LXVI.—*The Composition of Cooked Fish.*

By Miss KATHARINE I. WILLIAMS, Associate of University College,
Bristol.

THE investigations described in the following pages were commenced at the suggestion of Dr. Ramsay, and I have received much kind assistance from Dr. S. Young, in the way of advice as to working details.

The main object of the work was to gain information regarding the composition of foods as served at table.

Most of the previous work on this subject deals with analysis of raw foods, as may be seen by reference to "Die Menschlichen Nahrung und Genussmittel," by Dr. König; "Precis des Substance alimentaire," by Payen; or to "The Chemical Composition and Nutritive Values of Food-Fishes and Aquatic Invertebrates," a monograph extracted from the report of the U.S. Commissioner of Fish and Fisheries for 1888, where full details will be found of Dr. W. O. Atwater's own investigations, as well as of those of several European analysts. As explained in the author's previous paper on "The Composition of Cooked Vegetables" (Trans., 1892, 61, 226), little is known with regard to the changes produced during the processes of cooking. Of the fish used, a considerable number were bought when in full season from fishmongers in Clifton, whilst the cod, lemon soles, and turbot came from Grimsby.

General Preparation of the Samples used.

The fish was prepared just as it would be served at table, first cleaned, and then boiled in undistilled water, as supplied by the Bristol Water Company, which shows about 26 degrees of hardness, chiefly due to calcium carbonate. The salt cod and herrings were soaked in cold water for several hours before cooking to dissolve out some of the salt; while the sardines and tunny were well washed in both boiling and cold distilled water, to remove as much of the surface oil as possible. When cold, all the bones, head, and such portion of the skin as would not be eaten were removed and carefully weighed, crushed with a pestle and mortar, boiled in distilled water, the filtrate siphoned off, and evaporated over a water bath till the weight of the residue was constant; this residue was taken as gelatin.

Name of fish.	Date.	Portion analysed.	As served at table.			
			Waste bones, &c.	Gelatin.	Water.	Nutrients.
Herrings	February ...	Whole	11·74	0·63	52·99	34·54
Salt herrings	January	Flesh	—	—	46·03	53·97
Sprats	November...	Whole	17·90	0·90	61·50	19·70
Sardines	March	Whole	4·91	—	42·17	52·92
Salmon	July	Section	5·99	0·53	61·06	32·02
Salmon peal	July	Section, body and head	17·87	0·21	33·51	48·41
Trout	May	Whole	8·23	0·55	67·12	24·10
Smelts	March	Whole	18·86	0·38	65·20	15·56
California salmon	Spring catch	Flesh from section.	—	—	61·90	38·10
Eels	October	Heads removed ...	11·66	1·09	53·29	33·96
Red Mullet	February	Whole	24·28	2·41	50·05	23·26
Roach	January	Whole	24·37	0·65	56·52	18·46
Gurnet	February	Whole	46·30	0·65	39·13	13·92
Mackerel	April	Whole	10·51	0·25	65·21	24·03
Tunny	May	Flesh from section.	—	—	63·49	36·51
Cod	January	Section	15·99	0·43	63·78	19·79
Salt cod	February	Section	6·13	0·33	67·68	25·86
Haddock	January	Whole	35·10	0·80	46·46	17·64
Whiting	January	Whole	21·50	0·86	61·29	16·35
Hake	February	Section	7·84	0·26	78·01	13·89
Turbot	February	Anterior and head..	31·20	0·59	53·09	15·12
Brill	March	Section	8·19	0·19	57·49	34·13
Halibut	May	Section	6·84	0·03	69·35	23·78
Plaice	December	Flesh	—	—	79·86	20·14
Soles	March	Whole	22·02	0·74	61·18	16·06
Lemon soles	January	Whole	26·17	1·42	56·56	15·85
John Dory	June	Whole	20·91	0·98	60·82	17·29
Oysters	March	Shell contents	—	—	77·71	22·29

Method of Analysis of the Flesh.

The methods employed were as follows.

Determination of Water.—Every sample of the flesh of the fish was broken up into small pieces, and the surface water removed before the process of drying was commenced. A small portion of each fish, weighed in an evaporating dish, was heated from 12—24 hours, first in a steam bath, and then in an air bath at a temperature which did not exceed 110°. When the sample was fairly firm, it was allowed to cool in a desiccator, weighed again, reduced to powder in a coffee mill, or in samples containing a high percentage of fat crushed in a mortar. The residue was again weighed, placed in the air bath, and kept at a temperature not exceeding 110° until the weight remained constant; from these results, the percentage of water was calculated.

