent as far as possible a fair

average of these factors,

-

As the fat content of the whole fish and that of the muscle are

the most important from the dietetic and industrial point of view,

it was decided in the first place to carry out estimations on samples

from this point of view.

Later on and during the summer fishery of 1935, when the fish

were poor and lean and of little invportance for canning or production

of oil, attention was given to the study of the chemical changes which

occur during the process of maturation and investigations made as

to any possible difference between. males and females in this respect.

The selected fish were weighed in granis and treated as follows :—-

(a) After the careful removal of the scales. the fish were taken for

the determination of the fat content and were finely cut

into small pieces.

(b) In the case of the estimation of the fat-content of flesh, the

sample was taken by cutting a narrow fillet of the flesh,

from behind the head to the tail region after careful removal

of the skin.

(c) Gonads were readily obtamed by dissecting the selected fish.

The selected samples were then stored in stoppered jars

under excess of acetone until they were later worked up,

as time allowed. Table IJ gives the history of all the

samples taken for analyses.

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METHODS OF ANALYSES

The methods of analyses were very sinilar to those described by

Channon and Saby (1932) in their preliminary study of “Fat Me-

tabolism of the Herring.” In all cases the acetone was removed fron

each sample by filtration through a Buchner funnel. ‘The residue

was repeatedly treated with warm fresh aectone and filtered. The

final residue, after being finely ground in a mortar, was then extracted

with ether in a Soxblet apparatus for about 6 hours. The combined

acetone extracts was evaporated to dryness in vacuo and the residue

was dissolved in ether and filtered. The filtrate obtained was added

to the ethereal extract from the Soxhlet extractor and the whole

was then distilled and evaporated and dried 7 vacuo at 100°C. The

fat-content of the tissue is expressed as the weight of this ethereal

extract.

In some samples the amount of the ethereal extract was so small

‘that only a few of the fat constants could be determined on account

of lack of material. In these cases the fat was saponified and deter-

minations of iodine number of the unsaponifiable fraction and of

the fatty acids made.

Acid Value: 3 to 5 grams of the fat were dissolved in 40 ce. of

neutral mixture of alcohol and ether (7 parts alcohol to 3 parts ether)

and titrated with 0-1 N alcoholic sodium hydroxide solution, using

phenolpbthalein as indicator. The results were calculated as mg

of potassium, hydroxide required to neutralise the free fatty acids of

one gram of the ethereal extract.

A portion. of the fat was then saponified by boiling with excess

of alcoholic potash until much of the alcohol was removed. This

was followed by dilution with water in an extraction funnel and the

ethereal extract of the unsaponifiable fraction was obtained by 5 to 6

extractions with ether. The ethereal extract, after washing with

water to neutrality, was distilled and dried at 100° C in vacuo and the

unsaponifiable fraction thus obtained. The combined soap solutions

and aqueous washings were then acidified with conc. Hydrochloric

acid, and similarly extracted with ether. After washing to neutrality

the ethereal extract was evaporated and the residue dried in vacuo

at 100°C. It was then dissolved in petroleum ether and allowed

to stand over night. The light petroleum solution, after being filtered,

was evaporated to dryness at 100°C im vacuo, and the fatty acids

are obtained.

Todine values of the unsaponifiable fraction and the fatty acids

were determined according to the method of Rosenmund and

WKuhnhenn (1923.)

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RESULTS

PART J,

The Fat Content of Whole Fish Analyses

The amounts of the ethereal extract (gram per 100 g. of fresh

sample) and the variation in the percentage yields of the fatty acids

and unsaponifiable matter with the iodine values and the acid number

of the fat of whole fish are reeorded in Table IIT for 8. aurita. and

Table IV for 8. eba.

