THE IRON CONTENT OF PLANT AND ANIMAL FOODS.*

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As more data are accumulated it becomes increasingly evident that great variations exist in the mineral content of different samples of the same foodstuff. Only when a large number of samples from different parts of the country have been analyzed will it be possible to approximate the probable mineral content of our diet. With the data now available it is difficult to draw any safe conclusion as to the adequacy or inadequacy of the supply of the mineral elements in an average diet.

In a previous paper (1) the iron content of certain tissues was given. In the present paper figures will be given for the percentage of iron in about 150 of our common food materials. Most of these analyses are of plant materials, but figures for a number of samples of fish and poultry are also included. Included in the averages are the data reported in two previous papers (2, 3) for the iron content of about twenty vegetables.

EXPERIMENTAL.

Preparation of Samples.—The materials used in this study were for the most part bought in the local markets. The fruits and vegetables were carefully washed, spread out in thin layers, and left until the water had evaporated. They were then cut in small pieces and *moisture* was determined by drying to constant weight at 100°. The dried materials were ground in a glass mortar and kept in stoppered bottles until the time of analysis. Before a sample was taken for this purpose the material was dried for several hours to remove any absorbed moisture.

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The cereals were partly broken but not dried before analysis. The nuts were ground but not dried before the sample was taken for analysis. This was necessary in order to avoid a change in the uniformity of the sample due to the separation of fat during the drying. *Moisture* in the cereals and nuts was determined by drying other ground samples to constant weight at 100°.

Methods for the Determination of Iron.—The ferric thiocyanate colorimetric method as described in Standard Methods for the

TABLE I

Detailed Data for Certain Representative Foods, Illustrating Method for Determination of Iron.

Food.		Weight of dry sample.	Fe in standard.	Reading of colorimeter.*	Iron.	Recovery of added iron.	Iron in sample (dry basis).
Class.	Sample.						
		gm.	*mg.*	*mm.*	*mg.*	*per cent*	*per cent*
Cereals.	Wheat flour.	8	0.1	27.3	0.073		0.00091
	" " + 0.1 mg. Fe.	8	0.1	11.6	0.172	99	
Fish.	Salmon.	5	0.2	23.2	0.172		0.00344
	" + 0.1 mg. Fe.	5	0.2	14.8	0.270	98	
Fruits.	Peaches.	3	0.1	23.4	0.085		0.00285
	" + 0.1 mg. Fe.	3	0.1	10.8	0.185	100	
Nuts.	Almonds.	4.85	0.3	29.3	0.205		0.00423
	" + 0.1 mg. Fe.	4.85	0.3	19.8	0.303	98	
Vegetables.	Potatoes.	5	0.2	20.7	0.193		0.00386
	" + 0.1 mg. Fe.	5	0.2	13.4	0.298	105	
	Head lettuce.	1	0.1	15.9	0.126		0.01260
	" " + 0.1 mg. Fe.	1	0.1	8.9	0.225	99	

* Standard set at 20 mm.

Examination of Water and Sewage (4) was used when the phosphate content was not so great as to produce fading. To determine whether phosphates or other compounds were interfering, all analyses were run in triplicate and a known quantity of iron (usually 0.1 mg.) was added to one of the three samples. If a recovery of 95 per cent or more was obtained, it was assumed that there was no interference. If a satisfactory recovery was not obtained, the analysis was repeated on a smaller quantity of material. The disturbing effect of phosphates seems to disappear

when the quantity falls below a certain minimum. If the iron content was too low to permit of a reduction in the size of the sample, the analysis was made by the method of Elvehjem and Hart (5).

In Table I are given the complete analytical data for several representative foodstuffs ranging from low to high in their iron content. The recovery of added iron is more than 95 per cent in every case. The same procedure was followed with every sample analyzed and good recovery of added iron was obtained. For this reason we feel that the figures reported in this paper actually express the iron content of these samples.

Iron Content of Foods.—In Table II are given the moisture and iron content of the samples analyzed.

The figures range from 0.00015 per cent of iron for lemon juice to 0.0192 per cent for parsley. The figure for parsley was so suprisingly high that another sample bought a year later was analyzed and was found to contain approximately the same percentage of iron as the first sample. As a carrier of iron, spinach does not compare with parsley. It would be desirable to compare a number of samples of these two vegetables to see whether parsley generally exceeds spinach in its iron content.

If the groups of foodstuffs are arranged in descending order with reference to their iron content, the following series is obtained: Three dried legume seeds, 0.0094 per cent; seven green leafy vegetables, 0.0069 per cent; seven dried fruits, 0.0054 per cent; twelve nuts, 0.0041 per cent; eighteen cereals and their products, 0.0034 per cent; four kinds of poultry, 0.0014 per cent; two green legumes, 0.0014 per cent; fourteen roots, tubers, stalks, and bulbs, 0.0011 per cent; fifteen non-leafy vegetables, 0.00085 per cent; twenty kinds of fish, 0.00083 per cent; twenty-three fresh fruits, 0.00066 per cent.

