THE ASSOCIATION OF VITAMIN A WITH GREENNESS IN PLANT TISSUE.

II. THE VITAMIN A CONTENT OF ASPARAGUS.*

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(Received for publication, January 7, 1929.)

Since previous experiments (1) showed that the vitamin A content of head and leaf lettuce varied more or less directly with the greenness of the plant tissue, investigations in which asparagus was used as the source of this vitamin were undertaken. It was thought that certain questions concerning the vitamin properties of asparagus, which arise from the fact that it is offered for consumption in both the green and bleached state and also as a canned product, might be answered.

The experiments have been in progress over a period of 2 years (1927-1928), within which time some of the results from the first season's work have been checked by those of the second. Experimental technique was essentially the same as that employed in the tests with lettuce (1). Albino rats were placed on a vitamin A-free ration, complete in all other dietary essentials, until their store of the vitamin was depleted. Following this, different types and varying amounts of asparagus were fed and growth determined over a period of 8 weeks.

The asparagus was of the Martha Washington variety, from plants growing in the college gardens, these plants being several years old, vigorous, and free from disease. Bleached (term used where tissues have never been allowed to become green) tips were secured, in season, by covering over certain rows with about 4 inches of soil and cutting the stalks just before their emergence above the surface of the ground. When freshly cooked tips were

* Published from the Michigan State College Agricultural Experiment Station as Paper 1, new series.
used, these were prepared each day by cooking with water in a glass beaker just prior to feeding. The time of cooking was regulated by the softening of the tips, usually being about 15 minutes. Tips for canning were taken from this same bed of plants and canned as follows: blanched 3 minutes in boiling water; packed in tin cans; the cans sealed and then processed for 25 minutes at 10 pounds pressure in a pressure cooker.

Chemical analyses were made by the Experiment Station Chemist after the following methods: nitrogen, Kjeldahl-Gunning-Arnold; sulfur, Association of Official Agricultural Chemists magnesium nitrate; manganese, Willard and Greathouse; iron, Association of Official Agricultural Chemists colorimetric; calcium, Shohl modification of McCrudden; phosphorus, Briggs' modification of Bell-Doisy.

**Fresh Asparagus, Green and Bleached.**

In both years, the daily amount of fresh green asparagus fed to each animal was 0.1 gm. In the 1928 experiments there were

![Graph showing growth curves for animals fed fresh green and bleached asparagus.](http://www.jbc.org)
two lots of animals on fresh bleached asparagus, one of which had a daily quantity of 0.1 gm. and the other 0.5 gm. The part of the stalk from which the portion for feeding was taken was the same in all the experiments, the second internode back of the tip end. Fig. 1 shows the combined results for the 2 years. Negative controls consisting of one animal from each litter used were run in every case, but are not included on the graphs since without exception the animals continued to lose weight and death ensued.

![Figure 1](http://www.jbc.org/)

**TABLE I.**

**Water in Fresh Tissue, and Partial Chemical Analyses (Oven-Dry Basis) of Asparagus Tips.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Water content</th>
<th>Ash</th>
<th>N</th>
<th>Fe</th>
<th>Mn</th>
<th>S</th>
<th>Ca</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleached (entire stalk)</td>
<td>93.2</td>
<td>7.72</td>
<td>4.62</td>
<td>0.0120</td>
<td>?</td>
<td>0.441</td>
<td>0.175</td>
<td>0.632</td>
</tr>
<tr>
<td>Green</td>
<td>91.7</td>
<td>8.69</td>
<td>6.36</td>
<td>0.001</td>
<td>0.600</td>
<td>0.254</td>
<td>0.822</td>
<td></td>
</tr>
<tr>
<td>Bleached (entire stalk)</td>
<td>92.2</td>
<td>6.42</td>
<td>4.15</td>
<td>0.0231</td>
<td>?</td>
<td>0.351</td>
<td>0.176</td>
<td>0.570</td>
</tr>
<tr>
<td>Green</td>
<td>91.1</td>
<td>5.51</td>
<td>5.87</td>
<td>0.0119</td>
<td>0.001</td>
<td>0.512</td>
<td>0.244</td>
<td>0.761</td>
</tr>
<tr>
<td>Green* (bleached base)</td>
<td>93.2</td>
<td>6.98</td>
<td>3.45</td>
<td>0.0199</td>
<td>Trace.</td>
<td>0.344</td>
<td>0.153</td>
<td>0.509</td>
</tr>
<tr>
<td>&quot; (green tips)</td>
<td>91.8</td>
<td>6.35</td>
<td>5.76</td>
<td>0.0147</td>
<td>Trace.</td>
<td>0.568</td>
<td>0.205</td>
<td>0.755</td>
</tr>
<tr>
<td>Green* (bleached base)</td>
<td>92.2</td>
<td>6.74</td>
<td>3.58</td>
<td>0.0164</td>
<td>Trace.</td>
<td>0.317</td>
<td>0.132</td>
<td>0.504</td>
</tr>
<tr>
<td>&quot; (green tips)</td>
<td>91.5</td>
<td>6.85</td>
<td>5.96</td>
<td>0.0153</td>
<td>Trace.</td>
<td>0.478</td>
<td>0.212</td>
<td>0.780</td>
</tr>
</tbody>
</table>

* Parts of the same stalk.

Fig. 1 shows clearly the superiority of the fresh green asparagus. The cumulative average gain was 20 gm., with no deaths. As regards the animals fed bleached asparagus (fresh), decline in health and weight was continuous and all were dead at the end of the 5th week. This held true for those fed 0.5 gm. daily (1 year's work, 1928) as well as for the lots fed 0.1 gm.

Partial chemical analyses of the fresh asparagus used in each of the two experiments were made. The order of the results for the 2 years was the same, and hence only those for 1927 are presented. These are given in Table I.