TaBLe TTE—-VaeratioN IN THE PERCENTAGH YIELDS OF

Farin 8, Aunira (WHo te Frise).

oF vield a Iodine | 1% yield | Todine os

Xo. of | Date of ethereal vt fatty Value of “of uns: np. | value of | Aoi

Sample ' . acids in mutterin |; unsap. ‘Number

extract the extract fatty OY 80188 the extract matter

3 13-10. 1933 30°79 Jost - | Jost — 31

6 20-10-1933 30°29 8750 11076, O° 95 82° 5:9

) 7-11-1933 34°66) 92°70, 10ke3 O73 -B6°6 3°8

IB T- Ie 1933 30°60, O54 1056! w68 62:7 nT

45 3- 1-1 934 30° 63 90°65 {10-2 7st 60°8 u'4

19 25- 5-1935 3°37 86° 20 144-4 4°20; 70°4 QR°5

23 | - 1y3h 3°78, 77°96 138° 1 £96, 59-4 B74

Ty 30 81985 TB 796 LTB 296, 745 256

46 30 - 81935 S10, 84°53 125-0 2°88 776 21°8

49° 27-10-1935 23°76) 8324 ivan O9L, 60-9 11:6

5| 18-11 1935 B27 18 GI 35 129°2 105) 91-0 i4°2

Mean Values 2.0... 2174] 86 3 [L&-9 197° «69°6 131

% yield | 4 yield | Todine

: ©’ vie 0 i

No. of vo yield of fatty Jodine | of unsap, value of | Acid

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“amy extract fatty acids, ,

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4) 13-10-1933 42-47 89°60. 0° 35! 65° 4

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1d) 10-11-1933 28°86 G07 969, 108 BOB, BB

V7 3-1-1984 24°42 86°92 10370! 1-03! 552) OT

27 2D - 7-1935 7°19 86°74 33°9 a0

3°48) 780 19°

Mean Values ... 0... 25°66: 8B AR 11:3

149) 649

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On account of the rarity of 8. granigera and to the limited period

of its appearance one sample only No. 21 of the whole fish was taken

on May 30. 1985. The results of the analyses as follows :—

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| fy : I

9% yield of ether | °% yield of fatty | Todine value of | ‘0 yield of nea. ' Todine value of

extract, acids acids ! aera “ . ansap. matter:

; ! extract

et Po . \_ yo a

2°92 82°13 16774 573 70°41

It should be noted that carly in summer small quantities of

poor fish are caught in the coastal waters from Alexandria to Abou

Kir. These fish, being very lean and generally either unripe or im-

mature start to feed on the zooplankton mainly Copepoda and in

the meantime the reproductive organs mature. As the fish feed, the

fat content increases up until it reaches its maximum for this period

just before the fish go on the hunger migration to spawn.

This summer fishery or the spawning period is represented m

Table IJ of 8. aurita by 4 samples Nos. 19, 23. 43 and 46: in Table IV

of 8. eba by one sample No. 27; and the one sample of S. gratugera.

while the rest of the samples of whole fish analyses of S. aurita and

8. eba were taken during the fishing season or the extensive feeding

period.

The results of the analyses of the spawning period show that

in the case of 8. aurnta the percentage yield of fat of the whole. fish

was in May < 3°37 when gonads were immature or unripe. shghtly in-

creased in July to 3°78, “while it rose up by the end of August to 81

when the fish were full and about to spawn. The mean value for the

four samples taken from this fish during summer period was 5°64 per

cent of fat. In the case of the other two species the process of gradual

increase of fat in the whole fish during this period could not be traced

as one sample only was Sample 21 of the whole fish

of S. granigera, taken in May contained 2°92 per cent while sample 27

of 8. eba taken in July contained 7:19 per cent of fat.

As the fish feed very vigorously during the fishing season on the

abundant marine Phytoplanktonic forms, the amount of fat in the

different tissues of the fish is continually enriched and the excess is

deposited as the “ Mesentric ” fat round the alimentary tract. The

results recorded in Table IIT for 8. aurita show a striking rise in the

fat content during this period as the percentage of fat in October

varied from 23°76 in sample 49 to 30°79 in sample 3 and rose to a

maximum 34°66 for sample 9 taken in November, with an average

value for the season—October to January—of 30°42 as against 5°64.

the mean value obtained during the spawning period.

Figures of Table [V of S. eba show great similarity as to the

striking increase of the fat content in the whole fish during the period

October to January, with a mean value of 31°82 per cent of fat as

against 7°19 per cent in July.

To record the seasonal changes in the fat content of the two species

8. aurita and S. eba, the results obtained in Table III and Table IV

for the fat content of the whole fish are expressed graphically in Fig. I,

assuming that samples of the two species were completed during the

fishing months of one and continuous period (May—-January). When-

ever more than one sample were dealt with in any month, the mean

value of their percentages of fat was taken. to represent the percentage

yield of the ethereal extract of the fish im that particular month.

