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THE IODINE CONTENT OF OYSTERS

By E. J. COULSON

Volume I

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THE IODINE CONTENT OF OYSTERS [1]

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INTRODUCTION

It has been known for some time that sea foods constitute our richest natural source of iodine. The use of seaweed and burnt sponge for the treatment of goiter was known to the ancients, but it was not realized until the researches of Chatin, in 1850, that this curative effect was due to iodine. Unfortunately, Chatin's conclusion that goiter was caused by a deficiency of iodine was not generally accepted and it remained for the convincing experiments of Marine and Kimball (1920), in the public schools of Akron, Ohio, to show that simple goiter could be prevented and frequently cured by treatment with small amounts of iodine. Following this work, an increasing amount of interest has been shown in the iodine content of the dietary and various workers have made large numbers of analyses for iodine, covering very nearly all of the common foods. These investigations have shown that foods grown in goitrous regions are lower in iodine than those grown in nongoitrous regions. Therefore, if the residents of goitrous regions are to depend upon their diet to furnish sufficient quantities of iodine, they must take care in choosing the proper food, or import foods which are naturally rich in iodine.

It has become apparent, in recent years, that there are wide variations in the composition of the same species of food fishes. Individual fish of the same school caught at the same time may often differ widely in composition (Clark and Clough, 1926). It has also been found that the locality in which the fish are caught may cause a variation in composition which is probably caused by differences in the available food supply of the different localities. This difference in food supply would particularly affect the composition of oysters since they are

[1] Acknowledgment is made of the cooperation of the South Carolina Food Research Commission, in whose laboratory this work was done, as well as the helpful supervision and suggestions of Dr. Roe E. Remington, of that laboratory. Investigational Report No. 17. Approved for publication, Jan. 19, 1934.

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unable to move about in obtaining their food but must depend upon that which is carried to them. Although the iodine content of sea water undiluted by land drainage is probably fairly constant, no one, so far as we know, has been able to determine whether the iodine of the oyster is derived from the iodide and iodate of sea water, or from the plankton, on which it feeds. Lunde and Closs (Lunde 1929) have shown that the iodine content of different fish varies with the iodine content of their diet. A large proportion of the food of the oyster is made up of plant forms known as diatoms (Churchill, 1920), and according to Lunde (1929), the production of these diatoms or plankton is periodic and depends especially upon the supply of nutrient materials from the land. Most oyster beds are situated in the estuaries of streams in which not only the salinity but also the flora will vary with the volume and composition of the drainage from the land. For these reasons many of the previous analyses cannot be used in calculating the value of the food in question as a source of the various minerals because of the very few specimens represented by the analysis. Thus, for example, oysters have been reported to contain the following amounts of iodine, in parts per billion, dry basis: 4,011 and 4,605 for Pacific coast oysters (Jarvis, 1928), 6,000 for the Atlantic coast (Tressler and Wells, 1924), and 15,800 for one sample of South Carolina oysters (Remington, McClendon, von Kolnitz, and Culp, 1930).

In view of the divergent results which have been reported, it was decided to make a study of variations in iodine content of oysters with respect to locality and season. A representative group of samples from all of the important oyster-producing areas of the United States at 2 seasons of the year was already available, having been collected for the purpose of a similar study of their iron, copper, and manganese content (Coulson, Levine, and Remington, 1932) (Coulson, 1933). These samples were shucked, washed, and handled in the usual commercial manner and, therefore, fairly represent the fresh oysters available on the market.

THE METHOD

The Karns technique as modified by von Kolnitz and Remington (1933) was used in determining the iodine content. In testing the method, recoveries of iodine, in form of standard thyroid powder, in five determinations, ranged from 93.5 percent to 98.4 percent, averaging 96 percent. The analyses were made in triplicate, the results varying, in a great majority of the cases, less than 5 percent.

IODINE CONTENT OF OYSTERS

Table 1 gives the iodine content of the individual oyster samples collected in the late spring of 1931 from various localities along the Atlantic, Gulf, and Pacific[2] coasts of the United States. The results reveal that there are extremely wide variations in the iodine content

[2] There are three types of oysters grown commercially on the Pacific coast; two of these, the Japanese and the eastern oysters, are imported as seed and allowed to grow to maturity in the inlets and bays along the coast.

of oysters. The quantities of iodine present in the spring samples range from 1,090 to 6,230 parts per billion on the dry basis, or from 232 to 911 parts per billion on the original moisture basis.

