XXXVIII.—ON THE RELATIVE DIGESTIBILITY OF FISH FLESH IN GASTRIC JUICE.

By R. H. Chittenden and George W. Cummins.

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The value of food as nutriment depends primarily upon the presence in suitable quantity of elements, or combinations of elements, capable of supplying the needs of the body; coupled with this, however, is the ease with which the food stuff in question can be rendered available by the system for its wants. This, or in other words its digestibility, constitutes a very important item in determining the true nutritive value of any food. If, of two foods possessing a like chemical composition, one is more easily digestible, that one, though containing no more available nutriment than the other, is in virtue of its easier digestibility more valuable as a food stuff, and in one sense more nutritious as well as more economical for the system.

Both chemists and physiologists have appreciated the importance of all data relative to the nutritive value of foods. But hitherto nearly all work in this direction has been confined to a study of chemical composition, and only occasionally to digestibility. The mere fact, however, that a substance contains a certain percentage of nitrogen is not alone sufficient. We need to know in addition, not only how much of the nitrogen passes through the body unabsorbed, thus indicating how much is ordinarily available for nutriment, but we need to know likewise how long the food stuff remains in the stomach, how quickly it is acted upon by the digestive juices, and, finally, how much passes out undigested—points of great importance to the healthy system, but still more so to the system weakened by disease.

There are two ways of determining the digestibility of a food stuff in gastric juice. One consists in the introduction of a weighed amount of the subtance into the stomach of a man or animal through a fistulous opening, and noting the length of time required for its solution; the other, in the use of an artificial gastric juice by which the amount of substance capable of being dissolved and digested in a given time can be quantitatively ascertained. The first of these methods was made use of by Dr. Beaumont in his celebrated experiments on the Canadian, Alexis St. Martin, about 1830, and has been employed many times since with animals by other workers. While it would appear in some respects to be the better method, there are reasons why it is not so advantageous as the other, mainly because it is not capable of showing such small differences, it is not free from nervous influences and personal idiosyncrasies, and, lastly, it is less convenient. The method with artificial gastric juice, on the other hand, admits of the conditions being the same in each case; and, since the digestion of a food is by itself simply a chemical process, it would seem better in a determination of digestibility that the process be shorn of all those conditions, natural or otherwise, which tend to interfere with the purely chemical action of the digestive juice.

Few experiments appear to have been made on the digestibility of fish; this is the more strange when we consider what an important item of food fish constitutes, particularly along our seaboard. Yet the idea is prevalent, based apparently on general grounds, that fish flesh is not easily digestible. Thus Maly[1] mentions that "fish flesh is difficult of digestion, although the reason is not known." Still, as Voit[2] remarks, "nothing certain is known regarding the digestibility of different kinds of flesh, although much is said concerning it. Probably digestibility is in part dependent upon the nature of the fat present and the manner of its distribution; thus the presence of a difficultly fusible fat with considerable stearin would tend to hinder digestibility (as in mutton); the same thing probably occurs when the contents of the sarcolemma are permeated with much fat (as in the lobster and eel)." This statement at once suggests the probability of great variation in the digestibility of the flesh of any one species, dependent on a large number of conditions, which, in the case of fish particularly, are somewhat difficult of control; thus age, sex, food, period of spawning, length of time they have been preserved, are a few of the many natural conditions which would tend to modify the digestibility of the flesh and render generalizations from even a large number of results somewhat uncertain.

Still, as no systematic experiments appear ever to have been tried with fish flesh, we have attempted to obtain some positive results concerning the relative digestibility of the more common edible species, as well as the general digestibility of fish as compared with beef, veal, lamb, &c.

THE METHODS EMPLOYED.

The gastric juice.—For reasons already given, artificial digestion was chosen as the best adapted for the purpose, and with this end in view a gastric juice was needed which should be both constant in composition and activity during the length of time required for trying the experiments. A large quantity of so-called "pure pepsin"[3] was

[1] Hermann's *Handbuch der Physiologie*, 5, 112.

[2] *Ibid.*, 6, 447.

