Brief Communications

Dietary Sources of Iodine in Areas with and without Iodine-Deficiency Goiter1,2

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Since endemic goiter caused by iodine deficiency currently afflicts a large segment of humanity (1), it is surprising that the iodine content of food has not received greater attention in the medical literature. In 1952 the Chilean Iodine Educational Bureau (2) reviewed the available data on the iodine content of foods. Not all these data, however, were obtained by the same technique and the values listed usually refer to the raw material. However, the iodine content of raw food may not equal that of the food on the plate (3), and so it is necessary to determine the iodine in fully prepared and ready-to-eat food items. Such a study was reported from the United States by Vought et al. (4) in which they found rather high values, possibly due to the widespread use of iodine-containing additives and preservatives.

In the present paper we report the iodine content of several food items in the fully prepared and ready-to-eat form, both from the areas of Thessalia, Greece, with endemic goiter previously shown to be due to iodine deficiency (5), and from the region of Athens, which is goiter-free, but where food additives are not used regularly. The samples have been prepared in the same way as in the work of Vought and London (4, 6) and the iodine estimations performed in the same laboratory, so as to allow a valid comparison. Finally, possible seasonal variations in the iodine content of drinking water and milk have been studied.

MATERIALS AND METHODS

Food portions were obtained in duplicate from restaurants of the average class in Athens, from Athenian homes, and from village households in the endemic areas. Great care was taken to make the portions average, i.e., of the same size that are usually served. Drinking water and milk samples were obtained regularly in the middle of each month from Athens and from the goitrous villages. In these villages, cow’s, goat’s, and sheep’s milk were obtained separately, whereas in Athens only cow’s milk is available commercially. Water in the villages was obtained mainly from wells, and it was not treated with chlorine or other antiseptics.

Milk and the various food items were processed as previously described by Vought and London (4, 6). Briefly, after weighing, two portions of each item were mixed in a Lourdes...
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TABLE I

Iodine content of water, milk, and food items

<table>
<thead>
<tr>
<th>Food item</th>
<th>Athens</th>
<th></th>
<th></th>
<th>Range</th>
<th>Endemic areas</th>
<th></th>
<th></th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>SE</td>
<td>Range</td>
<td>n</td>
<td>Mean</td>
<td>SE</td>
<td>Range</td>
</tr>
<tr>
<td>Drinker water, μg/100 ml</td>
<td>12</td>
<td>0.47</td>
<td>0.033</td>
<td>0.35-0.77</td>
<td>163</td>
<td>0.24</td>
<td>0.02</td>
<td>ND-1.0</td>
</tr>
<tr>
<td>Cow's milk, μg/100 ml</td>
<td>12</td>
<td>4.15</td>
<td>0.36</td>
<td>7.50-2.60</td>
<td>68</td>
<td>2.5</td>
<td>0.22</td>
<td>ND-9.0</td>
</tr>
<tr>
<td>Sheep's milk, μg/100 ml</td>
<td>9</td>
<td>9.4</td>
<td>0.93</td>
<td>1.5-35.3</td>
<td>59</td>
<td>9.4</td>
<td>0.93</td>
<td>ND-35.3</td>
</tr>
<tr>
<td>Goat's milk, μg/100 ml</td>
<td>6</td>
<td>2.2</td>
<td>0.33</td>
<td>ND-15.7</td>
<td>56</td>
<td>2.2</td>
<td>0.33</td>
<td>ND-15.7</td>
</tr>
<tr>
<td>Eggs, μg/egg</td>
<td>15</td>
<td>13.4</td>
<td>3.7</td>
<td>1.8-48.8</td>
<td>19</td>
<td>1.9</td>
<td>0.36</td>
<td>0.5-6.0</td>
</tr>
<tr>
<td>Chicken dishes, μg/portion;</td>
<td>16</td>
<td>125.5</td>
<td>42.6</td>
<td>2.7-597.0</td>
<td>16</td>
<td>23.8</td>
<td>10.5</td>
<td>ND-151.0</td>
</tr>
<tr>
<td>weight, 240 g (150-500)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat dishes, μg/portion;</td>
<td>10</td>
<td>6.5</td>
<td>1.9</td>
<td>ND-18.0</td>
<td>16</td>
<td>3.0</td>
<td>0.86</td>
<td>ND-12.3</td>
</tr>
<tr>
<td>weight, 250 g (150-500)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fish dishes, μg/portion;</td>
<td>9</td>
<td>63.9</td>
<td>29.6</td>
<td>2.4-158.0</td>
<td>9</td>
<td>20.9</td>
<td>10.6</td>
<td>ND-14.3</td>
</tr>
<tr>
<td>weight, 222 g (148-388)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legume dishes, μg/portion;</td>
<td>14</td>
<td>3.0</td>
<td>0.7</td>
<td>ND-7.6</td>
<td>16</td>
<td>2.0</td>
<td>1.0</td>
<td>ND-14.3</td>
</tr>
<tr>
<td>weight, 300 g (250-600)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greek soft cheese, μg/100 g</td>
<td>15</td>
<td>15.12</td>
<td>1.85</td>
<td>6.7-33.0</td>
<td>15</td>
<td>8.48</td>
<td>1.22</td>
<td>3.6-17.5</td>
</tr>
<tr>
<td>Bread, μg/100 g</td>
<td>12</td>
<td>1.56</td>
<td>1.20</td>
<td>ND-14.5</td>
<td>21</td>
<td>0.54</td>
<td>0.25</td>
<td>ND-3.7</td>
</tr>
</tbody>
</table>

