THE THIAMINE CONTENT OF PIG BLOOD*

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The normal concentration of thiamine in the blood of human subjects has been determined by several investigators. In most instances an average value of the order of 8.0 to 9.0 γ of thiamine per 100 ml. of whole blood has been found (1, 2). Goodhart and Sinclair (2) have reported a value of 5.7 γ per 100 ml. for the ox and the considerably higher value of 20.2 γ per 100 ml. for the pigeon. Schultz et al. (3) have found a value of 7.0 γ per 100 gm. of rat blood.

Since the thiamine content of the muscle tissue of the pig is normally much higher than that for the same tissue in other species, it is reasonable to expect that the thiamine content of pig blood would also be much higher. Similarly, because the thiamine content of muscle tissue in the pig may vary according to the amount of thiamine in the diet (4), the thiamine content of the blood should be related to the thiamine content of the diet or, more directly, to the thiamine content of the muscle tissue. Information on these points is given in this report.

EXPERIMENTAL

In order to determine the average normal concentration of thiamine, samples of blood were obtained from pigs receiving common herd rations. Some of the thiamine values represent pigs in the semifasting state, the blood samples having been taken at the time of slaughter from animals which had received no feed during the preceding 24 hours. In addition, non-fasting values were obtained from samples taken within 3 or 4 hours after the pigs had received a regular feeding. The blood samples were obtained from the anterior vena cava by the method of Carle and Dewhurst (5). Some of the blood samples were obtained from pigs fed ordinary fattening rations, the thiamine contents of which were not determined. However, most of the blood samples were taken from pigs receiving experimental diets of known thiamine content. In several instances pork samples were also obtained from these pigs.

In order to determine the effect of feeding relatively large amounts of

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thiamine upon the concentration of thiamine in the blood, daily individual doses of crystalline thiamine were administered orally to three groups of pigs. Each of a group of four pigs was given 25 mg. of thiamine for 7 days, and each pig in a similar group received 50 mg. of thiamine for the same period. Each of three pigs in a third group received 50 mg. of thiamine for a period of 11 days. Blood samples were taken before the thiamine feeding began and at regular intervals thereafter.

Thiamine was determined by a modification of the thiochrome method of Hennessy and Lewis (6). The method was modified in an attempt to reduce the hematin-catalyzed destruction of thiochrome by alkaline ferri-cyanide, as described by Owen, Weissmann, and Ferrebee (7). 5 ml. samples of whole, oxalated blood were pipetted into 40 ml. portions of 1 per cent acetic acid contained in 100 ml. volumetric flasks. The samples were heated at the temperature of boiling water for 10 minutes. After cooling, 0.3 gm. of taka-diastase in aqueous solution was added to each flask, and the samples were allowed to incubate at 45–50° for at least 2 hours. 40 ml. of 10 per cent trichloroacetic acid were then added to each flask, and the samples were allowed to stand for about 30 minutes. The pH was adjusted to about 4.5 with 2.5 M sodium acetate, the volume was made up to 100 ml., and the extracts were filtered. From this point the details of the published procedure were followed. Results were reproducible within ±15 per cent. A moderate decrease in the destruction of thiochrome was obtained with the modified procedure.

DISCUSSION

The results of the investigation are summarized in Table I and Fig. 1. Although a wide range of values was encountered in several of the groups, the standard errors of the mean values are well within the limits of the experimental error.

The normal concentration of thiamine in the blood of the pig appears to be about twice as high as that reported for human subjects. The mean value found for thirteen pigs in the semifasting state was 17 γ of thiamine per 100 ml. of whole blood. The mean blood thiamine value for nine non-fasting pigs was 21 γ per 100 ml. The difference between these values is statistically significant and suggests that the concentration of thiamine in the blood fluctuates during the progress of digestion in a manner similar to that of blood glucose and other substances.