[3] Manufactured by Henry Thayer & Co.

obtained, thoroughly sampled, and then placed in a tightly stoppered bottle and kept in a cool, dry place to prevent change. The acid used was pure hydrochloric of exactly 0.2 per cent strength. From this material fresh gastric juice was made for each series of experiments, 5 grams of the pepsin being dissolved in 1 liter of the dilute acid. This furnished a digestive mixture of suitable strength, and, as subsequent experiments showed, well adapted to the purpose.

Preparation of the flesh.—In order that a fair sample of the flesh might be obtained in each case, 100 grams, freed from tendons, fat, skin, and bones, were weighed off and finely divided by chopping. Small portions of the sample tissue were then taken for a determination of the amount of solid matter,[1] and then two portions of 20 grams each were weighed out to determine the digestibility. These two latter portions were placed in small porcelain mortars covered with watch glasses, and then set into a steam-bath heated by a large gas flame for 30 minutes. This bath was a small copper oven, on the bottom of which was a layer of water 1 or 2 inches in depth, while some distance above this was placed a perforated plate upon which the dishes were set, the whole provided with a tightly fitting cover, with a small outlet for the escaping steam. Heated in this for half an hour the fish or meat was thoroughly and evenly cooked without loss of any extractives, and being in mortars, the tissue after steaming could be ground up fine without loss. The flesh was then ready for digestion.

The digestion.—As already stated, two separate or duplicate determinations were made of each sample. Each portion of 20 grams was placed in a beaker with 200 cubic centimeters of the standard gastric juice, covered with a watch glass and set into a bath heated at 38° to 40° C. for 22 hours with occasional stirring. This bath consisted of a metal box with a movable cover, and having about midway of its height a perforated plate upon which the beakers were placed. The bath was filled with water to such an extent that the beakers were immersed about half an inch. The space above, when the bath was closed, was of course saturated with aqueous vapor, and thus any evaporation of the contents of the beakers was prevented. The temperature was kept quite constant by a small gas flame, and the extreme variations were not more than 35° to 42° C., these occurring only during the night and early morning. The length of time the mixtures were heated, namely, 22 hours, was no longer than was necessary to insure accurate and concordant results. In an artificial digestion the accumulation of the products formed tends to retard the action of the fluid, but in no case were our results impaired by saturation of the digestive mixture, for that this could never have occurred ordinarily is plainly shown by the large amount of *blood fibrin* dissolved by the gastric juice in a trial experiment. The addition of larger amounts of flesh, moreover, in the case of fish, 30 to 40 grams, simply diminished the digestive action.

[1] Determined by simply drying at 100° C. until of constant weight.

Determination of the amount digested.—This can be accomplished by either weighing the undigested residue, or by determining directly the amount dissolved. In a recent work by Jessen[1] on the influence of different modes of preparation on the digestibility of meat, the former method was used. Unless the amount of water contained in the meat experimented with, however, is determined, a very decided error may be introduced. Thus Jessen found by experiment with frogs' legs[2] that 2 grams of the raw flesh, introduced into the stomach of a dog, required on an average 4.46 hours for digestion, while the same amount of beef, similarly prepared, required on an average 5.58 hours, and thus from this experiment the relative digestibility of the two would be as 84:100. Our experiments, however, show quite a different result, easily explained by a determination of the percentage amount of solid matter in the two kinds of flesh. Thus, while 20 grams of beef contain on an average 5.1 grams of solid matter, the flesh of frogs' legs contains but 3.5 grams. It is evident from this example, then, that a determination of the total solid matter is necessary in each species of flesh; but even when that is done, and corrections made accordingly we have found a decided difficulty in filtering the digestive mixtures. The undissolved residue of the fish is so gelatinous that it is next to an impossibility to wash it entirely free from peptones. We therefore decided to work with the filtrate, and after several trials by precipitating the dissolved albumen with tannic acid, according to the method of Johnson,[3] and also by determining the specific gravity of the fluid after filtration, we finally adopted the following method, which has proved quite satisfactory. After the gastric juice has been allowed to act for the requisite length of time on the 20 grams of flesh the mixture is cooled to 20° C., and then diluted to 250 cubic centimeters, in a graduated flask, with distilled water. After being thoroughly mixed it is filtered on a dry filter, and then 50 cubic centimeters, or one-fifth of the entire mixture, is transferred by a pipette to a small weighed dish, and to it are added 5 cubic centimeters of a standard solution of sodium carbonate of such strength as exactly to neutralize the acid present. The fluid is then evaporated to dryness on the water-bath, and finally dried at 110° C. until of constant weight. In order that the results obtained may express the absolute amounts of matter dissolved by the gastric juice, it is necessary to carry on control experiments with the gastric juice itself. This is also desirable as a proof of the uniform strength of the gastric juice. Thus in each series of experiments 200 cubic centimeters of the standard juice were warmed at 38° to 40° C. for 22 hours, so that all albumen contained in the pepsin could be converted into peptone, then diluted to 250 cubic centimeters and 50 cubic centimeters, neutralized, evaporated, and dried as already described. This residue, subtracted from the

