THE IRON CONTENT OF MEATS.*

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Reawakened interest in the iron content of meat products has followed the very productive series of researches by Whipple, Hooper, and Robscheit-Robbins which have demonstrated, with the dog as a subject, among other points, "that the curve of hemoglobin regeneration can be influenced at will by various diet factors" (1); that liver, heart, and skeletal muscle "were most potent in effecting a rapid production of hemoglobin and red cells" (2); that "beef liver feeding in severe anemia is associated with a maximal regeneration of hemoglobin and red cells" (3); and that this is by no means simply an effect of the iron of the food though "long continued severe anemia due to hemorrhage may be associated with iron depletion and these experiments in dogs show a favorable reaction to iron treatment . . . . " (4).

A late paper by Hart and associates (5) has also contributed to our interest in the iron content of meats by materially extending our understanding of the method of participation of the iron of foods in the prevention and cure of anemia.

While it is well known that meats constitute an important source of iron in the diet, so little reliable information on the iron content of meats is on record that Sherman, in his text-book, Chemistry of Food and Nutrition (6), submits no detailed data, as with vegetable foods, but proposes the use of an average ash analysis for "meat," and another for "fish," as applying to 100 gm. of protein, in all cases.

With the thought of learning how nearly iron comes to varying in meats directly as the protein, as thus indicated, and therefore

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how great the need for individual iron determinations on meats, this study was undertaken.

The explanation of the remarkable paucity of information on this subject doubtless lies in the unusual difficulty involved in the preparation of samples of meat free from iron contamination.

In the solution of this problem we enjoyed the kindly cooperation of the Enterprise Manufacturing Co. of Philadelphia who assisted us in finding an unusually hard phosphor-bronze, and in casting a large knife, and making a power-driven meat chopper, entirely from this virtually iron-free alloy. Through the use of these mechanical facilities no unusual difficulties were experienced in the preparation of thoroughly good samples, the validity of which was attested by the entirely satisfactory agreement of triplicates, which could hardly have been contaminated, from the mechanical equipment, in a perfectly uniform manner.

The meats were all purchased in the local market, and were trimmed in a manner intended to approximate the condition in which they are ordinarily eaten. All portions which could have come in contact with a steel knife, or other sources of contamination, were cut away, with the bronze knife, and the entire portion, usually of several pounds, was then ground through the bronze chopper into a procelain dish.

A glance at the column of ether extract figures (Table I) shows that these were unusually lean meats; and a comparison of these data with the analyses of the same kinds and cuts of meat as reported in Office of Experiment Stations Bulletin 28, shows that, in general, our samples were of the fatness there designated "very lean."

Portions of about 50 gm. each, for iron estimation, were weighed out into porcelain dishes at the time of grinding, and were covered with watch-glasses and put into a cold storage room, where they remained, in a frozen condition, until the estimations could be made. Samples for ether extract, moisture, and nitrogen determination were also taken at the time of preparation. All estimations represent at least three agreeing determinations.

The samples for iron estimation were ignited to a white ash, and dissolved in hydrochloric acid, the iron being determined by titration with KMnO₄ solution which was about 0.005 normal. The triplicate iron estimations all agreed to 0.0001 per cent.

In the ashing of meats trouble often results from spattering,
especially if the samples contain a high percentage of fat. While most of our samples were low in fat, the bacon contained 64.10 per cent, and all were ashed without any spattering, by first drying the samples in an electric oven, and then ashing in an electric muffle furnace, with careful control of heat with the aid of a thermoelectric pyrometer.

At the beginning of the study the ashing was performed in porcelain dishes, but these were abandoned in favor of silica dishes, when it was observed that those samples of meat ash which fused removed the glaze from the dishes. This porcelain glaze, being transferred with the sample into the beaker in which the titration was made, gave a milky appearance to the solution, and rendered the end-point indistinct and difficult to catch. Platinum was also found to be quite impracticable.

Consequently, all determinations which had been made in porcelain dishes were repeated in dishes of silica. The end-points