TABLE 1.—*Iodine content of spring oysters* [1]

Oyster beds in the vicinity of—	Sample no.	Dry matter	Iodine content [2]	
			Dry basis	Fresh basis
NORTH ATLANTIC				
		Percent		
Providence, R.I.	12	22.60	1,090	246
South Norwalk, Conn.	14	18.64	1,730	323
Do.	21	16.65	3,010	501
Oyster Bay, N.Y.	1	16.58	1,700	282
Greenport, N.Y.	10	17.13	2,050	351
Do.	18	17.58	2,560	450
Port Norris, N.J.	4	12.07	2,070	250
Do.	19	11.52	2,010	232
Average		16.60	2,028±138	329±22
SOUTH ATLANTIC				
Crisfield, Md.	22	11.59	3,660	424
Norfolk, Va.	2	16.03	2,850	457
Do.	3	15.42	1,590	245
Do.	11	14.82	3,530	523
Morehead City, N.C.	17	14.63	6,230	911
McClellanville, S.C.	15	18.23	3,320	605
Daytona Beach, Fla.	23	13.79	2,150	297
Average		14.93	3,304±378	495±57
GULF				
Apalachicola, Fla.	5	19.72	3,930	775
Do.	8	20.66	3,490	721
Coden, Ala.	7	18.42	3,540	652
Biloxi, Miss.	9	15.47	2,800	433
Houma, La.	6	19.55	2,780	543
Do.	13	23.27	3,840	894
New Orleans, La.	20	19.83	3,850	763
Average		19.56	3,461±124	683±39
PACIFIC				
San Francisco, Calif.:				
Eastern	25	16.84	1,600	269
Natives	26	15.40	2,200	339
Blanchard, Wash. (Japanese)	27	20.29	1,900	386

[1] Collected in April 1931.
[2] Parts per billion.

A second set of samples (table 2), collected in November and December, 1931, in which approximately twice the previous number of samples was collected, shows a still greater variation in iodine content. These samples vary from 1,000 to 11,530 parts per billion dry basis, or from 194 to 1,652 parts per billion on the original moisture basis,

TABLE 2.—*Iodine content of winter oysters* [1]

Oyster beds in the vicinity of—	Sample no.	Dry matter	Iodine content [2] Dry basis	Fresh basis
NORTH ATLANTIC				
		Percent		
Cotuit, Mass	70	17.14	4,360	747
Do	74	20.91	4,480	937
Onset, Mass	80	14.77	4,480	662
Providence, R.I	33	18.93	3,180	602
East Providence, R.I	61	16.83	1,360	229
South Norwalk, Conn	29	19.54	1,890	369
Do	42	19.86	2,730	542
Greenport, N.Y	35	16.86	2,900	489
Do	50	21.66	2,950	639
Oyster Bay, N.Y	37	14.67	2,160	317
Do	65	16.41	1,390	228
West Sayville, N.Y	63	19.96	1,000	200
Port Norris, N.J	28	13.45	2,030	273
Do	30	12.22	1,590	194
Average		17.37	2,607±214	459±42
SOUTH ATLANTIC				
Crisfield, Md	48	14.06	2,900	408
Willis Wharf, Va	31	15.85	2,920	463
Wachapreague, Va	57	15.30	2,140	327
Norfolk, Va	45	12.35	2,020	250
Do	49	13.88	2,970	412
Do	52	12.82	6,630	850
Morehead City, N.C	36	16.65	3,780	629
Newport River, N.C	71	13.11	2,270	298
Pamlico Sound, N.C	72	13.95	3,590	501
McClellanville, S.C	79	15.24	2,580	393
Mount Pleasant, S.C	73	17.48	3,320	580
Edisto Island, S.C	59	17.77	2,450	435
Do	[3] 85	11.90	3,260	388
Beaufort, S.C	55	20.54	2,020	415
Do	54	18.26	2,120	387
Bluffton, S.C	53	18.77	2,590	486
Do	56	16.37	2,030	332
Port Orange, Fla	32	14.03	3,080	432
Average		15.46	2,926±172	444±22
GULF				
Apalachicola, Fla	38	15.60	3,650	569
Do	46	13.01	3,580	466
Do	60	15.99	2,860	457
Do	68	15.56	2,570	400
Biloxi, Miss	47	19.49	3,510	684
Houma, La	51	18.98	3,870	735
Do	44	14.33	11,530	1,652
New Orleans, La	41	16.75	2,450	411
Do	62	18.38	2,060	379
Do	66	17.84	2,430	434
Average		16.59	3,851±591	619±82
PACIFIC				
San Francisco, Calif. (eastern)	39	19.49	2,620	511
Olympia, Wash. (natives)	40	16.06	1,940	312
Do	75	18.81	1,450	273
Do	76	17.07	1,610	275
Olympia, Wash. (Japanese)	77	22.42	1,520	341
Do	78	17.90	1,990	356
Hoquiam, Wash. (Japanese)	84	21.21	1,710	363
Average		18.99	1,834±102	347±20