Carbon and hydrogen were estimated by the usual method.

Nitrogen.—The nitrogen was determined by Ruffle's, the soda-lime, and Schloesing's methods.

Ash.—The ash by combustion in a current of oxygen.

Sulphur and phosphorus by fusion with mixtures of sodium carbonate and potassium nitrate, and final estimation of the sulphur as barium sulphate, and of the phosphorus as magnesium ammonium phosphate, the percentage in the latter case being calculated from the pyrophosphate after ignition.

Fat.—The fat was extracted by means of ether vapour.

Reducing Substances reckoned as Glucose.—The fat was first removed by benzene, then solutions were prepared from the residues by digesting the fish-powder with 10 c.c. of hydrochloric acid (sp. gr. 1.125) and 100 c.c. of water, in a flask connected with a reflux condenser the whole was heated as strongly as possible over a water bath for 3 hours, the solution was then filtered, treated with basic lead acetate, and, after filtration, a current of sulphur dioxide was passed through the liquid to precipitate any lead present. The solution was filtered, concentrated at 100°, and a little washed alumina added until it was no longer dissolved; the solution was again filtered, evaporated to dryness over a water bath, the residue treated with boiling alcohol, filtered, and the alcohol distilled off. The residue was dissolved in water, and as all the solutions obtained in this way were coloured, they were boiled with animal charcoal and a few drops of milk of lime, and filtered before being titrated with Fehling's solution.

The proteids were determined by multiplying by 6.25 the nitrogen estimated by the soda-lime method.

Heats of Combustion.—In this section, the method used is the same as that adopted by the author in the case of "cooked vegetables," namely, that described by W. Thomson in a paper "On a New Apparatus for readily determining the Calorific Value of Fuel or other Organic Substances by Direct Combustion," published in the "Journal of the Society of Chemical Industry," vol. v, No. 11. The water value of the apparatus used was carefully calculated according to the directions given in the article. To secure accurate results, a series of experiments was first made with cane-sugar, giving a mean of 4021.35 calories, as compared with 3961.7 Berthelot and Vielle, and 4145.0 Rechenberg calculated from numbers given in the *Comptes rendus* (1886, 102, 1284).

As soon as the preliminary experiments were finished and the apparatus was proved to be in good working order, investigations were begun with the powdered fish; at least three determinations were made in every case.

In the table appended are the results of the various determinations, both those obtained by proximate and ultimate analyses, as also the heats