45

“ft

4g 4

35 +

30

% of ether extract of whole fish

May June July Aug sep Oct. Nov. Dee Jan.

Fre. I.—Variation in the Fat-content of whole-fish analyses of S. aurita and

8S. eba during fishing months (May-Jan.)

Before the discussion of the figures concerned with the varia-

tion in the percentage yields of fatty acids and unsaponifiable matter

with the iodine values and acid numbers, it is desirable to note that

the ethereal extract in the manner obtained in this work contains

a variety of substances :-—

(a) The unsaponifiable fraction —This consists largely of cho-

lesterol.

(b) Phosphatide.—This consists largely of lecithin.

(ec) Triglyceride.—This is the neutral fat “ oil.”

(d) Eatraneous material. which is not truly soluble wm pure ether.—

The material appears in the extract because of the presence

in them of phosphatide. If phosphatide is dissolved in

ether, the ether solution of the phosphatide will dissolve

many other things that are not soluble in pure ether.

The amount of (a), (6) and (d) will practically remain constant.

irrespective of whether the fish is rich or poor in fat (c). When the

fat content of the tissues increases, most tf not all that is mereasing in(e).

The next point to mention is that fatty acids which are present

in the phosphatide are more unsaturated usually than are those in

the triglyceride. Bearing these facts in mind the results recorded

in Tables LH and IV and in the case of the one sample of 8. granigera.

concerned with the variation of the vields of fatty acids and unsaponi-

fiable matter with their iodine values are easy to explain.

During summer fishery the fish are lean and the ethereal ex-

tracts of samples contain very little triglyceride as against a high

percentage of the other constituents— unsaponifiable matter, phos-

phatide, and extraneous materials—the properties of which would

be most prevailing in the analyses of the extracts of this period.

Fo. example the extracts would be expected to contain a lower per-

centage yields of fatty acids with more unsaturated nature due to the

concentration of phosphatide : a higher percentage of usnaponifiable

material: and an increased acid number on account of the higher

percentage of phosphatide and other extraneous material present. in

the extract.

When the fish fatten during the feeding season the amount of

the fat content rapidly increases due to the stziking ircrease of the

amounts of the triglyceride or the neutral fat, the properties of which

would be most prominent and dominating those of the other cons-

tituents in the analyses of the extracts of this period. For example

the percentage yield of fatty acids in the extract shows a tendency to

increase, while the fatty acids become less unsaturated ; a mucli

lower percentage yields of unsaponifiable matter : and a sharp decrease

in the acid number as phosphatide and other extraneous material

being subsided by the neutral fat.

The results obtained from the analyses were :—

(1) From May to August. or the spawning period, —-A conrpara-

ney lower percentage vields of fatty acids ranged in case of S. aurita

Table {17 between 77-96 and 86°20 with a mean value 82-09, and in

— b—

Table IV of 8. eba there was one sample only and its yield was 86°74

per cent while the sample of 8. granigera gave a corresponding value

of 82°13 per cent. The unsaponifiable matter in case of 8S. aurita

Table ITI varied from 2°88 per cent in August to 4°96 per cent in July

giving a mean value 3°75 per cent; the corresponding value in the

sample of 8. eba Table IV was 3°48 per cent while in the sample

of 8. granigera being 5°3 per cent.

The figures in Table III show that the iodine number of fatty

acids varied from 117°3 when percentage of fat was 7°3 to 144-1 when

percentage of fat was at its lowest 3:37, giving a mean value of 131°1

for this number during May to August, while the range of the variation

in the iodine number of the unsaponifiable matter during the period

was limited between 59°] and 77°6 with a mean value of 704. The

iodine number of fatty acids in the case of the sample of 8. eba and

that of 8S. granigera were 132°9 and 167'1 respectively while their

corresponding values for the iodine number of the unsaponifiable

matter were 78 and 70:1. In the case of 8 aurita Table III the acid

number varied between 218 and 37°3 with a mean 28°3 and in the

sample of 8. eba Table IV its value was 19 but in the case of the

sample of 8. granigera no determination was made due to the lack of

material.