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Kind of meat</th>
<th>Iron (per cent)</th>
<th>Nitrogen (N x 6.25, per cent)</th>
<th>Protein (per cent)</th>
<th>Ether extract (per cent)</th>
<th>Moisture (per cent)</th>
<th>Mg. iron per 100 gm. of protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>Bacon cured.</td>
<td>0.0013</td>
<td>1.67</td>
<td>10.44</td>
<td>64.10</td>
<td>22.31</td>
<td>12.5</td>
</tr>
<tr>
<td>107</td>
<td>Ham</td>
<td>0.0014</td>
<td>3.37</td>
<td>21.06</td>
<td>13.60</td>
<td>64.61</td>
<td>6.6</td>
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<tr>
<td>114</td>
<td>Pork shoulder.</td>
<td>0.0016</td>
<td>3.01</td>
<td>18.51</td>
<td>14.41</td>
<td>69.07</td>
<td>7.6</td>
</tr>
<tr>
<td>108</td>
<td>Hind quarter.</td>
<td>0.0016</td>
<td>3.25</td>
<td>20.31</td>
<td>10.54</td>
<td>72.95</td>
<td>8.5</td>
</tr>
<tr>
<td>112</td>
<td>Lamb shoulder.</td>
<td>0.0016</td>
<td>3.01</td>
<td>18.51</td>
<td>6.94</td>
<td>72.95</td>
<td>8.5</td>
</tr>
<tr>
<td>113</td>
<td>Hind quarter.</td>
<td>0.0016</td>
<td>3.25</td>
<td>20.31</td>
<td>6.94</td>
<td>72.95</td>
<td>8.5</td>
</tr>
<tr>
<td>102</td>
<td>Beef rib.</td>
<td>0.0024</td>
<td>3.24</td>
<td>20.25</td>
<td>6.05</td>
<td>72.70</td>
<td>11.9</td>
</tr>
<tr>
<td>100</td>
<td>Round.</td>
<td>0.0025</td>
<td>3.55</td>
<td>22.19</td>
<td>3.48</td>
<td>74.65</td>
<td>11.3</td>
</tr>
<tr>
<td>101</td>
<td>Loin.</td>
<td>0.0025</td>
<td>3.29</td>
<td>20.51</td>
<td>6.39</td>
<td>72.02</td>
<td>12.2</td>
</tr>
<tr>
<td>103</td>
<td>Chuck.</td>
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<td>3.17</td>
<td>19.81</td>
<td>7.13</td>
<td>72.84</td>
<td>12.6</td>
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<tr>
<td>109</td>
<td>Veal fore quarter.</td>
<td>0.0023</td>
<td>3.47</td>
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<td>1.70</td>
<td>76.08</td>
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<tr>
<td>110</td>
<td>Hind</td>
<td>0.0027</td>
<td>3.54</td>
<td>22.13</td>
<td>1.54</td>
<td>76.68</td>
<td>12.2</td>
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<td>116</td>
<td>Kidney.</td>
<td>0.0040</td>
<td>1.54</td>
<td>16.31</td>
<td>4.17</td>
<td>77.82</td>
<td>24.5</td>
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<td>Beef heart.</td>
<td>0.0044</td>
<td>2.59</td>
<td>16.19</td>
<td>4.94</td>
<td>78.91</td>
<td>27.2</td>
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<td>117</td>
<td>Brain.</td>
<td>0.0053</td>
<td>1.68</td>
<td>10.50</td>
<td>7.89</td>
<td>79.15</td>
<td>50.5</td>
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<td>104</td>
<td>Liver.</td>
<td>0.0052</td>
<td>3.30</td>
<td>20.63</td>
<td>4.66</td>
<td>68.33</td>
<td>39.7</td>
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<tr>
<td>115</td>
<td>Spleen.</td>
<td>0.0188</td>
<td>2.58</td>
<td>16.13</td>
<td>1.85</td>
<td>78.67</td>
<td>116.6</td>
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<tr>
<td>106</td>
<td>Kidney.</td>
<td>0.0188</td>
<td>3.03</td>
<td>18.94</td>
<td>1.90</td>
<td>77.50</td>
<td>72.9</td>
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<td>0.0444</td>
<td>2.87</td>
<td>17.94</td>
<td>80.99</td>
<td>247.5</td>
<td></td>
</tr>
</tbody>
</table>
where silica dishes were used were definite and distinct. The agreement with the estimations made in porcelain, however, was better than anticipated. Slightly higher results, about 0.0002 per cent, were obtained in nearly every determination ashed in a silica dish. This is probably due to an involuntary tendency to anticipate the end-point in solutions where it is not well defined. The end-points with samples ashed in silica dishes were as sharp as in distilled water.

The different kinds of meat differed greatly in their tendency to attack the dish during ashing; and this applies not only to porcelain but also to silica, which was sometimes etched. Those meats exhibiting the greatest tendency to etch the dishes were spleen, ham, and liver, while beef heart, beef loin, and lamb were entirely without effect to roughen the glaze of the dish.

When the samples of beef blood were ignited in silica dishes there remained in the dish, after boiling with concentrated HCl, a reddish-brown insoluble residue which could not be dissolved or scoured off. This was found to be iron. Fresh samples were ignited below redness, and extracted with HCl. The residue was then fully ignited, and added to the HCl extract which had been evaporated to dryness and also ignited, to eliminate the possibility of organic matter being present. By this procedure we avoided the insoluble combination of iron and silica dish. In general, an extraction which removes the readily soluble salts from the partially ashed meat prevents the dish from being attacked by the remaining constituents of the ash.

The potassium permanganate solution used was equivalent to approximately 0.275 mg. of Fe per cc., and was standardized, from time to time, with sodium oxalate. The KMnO₄ was carefully prepared, and the apparatus used was so arranged that the solution was never exposed to circulating air, or to dust. The first standardization, on June 3, showed a strength of 0.3007 mg. of Fe per cc. The last standardization, on October 20, showed a strength of 0.2940 mg. of Fe per cc. A half dozen standardizations, performed at more or less regular intervals between these dates, show that the slight loss in strength was a gradual one. In computing the iron in the meat samples the strength of KMnO₄ used was that obtained in the most recent standardization. In the case of a sample containing about 0.0025 per cent of iron it
would make a difference of only about 0.00006 per cent whether the first or last standardization was used.

An examination of the figures for iron shows a marked similarity of the iron content of muscle meat from different parts of the carcass.

Sherman’s factor of 15 mg. of iron per 100 gm. of protein seems to be a little high for beef and veal, and much too high for lamb and pork, while it does not apply at all closely in relation to heart, brain, liver, spleen, kidney, and blood.

The organ meats, or “extra carcass parts,” are all much richer in iron than carcass meat; indeed their richness in this important nutrient suggests that further attention should be given the utilization of these parts as human food.

Basing our comparisons with foods other than meats on the analyses compiled by Sherman—beef spleen, liver, kidney, and blood contain more iron than do any foods of vegetable origin.

Beef and veal contain two-thirds more iron than do pork and lamb, and ten times as much iron as does milk.

Beef heart and brain contain about twice as much iron as do beef and veal.

Beef liver contains twice as much iron as does beef heart.

Beef spleen contains half as much again of iron as does beef liver.

Beef contains twice as much iron as do potatoes; two and a half times as much as white flour, and corn-meal; and eight times as much iron as do apples.

Vegetable foods which contain more iron than does beef are peas, beans, lentils, graham flour, oatmeal, shredded wheat, and spinach.

BIBLIOGRAPHY.

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