[1] Collected in November and December 1931.
[2] Parts per billion.
[3] Collected in February 1933.

The average for the spring Atlantic and Gulf coast samples is 494 parts per billion (fresh basis) while the average for the winter samples is 490 parts per billion. This small difference is obviously not significant. The grand average for all of the 64 Atlantic and Gulf coast oysters is 492 parts per billion.

VARIATION WITH SEASON AND LOCALITY

In table 3 a comparison is made in the iodine content of oysters gathered in the spring as compared to those gathered in the winter. Only oysters from those beds which were represented in both series were used in calculating these averages.

TABLE 3.—*Variations of the average iodine content with locality and season* [1]

Coastal area	Spring samples [2]		Winter samples [3]	
	Dry basis	Fresh basis	Dry basis	Fresh basis
North Atlantic	2,028±138	329±22	2,429±139 [4] 2,977±215	428± 38 [4] 525± 45
South Atlantic	3,304±378	495±57	3,423±385	482± 50
Gulf	3,461±124	683±39	4,633±940 [5] 3,254±175	734±129 [5] 550± 45
Pacific	2,050	363	1,834±102	347± 20

[1] Results expressed in parts per billion.
[2] Collected in April 1931.
[3] Collected in November and December 1931.
[4] Massachusetts samples included.
[5] The one high result not included.

A statistical analysis of the results shown in table 3 revealed that, with the exception of the North Atlantic spring samples, there are no significant differences in the average iodine content of oysters from any of the three sections of the Atlantic and Gulf coasts. There likewise appears to be, in general, no significant variation of iodine content with season. With regard to the North Atlantic spring samples, it is impossible to say, with the available data, whether or not these actually are lower, on the average, than are oysters from the South Atlantic and Gulf coasts. Unfortunately, oysters from Massachusetts were not included in the spring group of samples. Analyses from the winter group reveal the Massachusetts oyster to be higher in iodine than those from other localities along the North Atlantic coast.

The Pacific coast oyster, although somewhat lower in iodine than oysters from the Atlantic and Gulf coasts, is also a good source of iodine. It is interesting to note, in light of our earlier discussion, that these oysters were grown in the estuaries of streams which drain soils which are said to be deficient in iodine and a section of the country where goiter is prevalent (Olesen, 1929).

THE EFFECT OF WASHING ON THE COMPOSITION OF OYSTERS

After the shucking process, oysters are washed in order to remove the particles of shell and other foreign material introduced during the shucking operation as well as for the removal of the mucus which clings to the mantle and gills of the oyster. No standard method of washing is employed universally throughout the country; and, therefore, the amount of washing and consequently the amount of solids and minerals removed from the oyster may vary enormously among stocks from different parts of the country. Hunter and Harrison (1928) have made quite a detailed study of the effect of different commercial methods of washing on the loss of solids, gain in volume, and the loss of salt content of oysters. They were also interested in the reduction of the bacterial count of oysters by the different methods of washing. Hunter and Harrison show that there are losses of from 4.5 percent to 18.8 percent of total solids and a gain in volume of from 4.2 percent to 18 percent, depending upon the methods of washing employed. The salt was also largely removed in the washing process.

The above results indicated the possibility that the differences in iron, copper, manganese, and iodine content which have been reported in oysters from various localities may be caused by the different methods of washing employed in these places rather than to the differences in the concentration of the metals in the unopened oyster.