(2) The feeding period October to January.--The yields of fatty

acids showed a tendency for increase in Table LIT of S. aurita the

percentage yields ranged between 85°24 and 927 with an average

value of 89°16, while this range of variation in the case of 8. eba

Table TV was between 86:92 and 91°07 giving a mean value 89-2.

The percentage yields of unsaponifiable matter in the extract de-

finitely decreased-.-these varied fron. 0°59 to 1°05 giving an average

vield for the whole season 0°78 per cent in the case of S. aurita Table ITT,

while in the case of 8. eba Table [TV the corresponding variation was

between 0°35 to 1-08 with a mean value of 0°83. During this period

the fatty acids become less tinsaturated and the iodine numbers

obtained varied in the case of 8. aurita Table IIT between the two

extremes 101-3 and 129°2. giving an average iodine value 110°7, and

in Table TV of 8. eba two deterninations only were made and gave

the numbers 96°9 and 103-0. The iedine numbers of the unsaponi-

fiable matter varied irregularly and insignificantly from a minimum

of 56°6 to a maximum of 91-0 giving a mean of 69 in the case of 8. aurita

Table TIT, and from 55-2 to 65°4 with a mean 60°5 in the case of 8. eba

analyses. During this period the acid numbers strikingly decreased

and their range of variation was from 3°8 to 14°2 with a mean 6°2 in

the analyses of S. aurita Table TTT, and from 3°5 to 7°8 with an average

value 6°0 in the analyses of 8. cba Table LV.

—1%I-—

PART IL.

The Fat Content of the Flesh and its Constants

The analytical data obtained for the amounts of the ethereal

extract and the variation in the percentage yields of the fatty acids

and unsaponifiable matter with the iodine values and acid numbers

of the flesh are recorded in Table V for the flesh of S. aurita and Table VI

for the flesh of 8. eba.

FROM THE FLesa or 8, AURITA,

TaBLE V.-—PERCENTAGE YreLDs oF Fat AND Its CONSTANTS

|. lo yield of — ,. |% yield of Iodine | Acid

No, of Date % yield of feet acids iodine f reap value of [number

Sample a in the alue Of | ter inthe | unsap. | of the

extract | extract fatty acids| oxtract matter | extract

\_ en \_ a Lone \_ \_ -

5 | 1310-1933 | 14-82) 85-11) lost 0°90 68° 8)no oil

7 + 280 10-1983 | BL 49 9G" 51! OL° 4. 0° 72) 72°6 ss

10 | 7-11-1933 | 2k50; 90°01] BBE BLL 48 Qt Hk

14) 7-12-1933 | yg-21] 85-91 99°6 0°93) OB)

[6 31-1984 | 24° 46 lost V17°3 0°63 D679 773

20 2PD- 8 1935 2°92 lost: {48° 1) 3°87) 75°3) uno oil

24 }. 7-1935 ! 2°65 lost | 144°3 4°66 91-0}

44 30. &-1935 9°16 87°76) 104-1 19]! 69° 5!

47. 30. 81935 | 6° 60 77°34 108°8 2°81" TIA: o

50 27-10-1935 12-0) 89°13 3B] 072) TOS) Lab

52 | 18-11-1935 | 24° 1 88°76 124°] 0°92 58° | Tl

Mean Values ... ... 15°54) 86°81] = 118°8 1:76 66°8| 82

\_ \_\_t \_ a

Taste VI.--PerRcentaGH YIELDS or Fat anp rts CoNsTaNts

FRoM THE FPLEsH or S, Epa.

; log yield off. % yield oft, .. Acid

sot anh tie, ayo ai

sam ple aco in the cor atty! matter in ue of UM) OF the

extract extract acids extract |22P: Matter! extract

8 20-10-1933 24°25 89° 80 lilo l O° 72 63°9 5° 6

12 10-11-1933 23°85 86°90 80'°5 0°88 56°5 4°5

18 3~ 1-1934 29°42) lost — lost — 17°5

28 25- 7T-1935 4°23 78°34 133°9 3°71 78° 8) no oil

30 29- 7-1935 2°55 = 138°0 4°56 74°0) ,,

32 29-— 7-19385 2°76 — 136°0 3°95 81°6) ,,

35 3— 8-1935 3°43) — 125°8 3°79 77°72),

37 38— 8-1935 3°34, 125°6 4°24 89°22),

39 15— 8+-1935 13°22 85° 69 121°8 1°49 79°3| 18°6

41 15- 8-1935 11°41 86° 64 126°3) 1°61 90°6) = 20°7

—— i = - - : eo pee oe

Mean Values ... 11°05 83°88 124°4 2°79, 76°8| 13°4

a [XS —

From the figures recorded in Table V and in Table VI, it is clear

that the fluctuations in the fat content of flesh are very similar to

those previously described in the case of the estimations of that of

the whole fish.