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[1] *Zeitschrift für Biologie*, 19, 130.

[2] *Ibid.*, p. 140.

[3] *Bulletin de la Société chimique de Paris*, 23, 40.

weight of the residue left by the evaporation of the 50 cubic centimeters of the digestive mixtures, multiplied by 5, gives quite accurately the amount of matter (peptones and intermediate products together with some salts) dissolved from the 20 grams of flesh. Theoretically there are one or two minor objections to this method, the most noticeable, perhaps, being the variable amount of undigested residue suspended in the fluid diluted to 250 cubic centimeters. The amount of space, however, occupied by this matter is not large, and its influence on the accuracy of the method not great. Again, by the evaporation of the peptones, and drying at 110° C., there is doubtless some slight oxidation, but still it cannot be great, as the dried residue is soon brought to a constant weight. While the method seems longer than to weigh the undissolved residue, it is by far more accurate, and in the end we believe shorter.

The fish experimented[1] with were obtained at a local market, and, while always quite fresh and in good condition, we had no means of knowing how long they had been out of water.

In all of the experiments the flesh was cooked by steaming, unless otherwise expressed.

Tables I to V give all the data of the experiments, while Table VI contains the average amounts digested of each sample of cooked flesh, together with the relative digestibility as compared with cooked (steamed) beef, taken as 100.

A glance at the results of the control analyses of the gastric juice alone plainly shows the constancy of its composition. The strength and activity of the digestive mixture, moreover, is easily seen from the amount of blood fibrin (Table IV) dissolved by 200 cubic centimeters of the fluid; an amount far in excess of the fish or beef dissolved by the same quantity of fluid.

The results of the analyses show plainly that the method adopted is as good as could be expected, for it must be remembered that the two results obtained from each sample of flesh are not merely from duplicated analyses, but from duplicated digestions as well, and in these, extending as they do over 22 hours, with slight variations in temperature and agitation, small differences are to be expected. The very great divergence noticed, however, in the results obtained from different samples of the same species of flesh show at once that there are other conditions, such as age, &c., which affect the digestibility of the flesh more or less, so that, in order to obtain results from which to draw strict generalizations, it would be necessary to experiment with fish of different species, of like age, sex, and reared under like conditions. As examples of this we have the very divergent results from two samples of veal, and also of two bluefish (88.69 and 73.44). As direct evidence that age, sex, &c., do exert a modifying influence on the digesti-

[1] For composition of the fish experimented with, see "*Zur Chemie der Fische,*" *Berichte der deutsch. chem. Gesell.*, 16, 1839, by Prof. W. O. Atwater.

bility of flesh, we have three experiments on the flesh of the lobster: one with a small young lobster, a second with a large female, and a third with a large male of the same species. The duplicate digestions gave fairly concordant results; the average relative digestibility being for the young specimen 87.81, for the large female 79.06, and for the male 69.13. This shows plainly some modifying influence in the flesh itself. In composition, so far as the solid matter is concerned, there was no appreciable difference in the three samples. Bearing in mind, however, these possible variations, it is very evident from our results that the average digestibility of fish flesh is far below that of beef similarly cooked. In but two instances, in the case of shad and white fish, does the digestibility of fish flesh approach that of beef, although, from the average of our experiments, several are as easily digestible as mutton, lamb, and chicken.