SE = standard error. ND = not detectable.

TABLE II

Seasonal fluctuations in the iodine content of drinking water and milk (μg/100 ml)

<table>
<thead>
<tr>
<th>Season</th>
<th>Athens</th>
<th></th>
<th></th>
<th></th>
<th>Endemic areas (Thessalia)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Cow's milk</td>
<td>Water</td>
<td>Cow's milk</td>
<td>Sheep's milk</td>
<td>Goat's milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January-April</td>
<td>0.42</td>
<td>4.45</td>
<td>0.30</td>
<td>2.44</td>
<td>7.03</td>
<td>1.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-August</td>
<td>0.53</td>
<td>3.95</td>
<td>0.26</td>
<td>2.28</td>
<td>12.70</td>
<td>3.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September-December</td>
<td>0.47</td>
<td>4.06</td>
<td>0.28</td>
<td>2.67</td>
<td>6.09</td>
<td>1.38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESULTS

The results are summarized in Tables I and II.

Drinking Water

The iodine content of drinking water from both Athens and the endemic areas is lower than 0.5 μg/100 ml (Table I), 0.3 μg/100 ml being the limit separating the endemic from the nonendemic areas in a British Medical Research Council study (8). In the endemic areas, however, the values are on the average less than half those in Athens, and the difference is statistically highly significant ($t = 6.92$, $P < 0.001$). There is no consistent seasonal fluctuation, either in Athens or in the endemic areas.
Milk

The cow's milk from the endemic areas contains significantly lower iodine than the milk commercially obtained in Athens ($t = 3.92, P < 0.001$). Boiling does not have a consistent effect. In the endemic areas sheep's milk contains significantly more iodine than either cow's milk ($t = 7.22, P < 0.001$) or goat's milk ($t = 7.28, P < 0.001$). Cow's milk does not show significant seasonal fluctuations, but sheep's and goat's milk contains more iodine during the middle months (Table II). The difference is significant for the sheep's milk: $t$ test between first and second part of the year, $t = 3.13, P < 0.01$, between second and third, $t = 3.27, P < 0.01$.

Common Foods

Eggs obtained commercially in Athens contain significantly more iodine than eggs produced in the endemic areas ($t = 3.10, P < 0.01$), and the same is true for chicken dishes ($t = 2.31, P < 0.05$) and cheese ($t = 2.97, P < 0.01$), whereas for meat dishes the difference is only suggestive ($t = 1.66, 0.10 < P < 0.20$). There is no significant difference in legume dishes and bread, but the large variations in the iodine content of the latter should be noted.