Here again it was found out that during the feeding season the

fat content of the flesh from 8. aurita Table V was lowest at 12 per cent:

in October ; rose to a maximum 28°21 per cent in December, and

ended in January at a value 24-46 per cent giving a mean value for

the whole fishing season 21°37 per cent of the fresh flesh In Table VI

three samples only Nos. 8, 12 and 18 were taken during this period

for the analyses of the flesh of S. eba-the fat content in them

varied from 23°85 per cent to 29°42 per cent with a mean value

25°84 per cent.

On the other hand the fat content of the flesh during the summer

fishery, May to August, is represented in Table V of 8. aurita with

four samples--its value varied between a minimum 2°65 per cent in

July and a maximum 9°16 per cent in August, with an average value

for this period of 5°33 per cent of the fresh tissue. In the case of the

flesh of 8S. eba Table VI seven samples were taken during this period,

the fat content in them varied between the two extremes 2°55 per cent

in July and 13-22 per cent in Angust giving a mean value of 5°85 per

cent.

In the case of S. aurita Table V the two samples 44 and 47 and in

the case of S. cba samples 30 and 32: 35 and 37: 39 and 41 are of

particular interest since each pair was taken on the same day under

simular conditions and from the same catch to show the difference,

if any, between the two sexes. The results obtained for the per-

centage yield of fat of the two sexes are tabulated in the following

table :-—-

| Males Females

Date poy ~: \_

| Sample No. | % fat | Sample No. | % fat

. en fo a =|

29-7-1985 0. oe | BO) BE BD TG

8-8-1985 ee el BT BBA BR BB

15-8-1985 ... ee ee

BU-B-1985 0 916 5 AT | 616

|

These figures show a close similarity between the two sexes in

the fat content. The apparent difference between the two samples

39 and 41 and the two samples 44 and 47 is probably attributed

to individual variations rather than to a sexual difference.

The seasonal changes in the percentage yields of fat from the

flesh of the two species 8. aurita and 8. eba are graphically expressed

in Fig. IL, assuming the continuity of sampling as was done in Fig. I.

Whenever more than one sample of flesh were taken from the

same species in any month, the mean values of the percentages of

fat were taken.

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May June July Aug, Sep. Oct. Nov. fee, Jan,

Fic. IT.—Variation in the Hat-content of the flesh of S. aurita and

S. eba during fishing months (May-Jan.)

Fig. [1 indicates a steady rise in the fat content of the flesh of

both fishes from summer, when ripening and maturing fish were

caught, to the autumn and early winter. when the fish were extensively

feeding.

— 0 —

The maximum amounts of fat were apparently attained later on,

at about the end of the fishing season. There was only one sample

No. 22 taken on June 30, for the flesh of 8. granigera. The ethereal

extract of the flesh was 3°14 per cent of its fresh weight. The yield

was insufficient for the analyses to be carried out.

The variations in the properties of the ethereal extracts of flesh

from both fish 8. aurita and S. cha show close similarities to those

of the ethereal extracts of the whole fish previously explained.

The extracts of the spawning period gave comparatively lower

percentage vields of fatty acids with more unsaturated nature: higher

percentage vields of unsaponifiable matter with increased iodine

values ; and a definite rise in the acid number, while the properties

of the extracts of the feeding period varied in a reverse sense. The

mean values obtained for the properties of fat from the flesh of both

species during the two periods of feeding and spawning are recorded

in the following table :--

“a.