OYSTER WASHING EXPERIMENTS

An experiment was conducted, therefore, to show the effect upon the iron and iodine content of oysters when washed by different methods. Unwashed oysters were shucked into dry containers, and the meats were thoroughly stirred. One-half gallon portions of the shucked oyster meats were then treated in the following manner: (1) Rinsed in 1 gallon of fresh water; (2) allowed to soak in 1 gallon of fresh water for 2 hours; (3) blown for 3 minutes in 1 gallon of 0.5 percent solution of brine; and (4) blown for 15 minutes in 1 gallon of fresh water.

The analyses of the oyster samples after treatment in the above described manner are shown in table 4.

TABLE 4.—*Analysis of washed oysters* [1]

Method of washing	Total solids	Total ash		Iodine, parts per billion		Iron, miligrams per kilo	
		Dry basis	Fresh basis	Dry basis	Fresh basis	Dry basis	Fresh basis
	Percent	*Percent*	*Percent*				
Unwashed [2]	19.25	11.08	2.13	2,165	417	442	85.1
Rinsed in fresh water	19.08	7.72	1.47	2,155	411	395	75.4
Soaked 2 hours in fresh water	16.43	6.66	1.09	1,785	293	361	59.3
Blown 3 minutes in 0.5 percent brine	19.33	7.80	1.51	1,880	363	385	74.4
Blown 15 minutes in fresh water	17.61	6.96	1.23	2,090	368	335	59.0

[1] Average of 2 tests on oysters from Newport River, Beaufort, N.C.
[2] Unwashed oysters shucked into dry containers. Liquor was not drawn off before sampling.

The results in table 4 reveal that the greatest losses of total solids, ash, iodine, and iron content occurred when the oysters were washed in fresh water. The data in table 5 show the changes in the composition of the washed oysters. In calculating these values the composition of the rinsed oysters was chosen as the basis for determining losses because of the fact that they probably represent the maximum value of the desirable constituents of the oyster which can be retained through any washing process. The superficial rinsing which these oysters received probably did not remove more than the liquor and pieces of shell as well as some mucus. This rinsing would not constitute good washing from the bacteriological standpoint (Hunter and Harrison, 1928).

TABLE 5.—*Effect of washing on composition of oysters* [1]

Method of washing	Change in volume	Loss of total solids	Loss of ash	Loss of iodine	Loss of iron
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Soaked 2 hours in fresh water	+11.4	4.1	17.2	20.2	12.3
Blown 3 minutes in 0.5 percent brine	−0.6	[2] None	[2] None	12.2	1.9
Blown 15 minutes in fresh water	+5.2	3.1	12.2	9.6	17.6

[1] The composition of rinsed oysters was used as basis for these calculations.
[2] Slight gain.

Table 5 indicates that of the methods studied in this experiment, the one in which the oysters were blown for 3 minutes in 0.5 percent brine solution caused the least change in composition. Hunter and Harrison (1928) concluded that the use of the blower for about 3 minutes, a weak brine (about 0.5 percent) being used as a washing

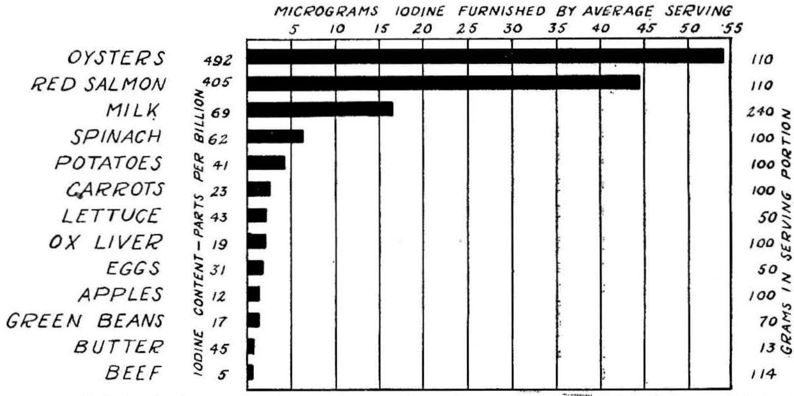

FIGURE 1.—Relative iodine content of serving portions of some common foods. Sources of data: The oysters are an average of 64 samples analyzed by us. Red salmon, from Jarvis, Clough, and Clark (1929); milk and vegetables, from analyses of South Carolina Food Research Laboratory; eggs, ox liver, and beef, from von Fellenberg (1923); butter, from Aitken (1932). Grams in serving portion, from Hodges and Peterson (1931).

medium, was the best cleansing method from the bacteriological and chemical standpoints.