DISCUSSION

The iodine content of several food items has been studied in a country where iodine additives are not regularly used. The main conclusion is that significant amounts of this essential element are present mainly in foods of animal origin with a high protein content. From these results it may be inferred that goiter resulting from iodine deficiency should correlate to some degree with protein undernutrition, but this hypothesis should be tested in practice.

Seasonal fluctuations in the iodine content, with higher values during the winter and lower during the summer, have been reported for the drinking water in Central Europe (9) and for the milk in Britain (10) and Finland (11). This has not been observed in the present study in Greece.

The iodine content of the food produced in the endemic goiter areas is on the whole lower than that of the food available in Athens, but food from any part of Greece contains substantially less iodine than the amounts reported from the United States where Vought and London (4, 6) found in healthy, nonhospitalized subjects a median dietary iodine intake of 128 μg/day for women and 360 μg/day for children. This may be due to a genuine difference in the iodine content of the soil in different regions, which may affect the food produced on it (2), although other factors, such as iodine trapping by plants from the atmosphere (12), may also be important. Work now in progress from our Unit tends to show that water from limestone soils is richer in iodine than water from other soils and that a low iodine content of the drinking water correlates with a low content of several other elements as well. A second reason for the differences in the iodine content of the food from various areas may be found in the use of commercial animal foods, iodized salt, or other additives, and the variable use of these explains the great variations in the iodine content of some foods. Vought and London (6) found in their study at the Clinical Center, National Institutes of Health, that food from the general kitchen contained more iodine than food from the dietetic kitchen, probably because of the use of food additives, preservatives, et cetera, in the former. Some farms feed chickens with fish products or use iodinated antiseptics such as iodoform in the water; London et al. (13) found that some bakeries add iodate to the bread as a “dough conditioner.”

A general conclusion of this study is that natural food contains scarcely the amounts of iodine required to protect the
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population from iodine-deficiency goiter, even in areas not considered endemic, such as Athens. From the results presented here it can be calculated that the dietary iodine intake in this city only occasionally exceeds 40–50 μg/day, and indeed the urinary iodine excretion in healthy Athenians has been reported (mean ± se) as 44.9 ± 5.15 μg/day (14). In a detailed study of healthy Belgian adolescents, Malvaux (15) found a mean dietary iodine intake of 30.3 ± 4.13 μg/day. These values are barely adequate to meet the minimal requirements, which have been estimated by Wayne et al. (3) to vary in different individuals from 42 to 99 μg/day. It is, therefore, not surprising that in countries where iodized salt is not generally used, many cases of so-called “sporadic goiter” are due, in fact, to iodine deficiency (16, 17). There is, therefore, a case for recommending the universal iodization of household salt, especially in developing countries, where many persons rely more heavily on locally produced vegetable foods.

SUMMARY

A study is presented on the iodine content of drinking water, milk (from cows, goats, and sheep) and various food items in the ready-to-eat form from Athens and from the endemic goiter areas of Thessalia, Greece. In general, the iodine content in Athens is lower than the values reported from the United States, and it is even lower in the endemic areas studied. There were no seasonal fluctuations of the iodine content of the water and the cow’s milk. Milk from sheep contained more iodine during the late spring and the early summer. Substantial amounts of iodine were found consistently only in foods of animal origin. The great variation in the iodine content of chicken, meat, and bread is attributed to the use of iodinated substances by some farms or bakeries. It is concluded that, even in areas without endemic goiter, the iodine content of natural food is barely adequate; the universal iodization of household salt is proposed as the best way to ensure a sufficient intake in all members of the community, irrespective of their individual food habits.

REFERENCES

14. MALAMOS, B., K. MIKAS, D. A. KOUTRAS, P. KOSTAMIS, D. BINGOPoulos, J. MANITZOS, G. LEVIS,