Pavy[1] states that fish with white flesh, such as the whiting, &c., are less stimulating and lighter to the stomach, or more easy of digestion, than fish with more or less red flesh, as the salmon. Our experiments confirm this statement so far as digestibility is concerned. Thus the average digestibility of the salmon and trout is considerably below the average of the more digestible white fish. The difference between the digestibility of the light and the dark meat of the same fish is somewhat striking, as in the case of the shad, where the digestibility of the former was found to be 97.25, as compared with beef, while the dark flesh was 87.32. A similar difference, though very much smaller, is to be noticed between the light and dark meat of the chicken.

This difference in digestibility is in part due, without doubt, to the amount of fat present, for, as Pavy states, in the flesh of white fish there is but little fat, it being accumulated mainly in the liver of the animal, while in red fish there is more or less fatty matter incorporated with the muscular fibers. For a similar reason, eels, mackerel, and herring are, according to Pavy, less suited to a delicate stomach than some of the white fish, and our experiments show that in digestibility two of them stand below the more digestible white fish; mackerel, however, from our single experiment with the white portion of the flesh, showed a comparatively high digestibility. In all of our experiments, however, with white fish, we rejected the outer layer of dark flesh, except in the case of the shad. The varying differences in digestibility are not to be considered as due wholly to differences in the amount of fat in the flesh; thus the flesh of fresh cod contains but little fat, and yet it is one of the most indigestible of the white fish experimented with. This agrees with Pavy's[2] experience "that it is a more trying article of food to the stomach than is generally credited." Again, Pavy[3] makes the following statement, based on his experience in fish dietetics, "of all fish, the whiting may be regarded as the most delicate, tender, and easy of digestion."

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[1] On food and dietetics, Amer. ed., 1874, p. 171.

[2] *Ibid.*, p. 173.

[3] *Ibid.*, p. 172.

"The haddock is somewhat closely allied, but is inferior in digestibility," while "the flounder is light and easy of digestion, but insipid." With all these statements our results agree perfectly, assuming the white-fish of our experiments to be analogous to the English whiting.

Maly,[1] in speaking of the digestive processes in the living stomach, says that raw flesh is more slowly digested than cooked, probably for the reason that with dilute acids the coagulated albumen of cooked flesh is more easily converted into acid albumen. Likewise, that the flesh of young animals is more rapidly digested than that of older ones, while fat flesh is but slowly attacked, as the melted fat surrounds the muscle fibers. With reference to the first of these statements, Jessen[2] found, by experimenting with perfectly lean beef of known age, that he had only a small indigested residue in an artificial digestion of the raw beef, but with the same amount of partially boiled beef a much larger amount remained indigested, and when thoroughly boiled a still larger residue was found. Taking the amount of indigested residue as a measure of the digestibility, the proportion with the same sample of beef was as follows: Raw beef, 100; partially boiled, 167; thoroughly boiled, 317. The gastric juice employed by Jessen, however, could hardly be considered as made up of a dilute acid, containing, as it did, 2.5 and 5 per cent of concentrated hydrochloric acid.

In our own experiments, with a gastric juice containing but 0.2 per cent of pure hydrochloric acid, positive results were obtained as follows:

	First sample of beef.		Second sample of beef.	
	Raw.	Cooked (steamed).	Raw.	Cooked (steamed).
Amount digested from 20 grams	4.0792	3.8610	4.3785	4.1607
Relative proportion	100.0	94.65	100.0	95.04

The difference here, then, is not so great, though sufficiently pronounced to indicate plainly the influence of cooking.

A similar experiment with a sample of bluefish gave a like result:

	Raw.	Cooked (steamed).
Amount digested from 20 grams	3.7617	3.5885
Relative proportion	100.0	95.39

With the raw beef, however, digestion was so near complete that a second experiment was tried with a larger quantity, as follows:

	From 20 grams.	From 30 grams.
Amount digested (raw beef)	4.3785	5.7610
Relative proportion	100.0	131.57

[1] Hermann's *Handbuch der Physiologie*, 5, 111.
[2] *Zeitschrift für Biologie*, 19, 128.

This would make the relative digestibility of cooked (steamed) and raw beef as 100 : 142.38, a difference nearly as great as that found by Jessen between raw and partially boiled beef. It is plain, then, that the digestibility of raw beef is considerably greater than cooked.