In general, the concentration of thiamine in the blood becomes higher as the thiamine content of the diet is increased. In addition, there appears to be a rather direct relationship between the thiamine content of the muscle tissue of the pig and the concentration of thiamine in the blood. The data for Group 7. Table I, show clearly that when the tissue stores are
large the blood thiamine level is high, even though the daily thiamine intake has been at an average level for some time. Similarly, in Group 8, although the daily thiamine intake was high, the tissue stores and the blood level of thiamine were only slightly above average. The relatively low tissue storage of thiamine in the latter animals is considered anomalous, as discussed elsewhere.1

### Table I

**Concentration of Thiamine in Normal Pig Blood and Its Relation to Thiamine Content of Diet and to Thiamine Content of Muscle Tissue**

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Description of ration</th>
<th>Type of blood sample</th>
<th>No. of animals</th>
<th>Thiamine per 100 ml. whole blood</th>
<th>Average thiamine per gm. fresh lean tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Herd ration of unknown thiamine content</td>
<td>Fasting</td>
<td>13</td>
<td>11-21</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>&quot; &quot; &quot; &quot;</td>
<td>Non-fasting</td>
<td>5</td>
<td>16-21</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Herd ration containing 1.68 mg. thiamine per lb. feed</td>
<td>Fasting</td>
<td>4</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Herd ration containing 1.75 mg. thiamine per lb. feed</td>
<td>Fasting</td>
<td>3*</td>
<td>16-20</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Grain ration + legume pasture</td>
<td>&quot; &quot;</td>
<td>2*</td>
<td>15-17</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>Herd ration + peanut skins or 50 mg. thiamine per day</td>
<td>&quot; &quot;</td>
<td>4</td>
<td>25-35</td>
<td>29</td>
</tr>
<tr>
<td>7</td>
<td>Herd ration + 50 mg. thiamine for 35 days; then no extra thiamine for 35 days prior to slaughter</td>
<td>&quot; &quot;</td>
<td>3</td>
<td>26-30</td>
<td>28</td>
</tr>
<tr>
<td>8</td>
<td>Herd ration + 50 mg. thiamine for 84 days</td>
<td>Non-fasting</td>
<td>3†</td>
<td>19-28</td>
<td>23</td>
</tr>
</tbody>
</table>

* Also included in Group 1.
† A total of ten determinations on samples of 3 succeeding days.

The influence of 7 days of feeding relatively large amounts of thiamine on the thiamine content of the blood is shown in Fig. 1. The level of thiamine in the blood increased rapidly during the period of administration of the vitamin, and decreased just as rapidly after the extra thiamine was discontinued. When the vitamin was fed for a period of 11 days (results not shown), the maximum blood level values attained were no higher than those reached within 5 to 7 days.

1 Pence, J. W., Miller, R. C., Dutcher, R. A., and Ziegler, P. T., unpublished data.
There are several points of difference in the results obtained in this investigation and those obtained with human subjects. Benson et al. (1, 8), Youmans et al. (9), and other workers have found that the concentration of thiamine in human blood bears little relationship to the state of saturation of the tissues. Only in cases of severe thiamine deficiency does the blood level of thiamine fall below the normal range. In a deficient human subject, the administration of thiamine will cause the blood level to rise to normal values, but in mildly deficient or normal subjects an increase in the thiamine intake will not lead to higher blood thiamine values. Najjar and Holt (10), among others, report that when relatively large amounts of thiamine are injected into human subjects the blood level rises to very high values, but returns to normal within a few hours.

The authors have shown\(^1\) that the pig has the ability to accumulate large amounts of thiamine in muscle tissue quite rapidly. With an intake of 50 mg. of thiamine per day a maximum storage is obtained within 5 weeks, the thiamine content of these saturated tissues being nearly twice as high as that obtained from an average thiamine intake. Thus, if a high intake of thiamine is continued long enough to increase the storage of the vitamin in the muscle tissue materially, the concentration of thiamine in the blood will remain above normal even though the intake has been reduced (see the data for Group 7, Table I).

Within limitations, the concentration of thiamine in the blood may be used as a rough index of the storage of thiamine in the muscle tissue of the pig.
pig. The storage of extra thiamine in the muscle tissue is indicated by an elevated blood thiamine value, provided that any substantial increase in the daily intake, immediately prior to sampling, has been of sufficient duration to have exerted its full effect upon the storage of this vitamin in the muscle tissue.

**SUMMARY**

The normal concentration of thiamine in the blood of pigs was found to be 17 and 21 γ per 100 ml. for semifasting and non-fasting pigs, respectively. These values are approximately twice as high as those reported for normal human subjects.

A rise in the blood thiamine level to approximately 30 γ per 100 ml. of whole blood occurred within a week when pure crystalline thiamine was fed in daily amounts of 25 or 50 mg.

The concentration of blood thiamine in the pig is directly related to the amount of thiamine in the diet and to the thiamine content of the muscle tissue.

**BIBLIOGRAPHY**

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