The Addition of Xanthan Gum to Enteral Nutrition Suppresses Postprandial Glycemia in Humans

Hiroshi Tanaka1,2, Yoshikazu Nishikawa2, Kotaro Kure1, Kinsuke Tsuda1 and Masaya Hosokawa1

1 Faculty of Human Sciences, Tezukayama-gakuin University, Osaka 590–0113, Japan
2 Department of Food and Human Health Sciences, Graduate School of Human Life Science, Osaka City University, Osaka 558–8585, Japan

(Received December 21, 2017)

Summary The semi-solidified nutrition supplemented with soluble dietary fiber, xanthan gum (XG), inhibited postprandial glycemia in rats. The purpose of the present study is to examine whether XG exerts the same effects in humans. Subjects fasted for 12 h and then ingested the enteral nutrient, Meibalance with or without XG at 9 AM. Blood glucose levels were measured 0, 20, 40, 60, and 120 min after its ingestion. Postprandial blood glucose levels were lower in the XG group than in the control group. At 20 min, postprandial blood glucose levels were significantly lower in the XG group (84±5.3 mg/dL) than in the control group (107±7.8 mg/dL) (p<0.05). A significant difference was also observed in ∆AUC between the two groups. These results demonstrate that XG exerts inhibitory effects on glucose excursion in humans.

Key Words semi-solid nutrient, xanthan gum, blood glucose, dietary fiber

Materials and Methods

Subjects Five healthy volunteers aged 21–22 y old (2 males and 3 females, BMI: 19.8±1.8 kg/m²) were included in the present study. All subjects gave informed consent for participation after agreeing to the purpose, methods, and significance of the study in compliance with the Declaration of Helsinki. The present study was approved by the Ethical Committee of Tezukayama-gakuin University (No. 29–3).

Study design Two days were set as experiment days. Subjects fasted for 12 h before each day of study. At 9 AM, fasting blood glucose levels were measured using the blood glucose meter GR-101 (Terumo, Tokyo, Japan). On the first experiment day, participants ingested 150 mL of the enteral nutrient, Meibalance® (Meiji, Tokyo, Japan) as a control. Nutritional information on Meibalance is shown in Table 1. Blood glucose levels were measured 20, 40, 60, and 120 min after the ingestion of Meibalance®. On the second experiment day, participants ingested 150 mL of Meibalance® supplemented with 1.0% (w/v) XG. Blood glucose levels were measured at the same time as that on the previous experiment day. The second experiment day was 7 d after the first experiment day.

Statistical analysis. Comparisons between the two groups were performed using a paired t-test. A value of p<0.05 was considered to be significant. BMI data are shown as the mean±SD. Experimental data are shown as the mean±SE.

Results and Discussion No significant differences were observed in fasting blood glucose levels between the two groups (control, 82.4±5.5 mg/dL; XG, 81±4.4 mg/dL) (Fig. 2A). Blood glucose levels were significantly lower in the XG group than in the control group 20 min after the oral ingestion of Meibalance (control, 107.4±7.8 mg/dL; XG, 84.0±5.3 mg/dL, p<0.05 vs. control), and were slightly lower in the XG group than in the control group after 40 (control, 116.6±12.5 mg/dL; XG, 99.8±3.4 mg/dL) and 60 min (control, 99.0±7.9 mg/dL; XG,

Note

E-mail: h-tanaka@tezuka-gu.ac.jp
Xanthan Gum Suppresses Postprandial Glycemia

92.4 ± 3.8 mg/dL). We also evaluated postprandial glycemia 120 min after the ingestion of Meibalance. The extent of the change observed was shown as the delta area under the blood concentration–time curve (\( \Delta AUC \)) (Fig. 2B). \( \Delta AUC \) was significantly smaller in the XG group (14.1 ± 5.1 mg/dL·h) than in the control group (29.5 ± 7.8 mg/dL·h). These results suggested that XG inhibited elevations in postprandial glycemia. Postprandial glycemia depends on the content of the meal as well as digestion and absorption rates. In rats, blood glucose levels were reduced by a semi-solidified nutrient that inhibited glucose absorption (10). Therefore, the effects of XG on blood glucose levels in humans may be due to the inhibition of glucose absorption.