Although there are some losses in the iron and iodine content of oysters by these different methods of washing, these differences are too small to account entirely for the larger differences which are found to occur in the oyster samples from various localities. Undoubtedly then the cause for the variations which have been found in the iron and iodine content of oysters must be looked for in the environment in which they grow.

VALUE OF OYSTERS AS A SOURCE OF IODINE

The average for the 64 samples of oysters from the Atlantic and Gulf coasts, shown in tables 1 and 2, is 492 parts per billion on the original moisture basis. One average serving of oysters (110 grams) would therefore furnish to the diet 54 micrograms of iodine. If we accept the values for the daily iodine requirement of an adult male, as given by Orr and Leitch (1929) to be 45 micrograms per day, then one serving of oysters would furnish 120 percent of the iodine requirement for that day. Figure 1 shows the relative amounts of iodine which are furnished to the diet by an average serving of several common foods. In studying this chart, one should bear in mind that the milk and vegetables shown are from a nongoitrous region (South Carolina) and hence are somewhat higher than the average and considerably higher than the same foods from goitrous regions. Thus, for example, while it may be possible to obtain the daily iodine requirement by drinking a quart of milk produced in a nongoitrous region, it may be necessary to drink a gallon or more of the milk which is produced in goitrous regions to secure the same quantity of iodine.

There are a few sea foods which rank higher in iodine content than the oyster, but these usually are not so widely distributed and so easily obtainable.

GENERAL DISCUSSION

The importance of a small amount of iodine in the daily diet is so well known that it hardly need be emphasized here. The question of the best method for the administration of this small amount of iodine, however, is still an open one. The present trend of thought favors the view that dietary deficiencies, in general, can best be prevented or corrected by the proper selection of foods rather than by the use of artificial concentrates. According to Lunde (1929), when inorganic iodine is fed, it leaves the body, almost quantitatively, in a rather short time (less than 24 hours), while the organically bound iodine of foodstuffs is set free only slowly in the organism and a much longer time elapses before it leaves the body. McClendon (1931) has the following to say in regard to this question:

> We do not know that it is safe to rely on iodized salt and tablets. There is still another consideration. Suppose the world would rid itself of goiter by the use of iodized tablets or salt; most people would then forget about goiter, which might then return with its original severity. If, however, the food habits are changed so as to eliminate goiter, the taste of the food and other characteristics might cause people to continue it, even though they did not know anything of either iodine or goiter.

Because of the recent developments in the preservation and transportation of perishable foods, oysters are becoming more readily available in the inland States which have heretofore been deprived of the delectability of sea foods which retain their sea tang. Canned oysters have long been available to all parts of the country and can be enjoyed by people where the fresh product is not available. Oysters therefore offer a delightful means of increasing the intake of iodine and thus combating goiter.

Oysters may be used with safety in the diet of the goitrous patient, despite their high iodine content. In this connection, Wiesel and Kretz (see Lunde, 1929a), write:

> * * * we have the fact that nonionized, organically combined iodine such as especially occurs in plants and in animal organisms, never leads to iodine intoxication, in spite of the fact that this iodine is ingested in quantitatively larger amounts than, for instance, in the iodized salt. Neither has there ever been known a case of persons moving from an iodine-deficient goitrous district to one that is non-goitrous and richer in iodine, getting symptoms of iodine intoxication.

SUMMARY AND CONCLUSIONS

The iodine content of fresh oysters, shucked and handled in the usual commercial manner, from all of the important producing areas of the United States, has been determined. The results vary from

1,000 to 11,530 parts per billion on the dry basis, or from 194 to 1,652 parts per billion on the original moisture basis. The average for 64 Atlantic and Gulf coast samples is 492 parts per billion, fresh basis.

Losses of from 9.6 percent to 20.2 percent occur in the iodine content of oysters and from 1.9 percent to 17.6 percent in the iron content by different washing processes, but these losses cannot account for the greater differences in iodine and iron content which are found in various individual samples.

When the average of the several individual determinations from any one coastal area is considered statistically, there appears to be no significant variation in iodine content of oysters from different localities along the Atlantic and Gulf coast, nor any significant variation with season. Pacific coast oysters are lower in iodine content than the Atlantic coast samples.

Oysters are recommended as an excellent source of naturally combined food iodine for the prophylaxis of simple goiter, especially in goitrous regions.

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