Inhibitory Effect of Palatinose on Glucose Absorption in Everted Rat Gut

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(Received May 9, 2006)

Summary We previously reported that the increase in blood glucose was more suppressed when palatinose was taken with sucrose or glucose than when either of these sugars was taken alone. In the present study, we examined whether or not palatinose suppresses glucose absorption using everted intestinal sacs from rats. Glucose absorption in the everted rat intestinal sac was measured with 0, 1, 2.5 or 5 mM of palatinose added to 20 mM glucose. The measurement was repeated five times for each palatinose level to calculate a mean value. The result showed glucose absorption to be reduced as the palatinose level increased. It was significantly reduced when 5 mM palatinose was added as compared with no palatinose addition (p<0.05). These results suggest that palatinose suppresses glucose absorption.

Key Words glucose absorption, enzyme inhibition, blood glucose

Palatinose (6-O-D-glucopyranosyl-D-fructofuranose), which is also called isomaltulose, has been used in various food products as a non-cariogenic natural sugar which has a good taste comparable to that of sugar (1, 2). Palatinose is characterized by excellent digestibility. Palatinose is catalyzed by an isomaltase, and the digestibility of palatinose is estimated to be about one-fifth that of sucrose (3). Thus, palatinose causes a gradual increase in blood glucose (4, 5). Furthermore, it is a safe sugar that does not cause diarrhea even when taken in large quantities because a sufficient amount of isomaltase is available in the small intestine.

Recent studies have identified several functions associated with the property of gradually increasing blood glucose (6, 7). We recently found that palatinose inhibited the blood glucose increases which occur in response to sucrose or glucose (8). One of the potential mechanisms of this suppressive effect is the inhibition of enzymes that degrade carbohydrates such as sucrose, maltose and starch (9). However, since this inhibitory effect alone cannot explain the suppressive effect of palatinose on the increase in blood glucose with the ingestion of glucose, which is a simple sugar, palatinose may suppress glucose absorption per se. The present study was therefore designed to investigate whether palatinose has any suppressive effects on glucose absorption using everted rat intestine.

Materials and Methods

1. Animals. Male Wistar rats weighing about 250 g (supplied by Charles River Laboratories Japan, Inc.) were used. The animals were anesthetized with pentobarbital, subjected to abdominal section, and exsanguinated by transection of the descending aorta. A 10-cm section of the jejunum was removed 15 cm below Treitz’s ligament of the small intestine.

2. Test solutions. Test solutions were prepared by dissolving [1] 20 mM glucose, [2] 20 mM glucose and 1 mM palatinose, [3] 20 mM glucose and 2.5 mM palatinose, or [4] 20 mM glucose and 5 mM palatinose in the standard buffer specified in Table 1.

3. Preparation of isolated everted intestinal segments. Each intestinal segment isolated was thoroughly washed with physiological saline and then with the standard buffer. The segment was then everted, and the upper portion was fixed to a polyethylene tube with a piece of thread and the bottom portion was tied with another piece of thread. The intestinal segment was filled with 2 mL of the standard buffer. At the same time, an appropriate number of 50-ml screw vials, each containing 36 mL of an appropriate test solution (20 mM glucose +), were pre-incubated at 37°C.

4. Glucose absorption test. Each intestinal segment containing the standard buffer was placed in an appropriate pre-incubated screw-top vial containing the test solution. Each vial was placed as shown in Fig. 1 and incubated for 15 min while being bubbled with a mixed gas (95% O₂ and 5% CO₂). The solution on the serous membrane side was quickly collected after completion of the reaction to immediately quantify glucose with a glucose measurement kit (F-Kit Glucose: R·Biopharm GmbH).

5. Statistical test. The above test was repeated five times, and the values for each data set were expressed as a mean. Statistical analysis of all data obtained in this study was conducted by one-way analysis of variance (Fisher’s least significant difference method). The program used was Microsoft Excel add-in software
Results and Discussion

Figure 2 shows glucose absorption when 0, 1, 2.5 or 5 mM palatinose was added to 20 mM glucose. Glucose absorption was inversely proportional to the palatinose level. In particular, glucose absorption was significantly reduced with the addition of 5 mM palatinose, compared with the absence of palatinose (p<0.05). This result supports human experimental results indicating that palatinose suppresses the increase in blood glucose which occurs in response to glucose. Palatinose is therefore considered to possibly suppress this increase in blood glucose by suppressing the absorption of glucose, which is a monosaccharide.

We found that palatinose suppressed the increase in blood glucose in response to sucrose, and that enzymatic inhibition is one of the mechanisms of this suppressive effect (8). That is, since palatinose has an affinity for sucrase, which is an enzyme that degrades sucrose, palatinose suppresses the degradation of sucrose by antagonizing this enzyme (9). Since the results of the present study indicate that palatinose also suppresses glucose absorption, palatinose is considered to possibly suppress the increase in blood glucose in response to sucrose through a combination of inhibitory effects on this enzyme and absorption. Furthermore, palatinose also inhibits the enzyme responsible for degrading starch (9). These results suggest that palatinose may similarly suppress the increase in blood glucose which occurs in response to carbohydrates, such as starch, through a combination of inhibitory effects on this enzyme and absorption.

In the present test system, the osmotic pressure of the reaction system was increased with palatinose addition because up to 5 mM of palatinose were added to 20 mM glucose. However, the buffer used in the present study had an increased osmotic pressure because it contained 220 mM mannitol to measure PD, i.e. the actual rate of glucose absorption from the intestine. Therefore, the results obtained are not considered to be attributable to the increased osmotic pressure produced by the added palatinose.

Although it remains unclear how palatinose suppresses glucose absorption, the present in vitro results indicate that the suppressive effect is unlikely to result from physical inhibition due to the presence of dietary fibers made of large molecules or from difference in transfer rate by high viscosity. Instead, palatinose may inhibit glucose absorption by directly influencing the active absorption mechanism of glucose or by physically inhibiting glucose absorption using its long combination period with isomaltase, an enzyme responsible for degrading palatinose.

REFERENCES

1) Ooshima T, Izumitani A, Sobue S, Okahashi N, Hamada


