Note

Effect of Acetic Acid and Vinegar on Blood Glucose and Insulin Responses to Orally Administered Sucrose and Starch

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Majchrowicz and Hunt[1] have reported that sodium acetate has an inhibitory effect on the rapid increase of blood ethanol concentration following oral administration of ethanol. Mochizuki *et al.*[2,3] have reported that acetic acid and vinegar also have this effect. It is considered that many dietary factors have effects on the blood glucose concentration after a meal,[4,5] so we examined the effect of acetic acid and vinegar (in which the major component is acetic acid) on the blood glucose response. In general, glucose has been used as a carbohydrate source in examining the effect of dietary factors on the response of blood glucose concentration. However, in everyday life we take too much sucrose and starch as carbohydrate sources compared with glucose. Therefore, in this experiment we used sucrose and starch instead of glucose as carbohydrate sources. Blood glucose concentration was measured by an enzymatic method (A-Gent Glucose-UV Test, Abbott Laboratory), and serum insulin concentration was measured by a double-antibody radioimmunoassay (Phadeseph Insulin RIA kit, Shionogi Pharmaceutical Co., Ltd.).

Male rats of the Sprague-Dawley strain (150 g, Shizuoka Animal Laboratory Center, Hamamatsu) were used. They were housed in suspended individual cages in a room with an inverted light and dark cycle (20:00 to 08:00 light and 08:00 to 20:00 dark) and were fed with a purified 25% casein-sucrose diet for 2 weeks. The animals were divided into two groups of 6 rats after fasting for 24 hr and then were given a 10% (w/v) α-corn starch solution with or without 2% (v/v) acetic acid *via* a stomach tube to provide 100 mg of starch per 100 g of body weight. Blood samples were collected from the tail vein at 0 (fasting blood sample), 15, 30, 60, 120 and 180 minutes after administering the starch solution. The rapid increase and decrease of blood glucose concentrations were inhibited in the group given acetic acid (Fig. 1).

Next, we used vinegar instead of acetic acid, as it is rare for acetic acid to be ingested in reality, and examined its effect on the blood glucose and insulin responses in man. Seven healthy subjects (6 men and 1 woman, aged 27～56, whose weights were within $-4\% \pm 2\%$ of the ideal mean weight[6]) were divided into two groups of 3 and 4 subjects after fasting overnight. Three-hundred ml of a sucrose solution containing 50 g of sucrose and 60 ml of commercial strawberry vinegar was administered to one group, and 300 ml of a sucrose solution containing 53.6 g sucrose (a control meal) to the other. The content of acetic acid in this commercial strawberry vinegar (Nakano Vinegar Co., Ltd.) was 5%, and the vinegar contained 6% sugar substance (sucrose + fructose + glucose). One week after the first trial was done, a similar experiment was run by reversing the meals for each group. Blood glucose and serum insulin responses to the two meals are shown in Fig. 2. The blood glucose responses shown in the lower panel (B) indicate that the two meals resulted in comparable glycemic responses, but that the time to attain the maximum level with the test meal was delayed compared with that for the control meal. On the other hand, the serum insulin responses to the two meals were quite different as shown in the upper panel (A), the area under the insulin response curve being about 20% smaller with the test meal than that with the control meal (19.5 μU/ml·hr for the test meal and 23.5 μU/ml·hr for the control meal).

The mechanism for the blood glucose- and insulin-flattening activities of acetic acid and vinegar are still not clear. However, Mochizuki *et al.*[2,3] have shown that acetic acid and vinegar have an inhibitory effect on the rapid

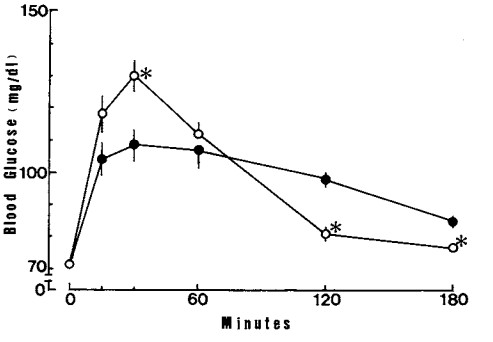

FIG. 1. Blood Glucose Response Curves to the Control Meal (α-Corn Starch Only, ○—○) and to the Test Meal (α-Corn Starch plus Acetic Acid, ●—●).

Adult male rats were intragastrically administered with a 10% (w/v) α-corn starch solution with or without 2% (v/v) acetic acid to provide 100 mg of α-corn starch per 100 g of body weight. Vertical bars represent the standard error of the mean ($n=6$). Asterisks indicate a significant difference from the test value ($p<0.05$). The statistical significance of this difference was assessed by Student's t-test.[7]

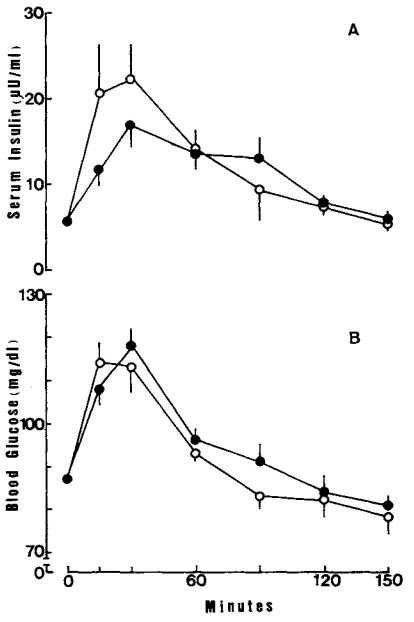

FIG. 2. Serum Insulin (A) and Blood Glucose (B) Response Curves to the Control Meal (53.6 g of Sucrose Only, ○—○) and to the Test Meal (50 g of Sucrose plus 60 ml of Strawberry Vinegar, ●—●) Dissolved in 300 ml of Water in 7 Subjects.

Vertical bars represent the standard error of the mean, and the value at time 0 is the overnight fasting level.

increase of blood ethanol concentration, delaying the time to attain the maximum blood ethanol level. One of the proposed mechanisms for the effect may be the delayed gastric emptying, resulting in a delay of the movement and/or the absorption of ethanol in the gastrointestinal tract. The blood glucose- and serum insulin-flattening activities of vinegar may be due in part to delayed gastric emptying. Further investigations are necessary to clarify the mechanism for the blood glucose- and serum insulin-flattening activities of vinegar, but vinegar might be applied to contol the hyperglycemic response after a meal.

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