	Water in flesh.	Ultimate analysis of the dried substance.						Heats of combustion calculated from ultimate analysis.	Difference = Absorption of heat.	Proximate analysis of the dried substance.				
		Ash.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.			Phosphorus.	Fats, or ether extract.	Proteids.	Reducing substances reckoned as glucose.	Nitrogen pentoxide.
Clupeidae.....	60.54	5.56	7.73	46.29	11.11	27.97	0.43	0.91	4655.63	6405.10	1749.47	25.25	67.07	0.66
<i>Clupea harengus</i> , Herring.....	46.03	19.69	7.32	48.13	7.12	26.22	0.63	0.89	4133.75	6412.60	2278.85	21.90	38.88	1.64
<i>Clupea harengus</i> , Salt herring.....	75.77	6.42	6.66	51.50	9.26	24.43	0.56	1.17	5019.30	6459.50	1440.20	27.37	57.94	9.88
<i>Clupea pinnatus</i> , Sprats.....	44.35	12.03	7.69	51.49	8.54	18.63	0.55	0.97	5135.90	6811.50	1675.60	33.49	55.44	—
<i>Clupea pilechardus</i> , Sardines.....	65.32	4.94	7.28	45.58	10.70	30.58	0.41	0.51	5532.00	6104.10	852.10	29.43	56.65	0.46
<i>Salmo salar</i> , Salmon.....	49.90	3.64	6.11	52.25	6.90	30.14	0.39	0.57	5142.45	6328.90	1176.45	43.95	41.61	13.10
<i>Salmo trutta</i> , Salmon pike.....	75.58	6.60	8.31	48.74	11.96	22.16	1.11	1.13	6153.16	6805.70	1648.54	8.84	80.00	4.68
<i>Salmo fario</i> , Trout.....	80.73	4.73	7.48	48.01	11.61	25.59	0.63	0.92	4551.70	6456.90	1903.50	9.76	82.59	9.17
<i>Oncorhynchus chonticha</i> , California salmon.....	61.90	5.65	8.34	54.91	8.80	21.16	0.47	0.58	4960.05	7350.10	2390.05	34.27	56.56	4.31
<i>Anguilla vulgaris</i> , Eel.....	68.26	5.43	9.66	51.31	7.36	25.82	0.44	0.42	5270.70	7412.10	2141.30	44.68	42.88	8.91
<i>Mullus surmuletus</i> , Red mullet.....	73.37	1.08	7.48	48.93	13.03	28.22	1.03	0.89	5003.03	6437.30	1384.97	24.52	66.26	9.79
<i>Trachurus radiatus</i> , Roach.....	73.77	3.53	6.10	45.75	14.24	29.17	0.64	0.47	5303.60	5801.50	1484.27	15.03	79.14	6.22
<i>Trigla gurnardus</i> , Gurnet or Gurnard.....	73.13	4.07	8.17	47.93	10.46	28.19	0.33	0.47	5303.60	5801.50	1497.90	1.81	89.16	—
<i>Scomber scomber</i> , Mackerel.....	73.13	4.07	8.17	47.93	10.46	28.19	0.33	0.85	4773.65	6388.10	1914.45	25.73	62.32	13.93
<i>Oreogobius thynnus</i> , Tunny.....	63.49	5.52	8.58	54.73	10.55	19.66	0.70	0.26	5080.30	7350.10	2299.80	30.68	66.08	—
<i>Gadus morhua</i> , Cod.....	76.32	3.31	8.10	48.43	15.30	23.70	0.54	0.62	5072.83	6707.10	1034.27	1.15	91.55	0.63
<i>Gadus aeglefinus</i> , Haddock.....	72.37	3.28	7.30	46.43	13.11	28.60	0.75	0.29	4546.56	5297.96	751.34	0.94	76.06	0.31
<i>Gadus morhua</i> , Salt cod.....	72.37	3.28	7.30	46.43	13.11	28.60	0.75	0.53	5212.80	6267.30	1054.50	1.29	79.57	0.43
<i>Merluccius vulgaris</i> , Hake.....	84.88	3.90	7.19	46.38	12.86	23.22	0.69	0.76	4328.15	6060.90	1899.95	5.67	81.36	13.94
<i>Merluccius merlangus</i> , Whiting.....	78.78	1.92	7.62	46.36	13.28	23.20	0.89	0.73	5190.73	6228.10	1183.07	1.76	79.55	—
<i>Gadus merlangus</i> , Turbot.....	77.84	2.41	7.16	44.46	13.76	31.16	0.48	0.57	5224.00	6060.90	836.90	4.75	84.71	11.81
<i>Rhombus maximus</i> , Turbot.....	62.74	4.42	7.25	45.87	15.49	25.55	0.73	0.69	5305.16	6204.70	999.54	1.62	99.95	—
<i>Rhombus lentus</i> , Brill.....	74.46	4.11	7.34	48.62	13.32	25.32	0.62	0.70	5216.03	6406.10	1244.07	15.81	79.67	—
<i>Hippoglossus vulgaris</i> , Halibut or Holibut.....	76.86	4.06	7.45	47.98	13.02	26.37	0.51	0.71	5765.76	6544.60	678.94	9.84	79.16	2.78
<i>Pleuronectes platessa</i> , Plaice.....	79.20	3.47	6.99	42.68	14.00	31.76	0.63	0.52	5846.70	5853.70	7.00	1.71	86.71	11.87
<i>Solea vulgaris</i> , Soles.....	77.89	2.06	7.09	46.01	13.32	30.32	0.94	0.54	4652.20	6077.70	1425.50	8.52	79.53	0.13
<i>Solea lascaris</i> , Lemon soles.....	78.11	4.42	7.91	48.97	11.04	26.61	0.51	0.54	5572.43	6689.40	1116.97	12.96	69.58	14.80
<i>Zeus fabar</i> , John Dory.....	77.89	2.06	7.09	46.01	13.32	30.32	0.94	0.26	4652.20	6077.70	1425.50	8.52	79.53	0.13
<i>Ostrea edulis</i> , Oyster.....	77.71	12.16	7.15	41.23	11.85	25.51	1.81	0.49	5363.63	5796.10	432.47	7.77	65.42	—

OXIDATION PRODUCTS OF $\alpha\gamma$ -DIMETHYL- α' -CHLOROPYRIDINE. 653

of combustion ; two other columns of numbers have also been added, giving the heats of combustion calculated from the results of the ultimate analysis, and the differences between these and the heats of combustion actually found by experiment are considered as absorption of heat in building up the flesh constituents.