STUDY OF GLYCEMIC INDEX OF DIABETES-SPECIFIC MODIFIED FORMULA AMONG HEALTHY ADULTS

Apussanee Boonyavarakul

Division of Endocrinology, Department of Internal Medicine, Phramongkutklao Hospital, Bangkok, Thailand

Abstract

Background: People with type 2 diabetes incorporate diabetes-specific nutritional formulas (DSNFs) in their nutrition therapy to enhance glycemic control and manage body weight. Among these formulas, the GEN-DM modified formula (GEN-DM MF) has been widely used for several years. However, the glycemic index (GI) of GEN-DM MF has not yet been determined.

Objective: This study aimed to assess the GI of GEN-DM MF.

Methods: Ten healthy adults with normal oral glucose tolerance were included. The plasma glucose was measured at 0 (baseline), 30, 60, 90 and 120 minutes after consuming 50 grams of glucose solution. On the subsequent two days, plasma glucose measurement was repeated using 84.46 g of GEN-DM MF containing 50 g of carbohydrates. The GI was calculated by dividing the incremental area under the glucose response curve (iAUC) of GEN-DM MF by the area under the glucose response curve of the glucose solution, then multiplying the result by 100. The glycemic load (GL) was calculated by multiplying the GI by the carbohydrate amount in one serving of GEN-DM MF (40 g) /100.

Results: Six healthy men and four women with an average age of 35.80 ± 6.89 years, ranging from 28 to 44, were included in the study. The plasma glucose levels at 30 and 60 minutes following the GEN-DM MF were significantly lower than the corresponding glucose levels with $p = 0.002$ and 0.013, respectively. The GI and GL of GEN-DM MF were 37.75 and 9, respectively, which was classified as low GI and low GL.

Conclusion: GEN-DM MF is classified as a low GI and low GL food, which could significantly lower plasma glucose levels among healthy individuals.

Keywords: GEN-DM, GEN-DM MF, Glycemic index, DSNFs, Diabetes

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Correspondence to:
Boonyavarakul A, Division of Endocrinology, Department of Internal Medicine, Phramongkutklao Hospital, Bangkok 10400, Thailand
E-mail: apussaneeb@gmail.com

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Introduction

Diabetes has become a global chronic metabolic disease. It has been estimated that in 2021, 537 million people worldwide experienced related complications and it directly caused more than one million deaths annually. Type 2 diabetes is the most prevalent form of the disease, and glucose control is essential for its prevention and treatment.[1] Diet plays a crucial role in diabetes management. The likelihood of developing diabetes is higher when consuming foods that are quickly converted to glucose, whereas incorporating foods that have a minimal impact on blood sugar levels is a key strategy for effectively controlling and preventing diabetes.[2,3] The glycemic index (GI) is a numerical scale to evaluate the impact of food on blood glucose levels ranging from 0 to 100. This evaluation is relative to a standard diet, such as glucose or white bread, which has a GI of 100. Foods composed of slowly absorbed carbohydrates typically have a low GI rating of 55 or below. For individuals with diabetes, knowing the carbohydrate quality in various food items can help them make dietary choices; thereby facilitating better glycemic control.[4] Including low GI components in a patient's regimen can enhance glycemic control. Integrating these nutritional formulas in clinical practice enables healthcare providers to implement them effectively in managing chronic illnesses.[5–7] GEN-DM MF is a commercial Diabetes-specific Nutrition Formula (DSNFs) made with a particular mix of nutrients that has been used for decades to help improve glycemic control and reduce fluctuations in blood glucose levels. The formula was initially developed from a DSNF called GEN-DM, which has been used in Thailand since 1991 and exported to Southeast Asia regions such as Lao PDR, Myanmar and Cambodia for commercial use. The goal is to adjust the carbohydrate composition to meet current dietary recommendations for controlling blood glucose levels. However, its GI has not been determined at this time. This study aimed to investigate the GI of GEN-DM MF to be used as a guide when choosing foods as a nutritional regimen for people with type 2 diabetes.

Methods

The study was reviewed and approved by the Institutional Review Board, Royal Thai Army Medical Department (IRB approval number 1120/2565). Healthy participants with normal glucose tolerance tests were recruited. The study conducted a thyroid function test, liver function and Oral Glucose Tolerance Test (OGTT) one week before initiating the study. Participants meeting the following criteria were eligible to participate in the study: a plasma glucose level of less than 140 mg/dL after a 2-hour OGTT and normal liver, kidney and thyroid function test results. Any individual hypersensitive or allergic to the testing meal or its additives was excluded. The participants were asked to avoid smoking, consuming alcohol and caffeine-containing drinks and maintain the same diet and physical activity during the study period.

A blood sample was obtained after a 12-hour fasting period on the first day of the research period. The participants consumed 50 g of glucose solution in 400 ml water within 5 minutes. After placing an intravenous lock in a forearm vein, blood samples were collected at 0 minutes (baseline), 30 minutes, 60 minutes, 90 minutes and 120 minutes, respectively. On the subsequent two days, this plasma glucose measurement was repeated with the test diet: GEN-DM MFTM (Thai Otsuka Pharmaceutical Co., Ltd.) 84.46 g of GEN-DM MF (50 g of carbohydrate equivalents (**Table 1**). Plasma glucose concentration was measured in duplicate using a glucose hexokinase assay (GLUC3(R), Roche), which has 0.7 and 1.1% Coefficient of Variation (CV) for intra- and interassays, respectively, on an automatic centrifugal spectrophotometric clinical chemistry analyzer (Cobas C702, Roche).