Whether the relative digestibility of raw and cooked fish, given above, would be changed by increasing the amount of flesh added, we cannot say. It is a point of little importance, but from the following experiment with cooked fish it probably would make but little difference. This experiment with cooked sea-bass was tried mainly to ascertain the quantity of flesh best adapted to 200 cubic centimeters of our standard gastric juice:

	From 20 grams.	From 30 grams.	From 40 grams.
Amount digested	3.3995	3.2325	2.52
Relative proportion	100.0	95.08	74.12

In this case, increasing the amount of material plainly diminishes the digestive action.

With regard to the second statement of Maly, above quoted, our experiments tend to show that, in some instances at least, the flesh of younger animals is less easily digestible than that of older animals of the same species. This is well illustrated in the greater digestibility of mutton as compared with lamb.

TABLE I.

	First series. April 18.				*Second series.* April 21.				*Third series.* April 23.				*Fourth series.* April 25.				*Fifth series.* April 28.			
	Hippoglossus vulgaris. Halibut.		Hiatula onitis. Tautog.		Salvelinus fontinalis. Brook-trout.		Scomber scombrus. Mackerel.		Esox lucius. Pike.		Roccus americanus. White Perch.		Pleuronectes americanus. Flat fish.		Perca americana. Yellow Perch.		Roccus lineatus. Striped Bass.		Salmo salar. Salmon.	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Grams taken	5.8010	5.1408	6.6509	6.4162	4.9927	5.4913	4.6668	5.9269	7.3142	4.8280	6.9013	6.1971	6.4699	7.2258	7.7499	8.3051	7.4441	7.2179	8.9633	9.5412
Gave dried residue	1.1857	1.0350	1.3703	1.3102	.9634	1.0703	1.1755	1.5316	1.4384	.9467	1.3497	1.2236	1.1081	1.2445	1.4029	1.5069	1.5497	1.4924	2.8687	2.9580
Per cent solid matter	20.43	20.13	20.60	20.60	19.49	19.67	25.18	25.84	19.66	19.61	19.55	19.74	17.09	17.22	18.10	18.14	20.81	20.66	32.00	31.00
Average per cent solid matter	20.28		20.60		19.58		25.51		19.635		19.695		17.155		18.12		20.735		31.50	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
20 gr. sampled flesh and 200 cc. S. G. J. 22 hrs. at 40°—diluted to 250 cc. 50 cc of this + 5 cc. Na_2CO_3 gave dried residue......	1.0070	1.0124	1.0223	1.0401	lost.	.9527	1.0201	1.0113	.9139	1.0540	.9102	.8950	.8437	.8641	.8962	.8905	.9612	.9704	1.0596	1.0206
200 cc. S. G. juice diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue......	0.3160				0.3178				0.3123				0.3126				0.3134			
Residue from digestion less the gastric juice residue	.6890	.6954	.7043	.7221	....	.6349	.7023	.6935	.6016	.7417	.5979	.5827	.5311	.5515	.5836	.5779	.6478	.6630	.7462	.7072
The above × 5 or the entire products of digestion from 20 gr	3.4450	3.4750	3.5215	3.6105	....	3.1745	3.5115	3.4675	3.0080	3.7085	2.9895	2.9135	2.6555	2.7575	2.9180	2.8895	3.2390	3.3150	3.7310	3.5360
Average of the above	3.4600		3.5660		3.1745		3.4895		3.35825		2.9515		2.7065		2.9037		3.2770		3.6335	

TABLE II.