Table 1. Nutritional information on the enteral nutrient, Meibalance.

| Nutritional information                  | 100 mL |
|-----------------------------------------|--------|
| Calories                                | 100 kcal |
| Total fat                               | 2.8 g |
| Sodium                                  | 110 mg |
| Total carbohydrate                      | 17.5 g |
| Dietary fiber (indigestible dextrin)    | 1.0 g |
| Protein                                 | 4.0 g |

Biotin 15 μg  Zinc 0.8 mg  Copper 0.08 mg

![Fig. 1. Structural formula of XG. XG is a polysaccharide consisting of repeated units of glucose, mannose, and glucuronic acid at a molar ratio of 2 : 2 : 1.](image)

![Fig. 2A. Xanthan gum inhibited postprandial glycemia. Postprandial glucose levels were significantly lower in the XG group than in the control group 20 min after the ingestion of the nutrient, Meibalance (\( p < 0.05 \)). White circles, control; black circles, xanthan gum. Values are the mean ± SE (n = 5).](image)

![Fig. 2B. Glucose excursion for 120 min is shown as \( \Delta AUC \). A significant difference was observed between the two groups (\( p < 0.05 \)). Open bar, control; closed bar, xanthan gum. Values are the mean ± SE (n = 5).](image)

The results of the present study have demonstrated that dietary fiber suppresses postprandial glycemia. However, an excessive intake of soluble dietary fiber may cause diarrhea. Dietary fiber also inhibits the absorption of not only carbohydrates, but also minerals and vitamins, resulting in mineral and vitamin deficiencies (12).

This is the first study to demonstrate that a semi-solidified nutrient supplemented with XG reduced postprandial blood glucose levels in humans. Fuwa et al. reported that the addition of XG to cooked rice suppressed blood glucose levels (13). Dikeman et al. indicated that the viscosity of 1% XG solution was the highest among other 1% dietary fiber solutions (14). Additionally, the higher the viscosity of dietary fiber, the more effective it was at suppressing postprandial blood glucose levels (15). Therefore, XG appears to suppress postprandial blood glucose levels and these effects are related to its high viscosity.

The suppressive effects of an \( \alpha \)-glucosidase inhibitor on blood glucose levels were shown to continue for 120 min after its administration to diabetic patients...
In the present study, the effects of XG were not observed 120 min after the ingestion of the nutrient by healthy volunteers. Alpha-glucosidase inhibitors are competitive inhibitors of enzymes that digest poly- and oligosaccharides in the intestinal membranes. However, soluble dietary fiber may inhibit glucose absorption by inhibiting carbohydrate diffusion in the lumen of the intestine due to its high viscosity. The reasons for the discrepancy between our results and the findings of Scott and Tattersall (16) currently remain unknown, but may be attributable to the differences in the α-glucosidase inhibitors and soluble dietary fibers used.

The limitations of the present study need to be considered. Blood insulin levels were not measured, and the effects of XG were not examined in patients with diabetes. Dietary fiber was previously reported to decrease blood insulin levels (17). Moreover, guar gum lowers postprandial blood glucose levels in diabetic patients (5). Hence, XG, a soluble dietary fiber like guar gum, may also be effective in the treatment of diabetes.

In conclusion, XG may not only contribute to increasing dietary fiber intake, but can also reduce the dosage of drugs administered to patients with diabetes. Since we only examined the effects of the single ingestion of Meibalance® supplemented with XG on glucose metabolism, further studies are needed in order to investigate the impact of the acute and chronic intake of XG in patients with diabetes.

Acknowledgments

We would like to thank DSP Gokyo Food & Chemical Co., Ltd. for providing XG. We are grateful to all participants in the study.

REFERENCES

1) Nishiwaki S, Araki H, Shirakami Y, Kawaguchi J, Kawade N, Iwashita M, Tagami A, Hatakeyama H, Hayashi T, Maeda T, Saitoh K. 2009. Inhibition of gastroesophageal reflux by semi-solid nutrients in patients with percutaneous endoscopic gastrostomy. [J PEN] 33: 513–519.