Mean % Yield of, Mean Iodine ‘yoano/ yield of| Mean Todine [yan Acid

| fatty acids value of fatty | unsap. matter value of unsap- | number

Species acids matter |

" oe - ae Be foe an +

i 1g : | . 7 |

Feeding Spawh- Feeding Spawn- Feeding | °P®¥™"\ Feeding Spawn- Feed.) BY

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tt —\_ ~ ae a a ' \_ cece oe is)

| |

S, aurita) 88°24, 82°55, 112-2) [26°33 0°88 BBE 609. TT-O! 87-2) —

| | : ; |

8. eba 88°35, 82°25: 95°38 128°0. 0° 80) 3°34. 60°72, 826) 9° 219°7

ee ee

PART IIT,

The Fat-Content of the Gonads

During the mouths July and August 1935 maturing and ripening

fish mainly of S. eba were caught with their gonads at the stages ITI,

TV and V of Hjort’s scale.

Samples of ovaries and testes of S. eba and S. aurita were taken

and treated in the same way as in the case of the flesh of each species

for the estimation of the fat content.

Due to the rarity of S, aurita in the summer catches, only 4 samples

taken for the maturing reproductive organs of this fish—2 for each

sex with their particulars ag recorded in Table VIL.

— 31 —~

Tasir VIL---VaRIATION IN THE PERCENTAGE YIELDS AND THE

PROPERTIES OF THE ETHEREAL EXTRACTS OBTAINED FROM TESTES AND

Ovartes or 8S. ARITA,

° Yield of % Fatty ' Todine values | % Unsap. | Todine value

No of; — ether acids in the of matter in of unsap.

Date jSam- extract extract fatty acids | the extract matter

ple Hi a \_

ot} 2 | ot 2 | 18 | ot 9 | oF Q

a en a a i

;

- 1 95/495) — | — | - a7) — j12°57) ~~ TB

719285 .

IT1989 dg) Ir-agl —— |50°53) L456) L665] — lez

‘ | 4516°03; —- |59°80! -— |108°6) — | 10°0,; — |70°2

81935 Bi i

30-8-1935 | 48) ~~ 16°88) 152738) -— 10374) -— 79 — 163°2

Mean Values ,..,5°49/7°06/59° 80/51°45/127°8)124°5 11°28/14°22)73'1 |62°8

pot

These data show a difference in the mean value of the percentage

yields of the fat content between testes and ovaries—the respective

values being 5-49 and 7:06. There are also apparent differences be-

tween the percentage yields of fatty acids and between the yields

of unsaponifiable substances in the extracts of testes and ovaries, but

it is not safe to make any deductions from only two analyses of each

sex. These differences are dealt with later when the results obtaimed

for 8. eba are discussed.

The variation in the amounts of fat content of the gonads of

S. eba with their properties are recorded in Table VIII.

TasLe VITL.--VariatioN In THE PERCENTAGE YIELDS AND THE

PROPERTIES OF THE ETHEREAL EXTRACT OBTAINED FROM TESTES AND

Ovaries or S, Epa.

= : 7

2 % Yield % Fatty | Iodine Value % Unsap. | Todine value

q of ether | acidsinthe | of fatty acids matter in of unsap.

Date R extract | extract in the extract | the extract | matter

rs) ee me es a | ee a

: | | | .

& ot | & ut | 2 | gt Pit | Pid ?

ee ee

\ 31/412; - 38°69 ~[ on. ee [813 Sh! es

29-7-1985 2.2 33 -'702) = HORT, = 132-8! 11°96) —- | 79°6

/ 341 16°90. — 68°32) 139°5' =~ [LE L0) --- | 85-9

5-8-1935 N86) 2 IT 72» - 56°69) 11679) - 12°12 - | 75-1

( 383°79) —- 39°06 1084 == LAT) 1688 |

I

\ 40.472) — 51390 1275, L099) TL

15~8-1935 ... “ ; . — — - -

PBL 301 595 g0r89 LLG) TY, = TRU

Mean Values £1669 43°05 58°90 115512675 14°86 LP 24731 782

pot |

— 22 -—

These figures show that the mean values of the percentage yields

of ether extracts from the gonads of S. eba varied between the two

sexes—being in milt 4°16 and in roes 69. This result fairly agrees

with the corresponding mean values in Table VIT obtained from the

analyses of the gonads of 8. aurita.

The amount of fatty acids in the extracts also varied between

males and females -its meat value in milt being 43°05 per cent and

in Ovaries 58°90 per cent. On the other hand, the yield of unsaponi-

fiable matter varies in the reverse sense, i.e. 14°86 per cent in males

and 11°24 per cent in females.