	Sixth series. April 30.				*Seventh series.* May 2.				*Eighth series.* May 5.				*Ninth series.* May 5.				*Tenth series.* May 12.			
	Sparus chrysops. Porgee.		Clupea sapidissima. Shad.		Lutjanus blackfordi. Red Snapper.		Anguilla rostrata. Eel.		Beef.		Veal.		Gadus æglifinus. Haddock.		Paralichthys dentatus. Flounder.		Bothus maculatus. Window-pane.		Prionotus palmipes. Sea-robin.	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Grams taken	7.6491	6.9193	8.2493	7.9472	6.8025	6.9713	6.5942	6.6020	5.4109	6.7188	6.2437	5.7730	6.9118	5.9901	6.9864	7.0080	6.6987	4.7163	6.3035	7.1382
Gave dried residue	1.7221	1.5647	2.6035	2.4791	1.5038	1.5406	1.4380	1.4375	1.3963	1.7681	1.5607	1.4395	1.2601	1.0941	1.6188	1.6065	1.2301	.8670	1.3676	1.5745
Per cent solid matter	22.51	22.61	31.57	31.11	22.10	22.09	21.80	21.77	25.76	26.31	24.99	24.93	18.23	18.26	23.17	22.92	18.37	18.38	21.69	22.05
Average per cent solid matter	22.56		31.335		22.095		21.785		26.035		24.96		18.245		23.045		18.375		21.87	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
20 gr. sampled flesh and 200 cc. S. G. J. 22 hrs. at 40°—diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	1.0081	1.0215	1.0536	1.0254	.9707	.9837	.9004	.8959	1.1404	1.1355	1.1553	1.1436	.9841	.9850	1.0090	1.0058	.8949	.8904	.9293	.9571
200 cc. standard gastric juice diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	0.3105				0.3164				0.3146				0.3169				0.3141			
Residue from digestion less the gastric juice residue	.6976	.7110	.7433	.7149	.6543	.6673	.5840	.5785	.8258	.8209	.8407	.8290	.6672	.6681	.6921	.6889	.5808	.5763	.6152	.6477
The above × 5 or the entire products of digestion from 20 gr	3.4880	3.5550	3.7165	3.5745	3.2715	3.3365	2.9200	2.8925	4.1290	4.1045	4.2035	4.1450	3.3360	3.3405	3.4605	3.4445	2.9040	2.8815	3.0760	3.2385
Average of the above	3.5215		3.6455		3.3040		2.9062		4.1167		4.1742		3.3382		3.4525		2.8927		3.1572	

TABLE III.

	Eleventh series. May 14.				*Twelfth series.* May 19.				*Thirteenth series.* May 19.				*Fourteenth series.* May 22.				*Fifteenth series.* June 2.			
	Salmo salar. Salmon.		Gadus callarias. Cod.		Coregonus clupeiformis. Whitefish.		Homarus americanus. Lobster. Young.		Crab.		Pomatomus saltator. Bluefish.		Cynoscion regale. Weakfish.		Veal.		Clupea harengus. Herring.		Stromateus triacanthus. Butter-fish.	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Grams taken	4.3430	4.8259	5.5281	5.8758	6.3449	4.9515	3.3703	2.8816	5.1634	5.0654	6.0347	5.0929	5.6586	5.6039	5.4457	4.4465	5.5057	4.7300	4.8831	3.7325
Gave dried residue	1.3383	1.5110	1.0194	1.0684	1.6253	1.2639	.7300	.6297	1.2195	1.1922	1.2901	1.1109	1.1279	1.1006	1.3332	1.0719	1.3483	1.1500	1.1186	.8513
Per cent solid matter	30.81	31.31	18.40	18.18	25.61	25.52	21.66	21.85	23.61	23.53	19.42	19.51	19.93	19.64	24.48	24.10	24.47	24.52	22.07	22.81
Average per cent solid matter	31.06		18.29		25.565		21.755		23.57		19.465		19.785		24.29		24.495		22.89	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
20 gr. sampled flesh and 200 cc. S. G. J. 22 hrs. at 40°—diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	1.0663	1.0495	.8922	.9015	1.0826	1.0842	1.0153	1.0388	.8621	.8591	.8712	.9421	.9090	lost.	1.0132	1.0397	.9780	.9811	.9570	.9644
200 cc. standard gastric juice 22 hrs. at 40°—diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	0.3110				0.3164				0.3123				0.3154				0.3137			
Residue from digestion less the gastric juice residue.	.7553	.7385	.5812	.5905	.7662	.7678	.6989	.7224	.5498	.5363	.5589	.6298	.5836	......	.6978	.7143	.0843	.6674	.6343	.6507
The above × 5 or the entire products of digestion from 20 gr.	3.7765	3.6925	2.9060	2.9525	3.8310	3.8390	3.4945	3.6120	2.7490	2.6840	2.7945	3.1498	2.9180	......	3.4890	3.5215	3.3265	3.3370	3.1715	3.2535
Average of the above.	3.7345		2.9292		3.8350		3.5532		2.7165		2.9717		2.9180		3.5052		3.3317		3.2125	

TABLE IV.

