THE FATE OF TARTARIC ACID IN THE HUMAN BODY*

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Until recently no accurate method existed for the quantitative determination of small amounts of tartaric acid in the urine. In 1931 Underhill, Peterman, and Krause (1) reported a colorimetric method based upon the reaction between metavanadates and tartaric acid in which a golden red color results. We are able to report upon its accuracy, for this identical method was developed independently by me in this laboratory and has been employed in our investigation upon tartaric acid during the past 3 years.

The fate of tartaric acid both in experimental animals and in the human body has been the subject of a great many studies, the most important of which are those of Pohl (2), Brion (3), Neuberg and Saneyoshi (4), Underhill and coworkers (5), Salant and Smith (6), and Simpson (7). Yet, uncertainty existed until recently concerning the fate of this fruit acid in the human body.

In general, the view has been that tartaric acid is oxidized in the body. Dakin in his book (8) p. 61) states that both d- and l-tartaric acids are oxidized in the body, though less readily than either malic or succinic acid. He quotes the work of Brion and of Neuberg. The results of the earlier work of Underhill (5) were also in accord with the view that tartaric acid is oxidized in the body. However, in these experiments upon rabbits, large doses of tartrates were used, causing damage to the kidney tubules and serious disturbances in renal function.

In their recent work, Underhill, Leonard, Gross, and Jaleski (9) report results in animals which are at variance with earlier reports. In both rabbits and dogs, when non-toxic doses of tartrate are administered either orally or intramuscularly, they were able to

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Tartaric Acid

recover from 74 to 99 per cent in the urine. When the dose of tartrate administered is sufficient to cause marked renal damage, the tartrate excretion is greatly diminished. In the rat, the average urinary output is 68 per cent and 79 per cent respectively for oral administration and subcutaneous injection. They found that the guinea pig is unique in that it excretes in the urine up to 27 per cent of tartrates administered by mouth, and practically 100 per cent of tartrates given subcutaneously.

Underhill, Peterman, Jaleski, and Leonard (10) report experiments in man in which they find that about 20 per cent of tartrates administered by mouth is excreted in the urine. Their results are therefore inconclusive as regards the fate of tartaric acid in man.

The experiments which we now report indicate that tartaric acid cannot be oxidized or otherwise utilized by human beings.

EXPERIMENTAL

Methods

The subjects of the experiments consisted of twenty-four male individuals (male, in order to facilitate collection of specimens) six of whom were interns. The remaining eighteen were patients on the service of Dr. George Baehr. All of the subjects were adults, none of whom suffered from renal disease. In view of the experimental observations of Underhill, Salant, and others which demonstrated that severe damage to renal tubules resulted from injection of large quantities of tartrate into laboratory animals, it is of interest to note that no untoward effects followed the administration of tartaric acid or sodium tartrate in any of our observations. Albumin did not appear in the urine.

In each instance preliminary examination of the urine showed that no tartrate was present. All the urine excreted from the time of administration of the tartaric acid was collected. In the first six subjects each specimen of urine voided was examined for the presence of tartrate. It was found that the total tartrate which appeared in the urine was always excreted within 12 hours after ingestion.

Fate of Tartaric Acid Given by Mouth—The first twelve subjects were given d-tartaric acid in two capsules of 1 gm. each, and were
permitted to drink as much water as desired. It was found unnecessary to impose dietary restrictions.

From Table I it is seen that only part of the tartaric acid taken by mouth is excreted in the urine. The amount ranges from 11 to 24 per cent of the total acid ingested, the average in the case of twelve individuals being approximately 17 per cent. The results are in agreement with those found by Underhill, Peterman, Jaleski, and Leonard (10) in their study of four individuals to whom they gave tartaric acid by mouth.

TABLE I
Excretion of Tartaric Acid in Urine Following Ingestion of 2 Gm. of Tartaric Acid by Mouth

