The Effect of Fat on the Gastric Responses to Foods\textsuperscript{1,2}

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Introduction

There has long been prevalent a popular belief that fats incorporated in foods during processes of cooking or baking render them difficult to digest even by the normal human subject. Among the phases of digestion assumed to be impeded by fats in foods are the functions of the stomach. Probably Boas and Ewald, in 1886, were the first to report impairment of gastric function produced by fats. Since that time numerous reports have appeared in clinical and physiological literature which purport to demonstrate that fats retard both gastric secretion and motility. It is not within the scope of this report to present a review of this extensive literature. It will suffice to say that in the large measure these conclusions have been based upon animal experiments in which the techniques employed excluded important factors such as palatability and flavors of foods, which are potent stimulants to gastric secretion. In the majority of experiments large amounts of fats have been fed alone or mixed with carbohydrates and proteins in proportions far exceeding the quantities of fat incorporated in foods by cooking or baking. These limitations of the experimental procedures render the conclusions drawn from them inapplicable to foods naturally containing fats or foods prepared with fats by good cooking.

In this laboratory during the past decade comprehensive experimental studies have been directed to determinations of the influences of fats, from different sources, upon the rates of digestion of carbohydrates and proteins with which they have been fed to human subjects. Observations have been made of the effects of fats either added to or intimately incorporated with carbohydrate and protein foods by the best culinary techniques. The initial steps in this investigation were concerned with the influence of fats upon gastric secretion in response to the consumption of the foods and upon the rate of evacuation of the food from the stomachs of average normal human subjects. This report has been limited to presentation of studies of the effects of foods containing different fats and varying amounts of fats upon the emptying time of the stomach. Subsequent communications will be devoted to discussions of the influence of these foods upon other phases of digestion and absorption.

Experimental

Ten adult subjects participated in the series of experiments described in this report. Seven of these (No. 1-No. 7, inclusive) were men and the remaining three were women.

On the basis of their gastric secretary and motor responses to test meals of dilute ethyl alcohol or of gruel, as determined by the fractional method of gastric analysis, the subjects have been classified as follows: subjects No. 1, No. 2, No. 4, and No. 9 showed normal curves for acidity and emptying times of their stomachs within the normal range. Subjects No. 3 and No. 8 exhibited normal curves for acidity but slowly emptying stomachs. Three subjects, No. 5, No. 6, and No. 7, gave curves for acidity typical of larval hyperacidity with rapidly emptying stomachs. One subject, No. 10, was representative of a persistent achlorhydria with a slowly emptying stomach.

The types of curves for gastric acidity referred to above have been described by Hawk and Bergeim (1). Times required for complete evacuation of test meals from the stomachs of the subjects were determined by the fractional method of gastric analysis as described by Hawk and Bergeim (2). The subjects reported at the laboratory in the morning of the day of the experiment after a fast for 12 to 15 hours. The Rehfuss gastric tube was introduced into the stomach of the subject sitting erect, and the gastric residuum was completely aspirated. The test meal was then fed and thoroughly masticated with the gastric tube in place. The samples of gastric contents not exceeding 15 cc. in volume were withdrawn by means of the gentle suction produced by a syringe at intervals of 15 minutes until the meal had been evacuated completely from the stomach, as determined by the procedure described by Hawk and Bergeim (3).

Experimental Results and Discussion

In any series of experiments undertaken to compare gastric evacuation times for two or more test meals,

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|c|c|}
\hline
Subjects & Test Meal & First Experiment & Second Experiment & Third Experiment & Averages & Average Deviations \\
\hline
1 & Pie Crust & 165 & 135 & 150 & 150 & \pm10 \\
2 & 50 gm. containing 16.3 gm. of fat & 165 & 135 & 150 & 150 & \pm10 \\
3 & Cake & 165 & 135 & 150 & 150 & \pm10 \\
4 & For All Experiments & 135 & \pm18 & & & \\
\hline
1 & Cake & 165 & 135 & 150 & 145 & \pm13 \\
2 & 50 gm. containing 7.9 gm. of fat & 120 & 120 & 120 & 120 & \pm0 \\
3 & For All Experiments & 120 & \pm15 & & & \\
\hline
\end{tabular}
\caption{Comparative Gastric Evacuation Time for Meals of Pie Crust or Cake in Repeated Experiments on Each of Four Subjects}
\end{table}
sive experimental studies have been made of gastric-evacuation times. Differences in evacuation times between two test meals with one test meal may be as great as ±18 minutes, whereas the deviation was 30 minutes. Average deviations observed in three consecutive tests on each of four subjects remained strikingly uniform from day to day, but great variations existed among the different individuals.

Table I presents data for gastric evacuation times found in three consecutive tests on each of four subjects in response to test meals of pie crust or pound cake which were consumed with 150 cc. of water. The maximum deviation between any two consecutive tests was 30 minutes. Average deviations observed in three tests on any one subject varied from ±0 to ±13 minutes.

The average evacuation times for 12 experiments with each test meal agreed within five minutes. In view of this close agreement between the results for the two meals the results for tests with both meals have been averaged for each subject. The average deviations for each subject in the tests with both meals vary from ±5 to ±13 minutes. For 24 experiments with both test meals the average gastric evacuation time was 133 ±17 minutes.