2) Shizuku T, Adachi K, Furuta K, Niigaki M, Miyaoka Y, Katoh S, Kobayashi K, Otani M, Kawashima K, Otani J, Kinoshita Y. 2011. Efficacy of half-solid nutrient for the elderly patients with percutaneous endoscopic gastrostomy. [J Clin Biochem Nutr] 48: 226–229.

3) Kanie J, Suzuki Y, Akatsu H, Kuzuyama M, Iguchi A. 2004. Prevention of late complications by half-solid enteral nutrients in percutaneous endoscopic gastrostomy tube feeding. Gerontology 50: 417–419.

4) Ray TK, Mansell KM, Knight LC, Malmud LS, Owen OE, Boden G. 1983. Long-term effects of dietary fiber on glucose tolerance and gastric emptying in non-insulin-dependent diabetic patients. [Am J Clin Nutr] 37: 376–381.

5) Smith U, Holm G. 1982. Effect of a modified guar gum preparation on glucose and lipid levels in diabetics and healthy volunteers. Atherosclerosis 45: 1–10.

6) Shen WJ, Anderson JW. 1979. Effects of guar gum and wheat bran on lipid metabolism of rats. [J Nutr] 109: 1028–1034.

7) Jonnalagadda SS, Thye FW, Robertson JL. 1993. Plasma total and lipoprotein cholesterol, liver cholesterol and fecal cholesterol excretion in hamsters fed fiber diets. [J Nutr] 123: 1377–1382.

8) Miettinen TA, Tarpila S. 1989. Serum lipids and cholesterol metabolism during guar gum, plantago ovata and high fibre treatments. [Clin Chim Acta] 31: 253–262.

9) Fernandez ML, Sun DM, Tosa M, McNamara DJ. 1995. Guar gum effects on plasma low-density lipoprotein and hepatic cholesterol metabolism in guinea pigs fed low- and high-cholesterol diets: a dose-response study. [Am J Clin Nutr] 61: 127–134.

10) Tanaka H, Hosokawa M, Iritani N, Inagaki N, Seino Y. 2014. The effect of addition of ticknener to enteral nutrient on postprandial glucose level. [Nippon Byoei Gakkaishi] 50: 417–419.

11) Ministry of Health and Welfare, Japan. 2016. The National Health and Nutrition Survey in Japan. 2013. Daiichi Shuppan, Tokyo (in Japanese).

12) Doi K, Matsuura M, Kawara A, Baba S, Nishikawa K. 1984. Influence of dietary fiber (Konjac mannan) on absorption of vitamin A, vitamin E and vitamin B12. [Nippon Toriyohyo Gakkaishi] (J Japan Diab) 27: 1163–1168 (in Japanese).

13) Fuwa M, Nakanishi Y, Morttaka H. 2016. Effect of xanthan gum on blood sugar level after cooked rice consumption. [Food Sci Technol Res] 22: 117–126.

14) Dikeman CL, Murphy MR, Fahey GC Jr. 2006. Dietary fibers affect viscosity of solutions and simulated human gastric and small intestinal digesta. [J Nutr] 136: 913–919.

15) Jenkins DJ, Wolerez TM, Leeds AR, Gassull MA, Haisman JP, Dilawari J, Goff DV, Metz GL, Alberti KG. 1978. Dietary fibres, fibre analogues, and glucose tolerance: importance of viscosity. [Br Med J] 1: 1392–1394.

16) Scott AR, Tattersall RB. 1988. Alpha glucosidase inhibition in the treatment of non-insulin-dependent diabetes mellitus. [Diabet Med] 5: 42–46.

17) Kirsten R, Nelson K, Storck J, Hübner-Steiner U, Speck U. 1991. Influence of two guar preparations on glucose and insulin levels during a glucose tolerance test in healthy volunteers. [Int J Clin Pharmacol Ther Toxicol] 29: 19–22.