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time of tartaric acid administration following meal (some cases after last meal of day)</th>
<th>Tartarate excreted in urine</th>
<th>Ingested tartarate excreted in urine</th>
<th>Time of tartaric acid administration following meal (some cases after last meal of day)</th>
<th>Tartarate excreted in urine</th>
<th>Ingested tartarate excreted in urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>En</td>
<td>2</td>
<td>230</td>
<td>11.5</td>
<td>4</td>
<td>366</td>
<td>18.3</td>
</tr>
<tr>
<td>Ma</td>
<td>2</td>
<td>227</td>
<td>11.3</td>
<td>2</td>
<td>380</td>
<td>19</td>
</tr>
<tr>
<td>La</td>
<td>2</td>
<td>315</td>
<td>15.7</td>
<td>2</td>
<td>405</td>
<td>20.2</td>
</tr>
<tr>
<td>Sa</td>
<td>4</td>
<td>286</td>
<td>14.3</td>
<td>2</td>
<td>344</td>
<td>17.2</td>
</tr>
<tr>
<td>Hi</td>
<td>4</td>
<td>400</td>
<td>20.0</td>
<td>2</td>
<td>495</td>
<td>24.7</td>
</tr>
<tr>
<td>Th</td>
<td>6</td>
<td>286</td>
<td>14.3</td>
<td>4</td>
<td>465</td>
<td>23.2</td>
</tr>
</tbody>
</table>

Average.................................................................17.4

Effect of Calcium-Rich Food Ingested Simultaneously with Tartaric Acid—In order to ascertain what the effect might be of taking food rich in calcium together with tartaric acid, two subjects were given 4 gm. of tartaric acid with two glasses of milk. This was administered in two equal doses 1 hour apart. One glass of milk was given with each dose.

Apparently (Table II) the ingestion of milk, which is high in calcium content, simultaneously with tartaric acid has no significant effect upon the tartrate excretion in the urine. The two subjects excreted 15.9 and 14.5 per cent respectively of the tartrate ingested. This is approximately equivalent to the quantity excreted by the other subjects who took only water with the tartaric acid.
From the foregoing it is clear that only a comparatively small proportion (less than 20 per cent) of the tartrate taken by mouth reappears in the urine. These facts may be interpreted in a number of ways. (1) The greater part of the tartrate ingested, about 80 per cent, may undergo oxidation in the body to CO$_2$ and water, as in the case of citric acid. (2) The tartrate may be stored in the body and eliminated as such in small quantities over a long period of time. (3) The greater part of tartaric acid taken by mouth is not absorbed. It is either destroyed in the intestinal tract by bacterial action, or is excreted in the stool in the form of calcium tartrate or other insoluble salt.

**TABLE II**

*Excretion of Tartrate in Urine Following Ingestion by Mouth of 4 Gm. of Tartaric Acid with Milk (for Calcium Content)*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Time of administration of 2 gm. tartaric acid with glass of milk (time of last meal, 4.30 p.m.)</th>
<th>Tartrate excreted in urine ma.</th>
<th>Ingested tartrate excreted in urine per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ei</td>
<td>8 p.m. 9 &quot;</td>
<td>635</td>
<td>15.9</td>
</tr>
<tr>
<td>Go</td>
<td>8 &quot;</td>
<td>582</td>
<td>14.5</td>
</tr>
</tbody>
</table>

*Fate of Tartrate Administered by Intramuscular Injection—*

In order to determine whether the human body is capable of utilizing tartaric acid, ten subjects were given sodium tartrate by intramuscular injection. By this means, also, the possibility of extraneous action by bacteria in the intestinal tract was obviated.

Neutral pure sodium tartrate in the form of a 20 per cent solution in distilled water was used, and the solution sterilized by boiling. In each of eight of the subjects 5 cc. of this solution (1 gm. of sodium tartrate) were injected into the gluteal muscles. Two other subjects received 10 cc. each. The urine was then collected for 12 hours.

As shown in Table III tartrate injected intramuscularly is eliminated almost quantitatively in the urine, within 12 hours. Between 85 per cent and 98.5 per cent of the quantity injected appeared in the urine in this period.
Rate of Excretion of Tartrate Injected Intramuscularly—To determine the rate at which the injected tartrate is excreted in the urine, in each of two of the subjects 2 gm. (10 cc. of a 20 per cent solution) of sodium tartrate were injected into the gluteal muscles. The urine was collected every 2 hours for a period of 12 hours, and the quantity of tartrate was determined in each specimen.