Since the average deviation in repeated experiments with one test meal may be as great as ±18 minutes, differences in evacuation times between two test meals should be greater than at least ±18 minutes in order to be significant.

During the past 10 years in this laboratory extensive experimental studies have been made of gastric-secretory and motor responses to many common foods and combinations of these foods. Results of some of these studies have been reported in Table II which presents data for caloric values and the fat and protein contents of the test meals as well as the gastric evacuation times.

Subjects No. 1 to No. 4 inclusive participated in these experiments. Three experiments with cake, bread and hydrogenated vegetable fat, and pie crust were carried out on each of the four subjects but only one experiment with the other test meals listed in the table. In all cases the meals were fed with 150 cc. of water.

There is evident no relationship between the quantity of fat in the portion of the test meal and the gastric evacuation time. Periods required for the evacuation from the stomach of the meals containing the largest quantities of fat, viz., bread and hydrogenated vegetable fat, and pie crust, are not greater than the gastric evacuation times of meals of low fat content, viz., bread and milk. It is of interest to note that the meals of pound cake and of lean beef contain approximately similar quantities of fat, but the evacuation time of the latter meal is significantly greater than that of the former. These findings suggest a closer relationship between the protein content of the meal and the time required for evacuation of the meal from the stomach than between the fat content and the emptying time of the stomach. This topic will be discussed more fully in a later communication.

Wishnofsky, Kane, and Spitz (6) compared changes in blood sugar and urine sugar after the administration to 11 diabetics of either 60 gm. of glucose or 60 gm. of glucose plus 120 gm. of olive oil. They observed that the concentration of blood sugar was significantly greater 90 minutes after the ingestion of glucose alone than after the ingestion of glucose and fat. This difference between the levels of blood sugar after the two test meals the authors attribute to a slowing of the emptying of the stomach produced by the fat fed with the glucose. Although they made no

one or two days intervened between two consecutive tests. A prerequisite for the evaluation of differences in gastric evacuation times for two or more test meals is a knowledge of the day to day variation in the gastric motor responses to the same test meal.

Ryle (4) states that the fractional method of gastric analysis is a valuable test of motility of the stomach and that the rate of emptying is the most constant and accurate of all the findings of gastric function obtained with this method.

Van Liere and Sleeth (5) utilized a radiographic method for determination of the emptying time of the stomach. From 77 tests on nine subjects they concluded that the emptying time of the stomach of any individual remained strikingly uniform from day to day, but great variations existed among the different individuals.

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### Table II

#### Comparative Gastric Evacuation Times for Meals Containing Varying Amounts of Fat and Protein

<table>
<thead>
<tr>
<th>Test Meal</th>
<th>Portion Fed</th>
<th>Number of Experiments</th>
<th>Calories Per Portion</th>
<th>Fat</th>
<th>Protein</th>
<th>Gastric Evacuation Times In Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gm.</td>
<td></td>
<td>gm. per portion</td>
<td>gm. per portion</td>
<td></td>
<td>Averages Average Deviations</td>
</tr>
<tr>
<td>Bread</td>
<td>50</td>
<td>4</td>
<td>128</td>
<td>0.7</td>
<td>4.6</td>
<td>154 ±13</td>
</tr>
<tr>
<td>Milk</td>
<td>175</td>
<td>4</td>
<td>120</td>
<td>7.0</td>
<td>5.3</td>
<td>159 ±15</td>
</tr>
<tr>
<td>Cake</td>
<td>60</td>
<td>12</td>
<td>214</td>
<td>7.8</td>
<td>13.2</td>
<td>180 ±15</td>
</tr>
<tr>
<td>Lean Beef</td>
<td>35</td>
<td>4</td>
<td>129</td>
<td>8.4</td>
<td>11.3</td>
<td>161 ±34</td>
</tr>
<tr>
<td>Egg</td>
<td>62</td>
<td>12</td>
<td>225</td>
<td>15.7</td>
<td>8.2</td>
<td>149 ±22</td>
</tr>
<tr>
<td>Bread and Hydrogenated Vegetable Fat.</td>
<td>15</td>
<td>12</td>
<td>291</td>
<td>16.2</td>
<td>6.7</td>
<td>135 ±18</td>
</tr>
</tbody>
</table>

### Table III

#### Comparative Gastric Evacuation Times for Test Meals of Glucose Alone or of Glucose with Supplements of Fat

<table>
<thead>
<tr>
<th>Test Meal</th>
<th>Quantities of Ingredients</th>
<th>Gastric Evacuation Times In Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gm. in 180 cc.</td>
<td>Subject 1</td>
</tr>
<tr>
<td>Glucose</td>
<td>50</td>
<td>105</td>
</tr>
<tr>
<td>Glucose and Heavy Cream.</td>
<td>50</td>
<td>195</td>
</tr>
<tr>
<td>Glucose and Hydrogenated Vegetable Fat.</td>
<td>35</td>
<td>180</td>
</tr>
</tbody>
</table>