The mean value of the iodine numbers of fatty acids showed a

difference between testes and ovaries, being in the former 115°5 and

in the latter 126-5. The analyses showed also a corresponding dif-

ference in the average iodine values of the unsaponifiable substances,

being intestes 73-09 andin ovaries 78°15. This difference in the iodine

values between testes and ovarics indicates that the fat of the testes

is more saturated than that of the ovaries, but this point—due to the

few analyses dealt with here- needs a farther study before it can be

finally settled.

CONCLUSION

The variation in the chemical composition of a species of fish

does not only occur between individuals, but it also occurs with the

different seasons of the year. This result was established by several

workers on the chemical composition of food fishes--among whom

Atwater (1888), who analysed 52 species of American food fishes ;

Clark and Aly (1918) in their work on 20 species of Atlantic food

fishes > Dill (1921) in bis study of a number of Pacific food fishes ;

Balland and Hollande in their study of Kuropean food fishes, and Saby

(1938) m the work on the dietetic value of 22 species of Egyptian

focd fishes may be mentioned.

The amount. of fat present in species having a low fat content

docs not undergo wide variation between individuals. On the other

hand the fat contents of fat-rich species such as: salmon, herring,

shad. sardine, ete.. show striking variations between individual fish,

between species in different localities and at different seasons of the

year,

The works of Vaescher-Ruesch on the Rhine salmon; Paton on

the Scotch salmon: Green (1919 and 1921) on the Pacific Coast

salmon: Milroy (1906. 1907. 1908) on the museles and gonads of

Loch Fyne herrings: Johnstone (1915, 1918. 1919. 1920) on the

estimations of the nuscle fat of Manx-herrings : Bruce (1924), Chan-

non and Saby (1932) on the fat metabolism of the Manx herrings

— 33 —

strikingly show that the fat stored in the body during the periods of

growth and feeding is the immediate source of energy expended by

the fish at the time of its spawning migration, when no food is taken.

The analyses of the three species of Sardinella were undertaken

over a period long enough to show the range of variations in the fat

content of whole fish. flesh. and gonads. The results of the analyses

showed a close similarity to those obtained by the different authors

in their investigations on herring, salmon, shad, etc., and can be

concluded in the following :—

(1) The comparison of the mean values obtained for the fat

content and its properties of whole fish, flesh, and gonads of 8. aurita

and §&. cba shows that these values are essentially identical in both

species all the year round. When 8. granigera appeared, it showed

similarity to the other two species.

(2) Radical changes occurred in the tissues as regards the fat

content and its properties. These changes could be pictured for the

two periods when the mean values of the results are tabulated such

as in Table EX.

Tapie UX, Misan Vabves or Far Content anb trs CONSTANTS FOR

Wuo tk Fisu ann FLesH of S, AugitA AND S, EBA puRING THE Two

PERIODS oF Ferping AND SPAWNING.

i | . 1 .

- ee ee

Period extract: acids fatty acids, Metter lsap matter) Yelue

atty acids Isap. |

ee \_ ae —\_— \_\_ — te

5 | |

os \ Feeding

= S. aurita ... | 31-12 89-18 | 105-3 0-80 | 64-7 6-08

{Spawning ... | 6-42) 84-82 | 182-5 3-62) 74-2 | 23°62

eo

Feedin |

od ; g

Es S.eba | 23-61 | 88-30 103-7 O84 | 60-6 8-69

| Spawning 6-56 82-80 | 187-2) 3-06 78-6 | 19-67

|

These figures show :—-

(a) Close similarity between the mean values obtained for the

analyses of the whole fish and flesh during the two periods

of feeding and spawning save the percentage yield of the fat

content of whole fish during feeding period was greater than

that of the flesh due to the presence and accumulation of the

“ Mesenteric fat” round the alimentary tract.

(6) The increase in the fat content of whole fish and flesh from

the spawning period to the feeding period in both species

S. aurita and 8. eba caused—an increase in the percentage

yield of fatty acids with a definite fall in their iodine values ;

a decrease in the unsaponifiable substances with an apparent

decrease in their iodme values ; and a striking fall in the acid

values of the extracts.

(3) Neither specific nor sexual differences were observed between

males and females of the two species 8. aurita and 8. eba as regards

difference in the fat content and the properties of the fat.

— 95 —

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