This order results from calculations made on the basis of the undried edible product. The high rank of legumes, dried fruits, and nuts is, of course, due in large part to the low percentage of moisture contained in these foods. If the calculations are made on the dry basis the leafy vegetables take the first place with more than 6 times as much iron as the next group, the dried legumes. The green leafy vegetables are *par excellence* the best source of iron in the diet.

TABLE II.

Iron Content of Foods (Calculated on Basis of Undried Material).

Food.*	Moisture.	Iron (Fe).
	per cent	*per cent*
Almonds	3.9	0.00407
Apples.		
Duchess	86.7	0.00031
Greening	82.5	0.00061
Yellow transparent	89.1	0.00022
Snow	83.9	0.00058
Apricots, dried (2)	40.7	0.00726
Artichoke	84.4	0.00189
Asparagus	91.8	0.00079
Bananas	75.4	0.00176
Barley	6.8	0.00358
Beans, Kidney	12.4	0.00692
" Lima	12.3	0.01166
" Navy	14.2	0.00952
" String.		
Maximum		0.00119
Minimum		0.00068
Average (7)	91.4	0.00093
Beets	82.3	0.00236
Beet greens, tops	90.3	0.00355
" " roots	87.2	0.00183
Blackberries	84.1	0.00100
Blueberries	81.3	0.00041
Bran flakes	6.5	0.00524
Brazil nuts	6.0	0.00393
Brussels sprouts	87.4	0.00223
Buckwheat	7.0	0.00320
Butternuts	3.0	0.00684
Cabbage.		
Maximum	93.6	0.00059
Minimum	91.0	0.00017
Average (20)	92.6	0.00034
Cantaloupe (2)	90.5	0.00051
Carrots	90.1	0.00107
Cauliflower	91.4	0.00143
Celery	94.0	0.00077
Celery cabbage	94.3	0.00057
Chard	91.5	0.00402
Cheese, American	32.3	0.00138
Cherries, black	81.9	0.00051
" red	88.0	0.00046

* When more than one sample was analyzed, the number of samples is indicated by the figure in parenthesis.

TABLE II—*Continued.*

Food.*	Moisture.	Iron (Fe).
	per cent	*per cent*
Chestnuts, Italian	34.5	0.00410
Chocolate, bitter	1.9	0.00315
Cocoa	4.5	0.00313
Coconut	39.3	0.00267
Corn, white	5.7	0.00297
" yellow	8.5	0.00228
Corn-meal, yellow	6.0	0.00130
Corn flakes	6.2	0.00278
Cream of Wheat	7.4	0.00085
Cucumbers	96.8	0.00035
Currants (2)	86.8	0.00070
" dried	32.7	0.00474
Dandelion	88.3	0.00604
Dates, dried	27.5	0.00507
Eggplant	92.5	0.00061
Eggs	71.9	0.00252
Egg yolk	49.5	0.00760
Figs, dried	38.0	0.00396
Fish and sea food.		
Bass	77.0	0.00026
Bluefish	76.7	0.00060
Catfish	80.0	0.00036
Cod	81.7	0.00034
Flounder	80.0	0.00073
Haddock	78.8	0.00042
Halibut	67.3	0.00093
Herring	77.6	0.00059
Lake trout	79.0	0.00078
Lobster	81.1	0.00044
Mackerel	77.6	0.00075
Oyster (2)	87.5	0.00314
Perch	80.4	0.00048
Pickerel	72.5	0.00080
Pike	80.2	0.00034
Red snapper	79.2	0.00040
Salmon	75.7	0.00083
Shad	69.8	0.00053
Shrimp	70.4	0.00267
Whitefish	79.8	0.00042
Flour, Graham		0.00370
" patent	8.9	0.00091
" rye	6.4	0.00283

TABLE II—*Continued.*

Food.*	Moisture.	Iron (Fe).
	per cent	*per cent*
Gooseberries	90.1	0.00047
Grapefruit, pulp	92.8	0.00027
Grapes, Concord.		
Pulp	72.5	0.00074
Skin	77.2	0.00136
Grapes, Malaga	79.6	0.00228
" red	83.2	0.00090
Hazelnuts	3.8	0.00450
Hickory nuts	2.9	0.00238
Hominy	7.5	0.00054
Honey		0.00115
Kohlrabi (2)	90.7	0.00068
Kumquats	85.0	0.00051
Lemon, juice	96.0	0.00015
" peel	87.5	0.00075
Lettuce, head	96.6	0.00042
" leaf	94.4	0.00187
Milk (20)	87.5	0.00024
Molasses	26.2	0.00797
Mushrooms	71.2	0.00314
Oatmeal (2)	6.4	0.00380
Oats	6.2	0.00840
Olives, green, canned	77.0	0.00211
Onions	93.7	0.00030
Orange, juice		0.00028
" peel	79.2	0.00042
" pulp (2)	87.0	0.00066
Oyster plant	76.5	0.00124
Parsley (2)	87.6	0.01921
Parsnips	82.7	0.00107
Peaches	87.2	0.00036
" dried	37.4	0.00606
Peanuts	2.0	0.00231
Pears	83.9	0.00046
Peas, green (3)	75.2	0.00177
Pecans	2.3	0.00258
Peppers, green	94.0	0.00041
" red	91.7	0.00060
Pineapple	92.0	0.00032
Pistachio nuts	4.0	0.00792
Plums (3)	84.9	0.00077
Pomegranate	73.5	0.00117