It is seen from Table IV that almost the total quantity of tar-

### TABLE III

**Excretion of Tartrate in Urine Following Intramuscular Injection of 20 Per Cent Sodium Tartrate Solution**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Injected Tartrate mg.</th>
<th>Excreted Tartrate mg.</th>
<th>per cent</th>
<th>Subject</th>
<th>Injected Tartrate mg.</th>
<th>Excreted Tartrate mg.</th>
<th>per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ho</td>
<td>1000</td>
<td>890</td>
<td>89</td>
<td>Ga</td>
<td>1000</td>
<td>860</td>
<td>86</td>
</tr>
<tr>
<td>So</td>
<td>1000</td>
<td>870</td>
<td>87</td>
<td>Ka</td>
<td>1000</td>
<td>960</td>
<td>96</td>
</tr>
<tr>
<td>San</td>
<td>1000</td>
<td>914</td>
<td>91.4</td>
<td>Mi</td>
<td>1000</td>
<td>850</td>
<td>85</td>
</tr>
<tr>
<td>Li</td>
<td>1000</td>
<td>910</td>
<td>91</td>
<td>Be</td>
<td>2000</td>
<td>1970</td>
<td>98.5</td>
</tr>
<tr>
<td>Ca</td>
<td>1000</td>
<td>870</td>
<td>87</td>
<td>Wi</td>
<td>2000</td>
<td>1900</td>
<td>95</td>
</tr>
</tbody>
</table>

Average .................................................... 90.5

### TABLE IV

**Rate of Excretion of Tartrate in Urine Following Intramuscular Injection of 20 Per Cent Sodium Tartrate Solution**

<table>
<thead>
<tr>
<th>Time after injection of tartrate</th>
<th>Subject Be. 2 gm. sodium tartrate injected at 6 a.m.</th>
<th>Subject Wi. 2 gm. sodium tartrate injected at 6 a.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>hrs.</td>
<td>Tartrate excreted in urine mg.</td>
<td>Injected tartrate excreted per cent</td>
</tr>
<tr>
<td></td>
<td>28.5</td>
<td>18.7</td>
</tr>
<tr>
<td>Total</td>
<td>1970</td>
<td>98.5</td>
</tr>
</tbody>
</table>
Tartaric acid appeared in the urine within 10 hours following injection. Almost 60 per cent of the injected tartrate reappeared in the urine within the first 4 hours following administration. In one subject, 90 per cent of the injected tartrate was excreted within 8 hours, and the remaining 8 per cent between the 8th and 10th hour. In the other subject 80 per cent of the injected tartrate was excreted within 6 hours, the remaining 15 per cent being excreted between the 6th and 8th hour after injection.

SUMMARY

The experiments demonstrate that tartaric acid (sodium tartrate) is not burned in the human body. When injected intramuscularly it reappears almost quantitatively in the urine within 10 hours, the major portion being excreted within the first 4 hours. Apparently the human body can neither oxidize nor otherwise transform this acid.

When taken by mouth, only about 20 per cent of ingested tartrate is eliminated in the urine. At no time in the course of investigations have any traces of tartrate taken by mouth been demonstrated in the feces. It has long been known that tartaric acid is destroyed by fungi and by certain bacteria. Pasteur (11) in 1860, treated a mixture of $d$- and $l$-tartaric acid with the mold, *Penicillium glaucum*, and found that the $d$-tartaric acid was destroyed by this organism. Maassen (12) in 1896 found that twenty-three varieties of bacteria were able to destroy tartaric acid, among those being the *Bacillus pyocyaneus*, the Friedländer bacillus, the typhoid bacillus, the *Bacterium enteritidis* of Gaertner, and the *Bacillus coli*. Underhill et al. (10) found that tartaric acid is destroyed by fecal material. It is therefore probable that the portion of tartaric acid given by mouth which fails to appear in the urine (80 per cent) is destroyed in the intestinal tract by bacterial action. 20 per cent or less is absorbed before it is subjected to the destructive action of the intestinal bacteria, and is excreted in the urine. The experiments of Pickens and Hetler (13) are in accord with these results. They gave large quantities of grape juice to their subjects and found that the urine was acid and not alkaline as might be expected from feeding of malic or citric acid. The excretion in the urine of a part of the tartaric acid present in the grape juice may account for their findings.
The conclusion that tartaric acid (sodium tartrate) cannot be utilized in the human body and is excreted by the kidneys is at variance with previous reports, probably owing to the fact that in the earlier experiments such large amounts were injected into small animals that severe injury to renal tubules resulted. The serious, often fatal disturbance in renal function delayed or prevented the excretion of much of the ingested acid. The methods for determination of small amounts of tartaric acid also were not as accurate as the methods utilized by us. The last experiments reported by Underhill et al. (9) indicate that neither the dog, rabbit, nor guinea pig can utilize tartaric acid. With the doses employed in our observations on human beings renal damage did not occur, and it is therefore possible to recover practically all of the injected tartrate in the urine and to demonstrate that none of this fruit acid is utilized by human beings.

BIBLIOGRAPHY
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