	Sixteenth series. May 7.				*Seventeenth series.* June 2.				*Eighteenth series.* June 2.				*Nineteenth series.* June 3.				*Twentieth series.* June 16.			
	Serranus atrarius. Sea-bass.		Serranus atrarius. Sea-bass.		Beef.		Beef.		Clupea sapidissima. Shad. Dark meat.		Clupea sapidissima. Shad. White meat.		Beef.		Beef.		Lobster. Large male.		Blood fibrin.	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*		
Grams taken	5.2485	6.0050	......	......	5.8633	5.7768	......	......	4.0414	4.4600	6.6883	5.1362	4.6522	5.0004	......	......	4.6161	5.1282	......	......
Gave dried residue	1.1153	1.2872	......	......	1.4781	1.4471	......	......	1.3118	1.4610	2.0627	1.5359	1.2089	1.2842	......	......	.9643	1.0610	......	......
Per cent solid matter	21.24	21.10	......	......	25.20	25.04	......	......	32.46	32.81	30.84	29.93	25.75	25.63	......	......	20.89	20.64	......	......
Average per cent solid matter	21.17		21.17		25.12		25.12		32.63		30.38		25.69		25.69		20.76			
	20 gr.	20 gr.	30 gr.	40 gr.	20 gr.	20 gr.	20 gr. raw.	30 gr. raw.	20 gr.	20 gr.	20 gr.	20 gr.	20 gr. raw.	20 gr. raw.	20 gr.	20 gr.	20 gr.	20 gr.	Added indef. quant.	
Sample flesh and 200 cc. S. G. J. 22 hrs. at 40°—diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	.9910	.9990	.9625	.8200	1.1476	1.1493	1.1920	1.4685	1.0290	1.0225	1.1136	1.0867	1.1329	1.1244	1.0668	1.1032	.8325	.9141	1.9238	......
200 cc. standard gastric juice diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	0.3160				0.3163				0.3141				0.3128				0.3141			
Residue from digestion less the gastric juice residue	.6759	.6839	.6465	.5040	.8313	.8330	.8757	1.1522	.7049	.7081	.8015	.7726	.8201	.8116	.7540	.7904	.5184	.6000	1.6097	......
The above × 5 or the entire products of digestion from 20 gr	3.3795	3.4195	3.2325	2.5200	4.1565	4.1650	4.3785	5.7610	3.5245	3.5120	4.0075	3.8630	4.1005	4.0580	3.7700	3.9520	2.5920	3.0000	8.0485	......
Average of the above.	3.3995		3.2325	2.5200	4.1607		4.3785	5.7610	3.5182		3.9352		4.0792		3.8610		2.7960		8.0485	

TABLE V.

	Twenty-first series. June 4.				Twenty-second series. June 9.				Twenty-third series. June 16.				Twenty-fourth series. June 18.			
	Lamb.		Mutton.		Pomatomus saltator. Bluefish.		Pomatomus saltator. Bluefish.		Light meat of spring chicken.		Dark meat of spring chicken.		Frogs' legs.		Lobster. Large female.	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Grams taken	4.4828	5.1652	5.2508	4.7776	5.1936	5.8776	......	......	4.7043	4.6394	4.3887	4.6880	5.1115	3.6942	4.3595	4.7139
Gave dried residue	1.3533	1.5272	1.6352	1.4594	1.0328	1.1639	......	......	1.2518	1.2384	1.1585	1.2742	.9105	.6618	.9238	1.0080
Per cent solid matter	30.18	29.56	31.14	30.54	19.88	19.80	......	......	26.60	26.69	26.39	27.01	17.81	17.91	21.19	21.39
Average per cent solid matter	29.87		30.84		19.84		19.84		26.645		26.70		17.86		21.29	
	a	*b*	*a*	*b*	*a* raw.	*b* raw.	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
20 gr. sampled flesh and 200 cc. S. G. J. 22 hrs. at 40°—diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	1.0313	1.0201	1.0753	1.0444	1.0632	1.0713	1.0412	1.0239	1.0308	1.0010	.9991	.9955	.9724	.9611	.9575	.9541
200 cc. standard gastric juice diluted to 250 cc. 50 cc. of this + 5 cc. Na_2CO_3 gave dried residue	0.3141				0.3149				0.3141				0.3160			
Residue from digestion less the gastric juice residue	.7172	.7060	.7612	.7303	.7483	.7564	.7264	.7090	.7167	.6869	.6850	.6814	.6564	.6451	.6415	.6381
The above × 5 or the entire products of digestion from 20 gr	3.5860	3.5300	3.8060	3.6515	3.7415	3.7820	3.6320	3.5450	3.5835	3.4345	3.4250	3.4070	3.2820	3.2250	3.2075	3.1905
Average of the above	3.5580		3.7287		3.7617		3.5885		3.5090		3.4160		3.2535		3.1990	