TABLE II—*Concluded.*

Food.*	Moisture.	Iron (Fe).
	per cent	*per cent*
Potatoes	78.2	0.00085
" sweet	72.1	0.00092
Poultry.		
Chicken, dark meat	67.5	0.00101
" light "	76.6	0.00070
Duck	43.7	0.00171
Goose	57.0	0.00202
Turkey, dark meat	72.1	0.00204
" light "	72.2	0.00103
Prunes, dried	44.1	0.00517
Puffed Rice	10.9	0.00107
Puffed Wheat	8.6	0.00410
Pumpkin	91.7	0.00110
Quinces	82.5	0.00101
Radishes (2)	94.4	0.00136
Raisins, seeded	28.2	0.00699
" seedless	31.9	0.00413
Raspberries (2)	84.1	0.00099
Rhubarb	94.4	0.00086
Rice, polished	9.5	0.00105
Rutabagas	80.9	0.00107
Rye	6.4	0.00370
Spinach	81.9	0.00660
Squash, Hubbard	90.4	0.00055
" Queen	81.1	0.00089
Strawberries (2)	90.3	0.00066
Sweet corn (2)	81.7	0.00051
Tangerines, pulp	86.0	0.00061
Tomatoes	94.2	0.00060
" canned		0.00130
Tomato puree, canned		0.00220
Turnips	91.5	0.00070
Walnuts, Black	2.0	0.00598
" English	3.3	0.00214
Watercress	92.5	0.00721
Watermelon	92.7	0.00023
Wheat	7.6	0.00372
" bran	3.4	0.00852

Attention is called to the low percentage of iron in cabbage, celery, and head lettuce as compared with the green leafy vegetables. A direct relation between iron content and presence of chlorophyll is evident. From the point of view of its iron content it is unfortunate that head lettuce is chosen by the public generally in preference to the superior leaf lettuce.

That soil and climatic conditions largely determine the iron content of the plant is shown by the great variations which exist in different samples of the same plant material; for example, apples, string beans, and cabbage. One sample may contain 2 or 3 times as much iron as another sample of the same product.

In a previous publication (1) it was noted that beef juice contained only a small percentage of the total iron in the original beef. The same tendency of iron to cling to the solid part of the material is observed in the case of orange juice and pulp. When orange juice was pressed out and strained as is the practice in preparing this material for feeding infants, only about 25 per cent of the total iron was obtained although more than 60 per cent of the weight of the orange pulp was represented by the expressed juice. Tomato juice similarily prepared contained about 38 per cent of the iron in the original vegetable. These facts indicate the desirability of feeding infants both juice and pulp as early as possible in order to take full advantage of the iron content of these materials.

An interesting condition was found to exist in the iron content of various kinds of fish. Salt water fish contained about 40 per cent more iron than the fresh water species. Fish with dark-colored tissue contained about 75 per cent more iron than those having light-colored tissue. The higher iron content of the dark-colored tissues was encountered in both the salt and the fresh water species.

If the figures for the different groups of foods are compared with the figures for the same materials given by Sherman (6), it will be found that the averages are about the same for cereals, nuts, and fish. For the most important sources of iron, the fruits and vegetables, our results are in most instances higher. The average for 62 fruits and vegetables is about 80 per cent higher than the figures given by Sherman. It is to be expected that individual samples would differ greatly but it does not seem reasonable that the average for a large number of samples should exhibit such differences. We are inclined to believe that Sherman's figures

are too low as they are compiled from different sources and are, as Sherman himself says, "of all degrees of probable reliability." The need of more analytical data on the mineral content of our foods is strongly emphasized by these differences.

SUMMARY.

The iron content of about 150 samples of our common food materials has been determined. The figures range from 0.00015 per cent for lemon juice to 0.0192 per cent for parsley. Arranged in descending order with reference to their iron content the classes of foods come as follows: dried legumes, green leafy vegetables, dried fruits, nuts, cereals, poultry, green legumes, roots and tubers, non-leafy vegetables, fish, and fruits.

Different samples of the same food material show great variations in their iron content. For example twenty samples of cabbage varied from 0.00017 per cent of iron to 0.00059 per cent. Vegetables containing but little chlorophyll, cabbage, celery, and head lettuce, were found to be low in iron.

The juice of oranges and tomatoes contains less of the total iron than is proportional to the weight of expressed juice; the iron clings to the solids.

Salt water fish contain more iron than fresh water fish. Fish with dark-colored tissue contain more iron than those with light-colored tissue. The dark meat of poultry is likewise higher in iron than the light meat.

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