Table I shows that the bleached asparagus, whether as such or
as the bleached basal portions of green stalks, was always higher in water content and iron but lower in ash and also in each of the several other elements determined, excepting possibly manganese. The quantities of manganese were so small that, though the very slight differences favored the green tissue, they cannot be taken as significant.

*Cooked Asparagus, Green and Bleached.*

The daily ration of cooked asparagus for the animal was 0.1 gm. Fig. 2 graphically summarizes the combined results of the 2 years work.

![Fig. 2. Growth curves for animals fed cooked green and bleached asparagus.](http://www.jbc.org/)

Fig. 2 demonstrates the higher vitamin A content of the cooked green asparagus as compared with the cooked bleached. The relationship is not identical with that which obtained when the two kinds of asparagus were fed in the fresh state (Fig. 1). Animals fed on the bleached cooked product fared better than those on the same amount of fresh bleached. This difference has occurred consistently in all of our experiments.
**Canned Asparagus, Green and Bleached.**

This was a single experiment, performed in 1927 and not repeated the following year. Animals on canned green asparagus were fed 0.1 gm. daily, those on canned bleached asparagus 0.2 gm. daily. Fig. 3 shows the results.

The animals on canned green asparagus promptly recovered and made good growth, while those on the canned bleached product kept declining and died at a rapid rate, after the 2nd week. This happened even though they received daily a quantity of the material double that provided for the other group.

**DISCUSSION.**

Again, as was shown formerly in the experiments with head and leaf lettuce (1), it appears that there exists a positive correlation between the degree of greenness in edible plant parts and their content of vitamin A. Differences between green and bleached...
asparagus were even more pronounced than obtained with the two types of lettuce. There is no direct evidence that the chlorophyll is the vitamin, nor that it would be impossible to create circumstances wherein the vitamin might be synthesized and made present in abundance though chlorophyll were not developed in appreciable quantity. However, the fact remains that where the tissues are decidedly green the vitamin is abundant. Whether or not the chlorophyll or some part of the chlorophyll molecule, as say the phytol alcohol unit, is the vitamin, or functions in production of the vitamin, or is merely a circumstance attendant upon the reactions of the plant when environed so as to effect the synthesis of the vitamin is an open question.

Moore's experiment (2), together with those of some other investigators whose publications are reviewed in his article, seemed to show that light is not necessary to the formation of vitamin A. Consequently, chlorophyll which forms in the light, unless the plants are denied some other factor essential to its formation (3), is not required. His contention is that etiolated wheat shoots contain vitamin A but in a quantity smaller than that of normally green shoots. Such shoots restore growth when fed in larger amounts. He fed rats at the rate of thirty shoots per day (equivalent to 1.5 gm. of dry wheat). Nevertheless, in our experiments, increases in the quantity of bleached asparagus fed to rats, from 0.1 to 0.2 gm. (canned) and even to 0.5 gm. (fresh) did not serve to bring about recovery, promote growth, and prevent death.

In considering this problem it is well to bear in mind (a) that chlorophyll may exist in elemental, more or less colorless form (4), and (b) that either the etiolation or bleaching of plants and plant parts leads to peculiarities in their chemical composition. Perhaps, the most obvious and important aspect of this altered chemical composition is the presence of amino and amido bodies such as glutamine, tyrosine, arginine, leucine, histidine, lupanine, trigonelline, and even choline and betaine either de novo or in quantitative proportions much greater than what is normal where neither etiolation nor bleaching has been accomplished. Numerous investigations have shown this to be true. Though light may not be absolutely necessary to protein synthesis when the plant
is adequately supplied with carbohydrates and available inorganic nitrogen (5), it remains true that in naturally etiolated and bleached plant parts there is an extra large accumulation of amino and amido compounds which are not promptly synthesized into the respective proteins. Experiments (6) have shown that when at least some of these intermediate compounds are ingested, especially in unduly high concentrations, by animals, their metabolism is unfavorably affected. If these considerations are taken into account, it is relevant to infer that the poor quality of bleached asparagus as food for the animal may not be due alone to vitamin A deficiency but also to an overabundance of deleterious chemical compounds. This conclusion has some additional support in the fact that cooking the white asparagus improved its nutritive value to some extent; a result which could have been due to the effect of the cooking process on the chemical constituents of the tissues.

That a positive relationship exists between chlorophyll development and vitamin A content seems to be established. Whether or not this association is unalterably one of cause and effect is a question still to be answered, and probably hinges upon the experimental task of procuring plant tissue which is non-green, and yet whose chemical composition is not such as to introduce factors which complicate the results.

SUMMARY.

1. Green asparagus, whether fresh, freshly cooked, or canned, when fed daily at the rate of 0.1 gm. per animal, contained vitamin A in quantity sufficient to promote health and growth in albino rats.

2. Fresh bleached asparagus, when fed daily at the rate of either 0.1 or 0.5 gm. per animal gave no stimulus to health and growth. The animals died as rapidly as the negative controls.

3. Cooking in open kettle fashion effected an improvement in the nutritive quality of bleached asparagus, though not rendering its value comparable to that of the green product cooked in the same manner.

4. Green asparagus tissue had lower percentages of water and iron than the bleached tissue, but higher percentages of ash, nitrogen, sulfur, calcium, phosphorus, and possibly manganese.
5. The data from these experiments support the conclusion that the vitamin A content of plant tissue is associated with its greenness.

**BIBLIOGRAPHY.**

THE ASSOCIATION OF VITAMIN A WITH GREENNESS IN PLANT TISSUE: II. THE VITAMIN A CONTENT OF ASPARAGUS
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J. Biol. Chem. 1929, 81:525-532.

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