TABLE VI.

Average results from each sample of cooked flesh.

	Percentage solid matter.	Solid matter in 20 grams.	Average amount digested from 20 grams.	Relation of the amounts digested to the amount digested from 20 grams cooked beef = 4.0461.
Beef	25.12	5.024	4.1607	=100.00
Beef	26.03	5.206	4.1167	
Beef	25.69	5.138	3.8610	
Veal	24.96	4.992	4.1742	=94.89
Veal	24.29	4.858	3.5052	
Mutton	30.84	6.168	3.7287	92.16
Lamb	29.87	5.974	3.5580	87.93
Spring chicken (light meat)	26.64	5.328	3.5090	86.72
" (dark meat)	26.70	5.340	3.4160	84.42
Whitefish (Coregonus clupeiformis)	25.56	5.112	3.8350	94.78
Shad (Clupea sapidissima)	31.33	6.266	3.6455	90.09
" " (light meat)	30.38	6.076	3.9352	97.25
" " (dark meat)	32.63	6.526	3.5332	87.32
Salmon (Salmo salar)	31.06	6.212	3.7345	92.29
" "	31.50	6.300	3.6335	89.80
Tautog (Hiatula onitis)	20.60	4.120	3.5660	88.13
Porgee (Sparus chrysops)	22.56	4.512	3.5215	87.03
Bluefish (Pomatomus saltator)	19.84	3.968	3.5885	88.69
" "	19.46	3.892	2.9717	73.44
Mackerel (Scomber scombrus)	25.51	5.102	3.4895	86.24
Halibut (Hippoglossus vulgaris)	20.28	4.056	3.4600	85.51
Flounder (Paralichthys dentatus)	23.04	4.608	3.4525	85.32
Sea-bass (Serranus atrarius)	21.17	4.234	3.3995	84.01
Pike (Esox lucius)	19.63	3.926	3.3582	82.99
Haddock (Gadus æglifinus)	18.24	3.648	3.3382	82.50
Herring (Clupea harengus)	24.49	4.898	3.3317	82.34
Striped Bass (Roccus lineatus)	20.73	4.164	3.2770	80.99
Red Snapper (Lutjanus blackfordi)	22.09	4.418	3.3040	81.65
Brook-trout (Salvelinus fontinalis)	19.58	3.916	3.1745	78.45
Sea-robin (Prionotus palmipes)	21.87	4.374	3.1572	78.03
White Perch (Roccus americanus)	19.69	3.938	2.9515	72.94
Fresh Cod (Gadus callarias)	18.29	3.658	2.9292	72.39
Weakfish (Cynoscion regale)	19.78	3.956	2.9180	72.11
Yellow Perch (Perca americana)	18.12	3.624	2.9037	71.76
Eel (Anguilla rostrata)	21.78	4.356	2.9002	71.82
Window-pane (Bothus maculatus)	18.37	3.674	2.8927	71.49
Flat-fish (Pleuronectes americanus)	17.16	3.430	2.7065	66.89
Lobster (young)	21.75	4.350	3.5532	87.81
" (large female)	21.29	4.258	3.1990	79.06
" (large male)	20.76	4.152	2.7990	69.18
Crab	23.57	4.714	2.7165	67.13
Frogs' legs	17.86	3.572	3.2535	80.46