The study was conducted following the internationally endorsed GI protocol, based on the recommendations of the 1997 Joint FAO/WHO Expert Consultation on Carbohydrates and Human Nutrition report. The incremental area under the glucose response curve (AUC) above the fasting glucose concentration was calculated using the trapezoid rule.[8] The AUC of each participant after each test food was expressed as a percentage of the mean AUC elicited by

the reference food (glucose) in the same subject. The study evaluated the GI of 50 gm of carbohydrate-containing foods per serving. The average calculation of the mentioned values across all subjects was designated as the GI of the food. The glycemic load (GL) of the foods was determined through a mathematical process involving the multiplication of the GI percentage of the foods and the available carbohydrate content of the food per serving (GI of test food × amount of carbohydrate in a serving of test food (g))/100.[9]

Statistical analysis

Statistical analyses were performed using SPSS, Version 25.0 Statistical Software. Continuous variables were summarized using summary statistics (number of observations, mean, standard deviation (SD) or median with a minimum and maximum range). Categorical values were summarized using frequencies and percentages. A paired t-test was used to simultaneously evaluate all the continuous parameters for each patient between consumption groups, while Fisher's exact test was used to compare categorical variables. All two-tailed statistical tests were subjected to a threshold for statistical significance set at a p-value of less than or equal to 0.05.

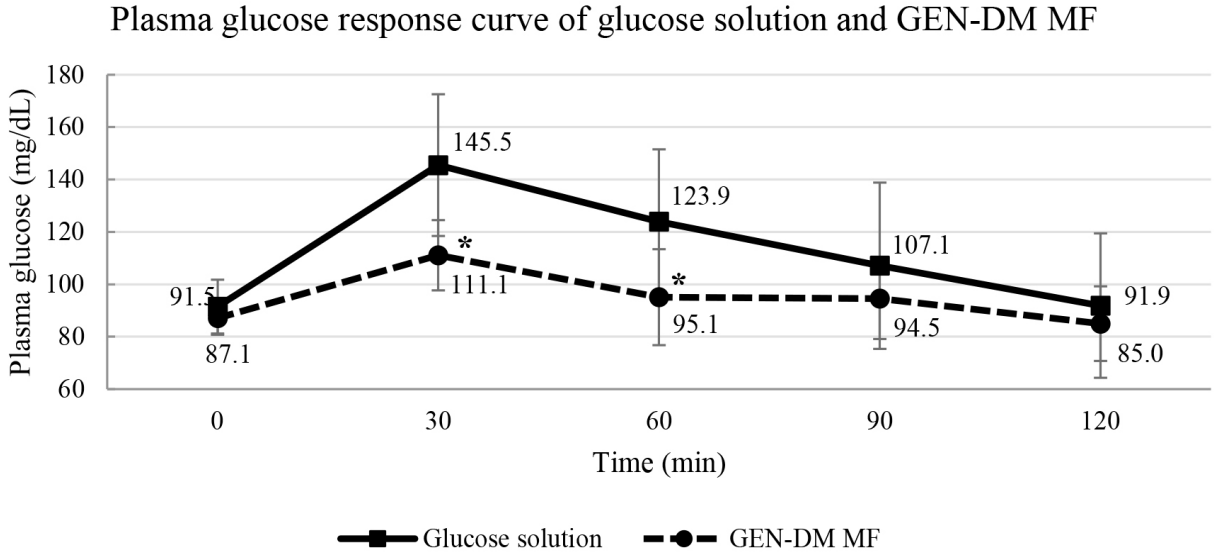

Figure 1. Plasma glucose levels at each time after glucose and GEN-DM MF consumption

Table 1. GEN-DM and GEN DM-MF composition

Ingredients	GEN-DM Content (g) per 100 kcal	GEN-DM MF Content (g) per 100 kcal
Caloric distribution	17: 53: 30	17: 53: 30
Carbohydrate	13.6 Maltodextrin Fructose Fructo-oligosaccharide Polydextrose	13.1 Maltodextrin Fructose Fructo-oligosaccharide Maltitol Oat fiber
Protein	3.8 Sodium Caseinate Soy Protein Isolated	4.3 Sodium Caseinate Soy Protein Isolated
Fat	3.4 Soy Bean oil	3.4 Soy Bean oil

Results

In the screening phase, 12 individuals participated. However, due to elevated thyroid hormone levels, two were found to have excessively high thyroid hormone levels and were excluded from the study. A group of ten healthy people, six men and four women, were included in the study. The average age was 35.80 ± 6.89 years, ranging from 28 to 44. The average body weight was 63.95 ± 8.75 kg, and the average body mass index was 23.05 ± 1.72 kg/m^2. All ten participants received normal glucose tolerance tests, as confirmed by the OGTT, with a mean plasma glucose level of 80.00 ± 11.42 mg/dL **(Table 2)**.

The plasma glucose levels peaked after 30 minutes in both the glucose solution and GEN-DM MF, followed by a gradual decline, as shown in **Figure 1**. The plasma glucose levels at 30 and 60 minutes following the GEN-DM MF were observed to be significantly lower than the corresponding glucose levels (p= 0.002 and 0.013, respectively).

The GI was computed based on the incremental area under the glucose response curve (**Figure 2.**). GEN-DM MF has a GI of 37.75. Additionally, the GL was calculated by multiplying the GI by the carbohydrate content of the food and dividing it by 100. GEN-DM MF is a low-glycemic meal with a GL of 9 per serving (40 gm in 180 ml providing 180 kcal of energy). No adverse events occurred during the trial process.

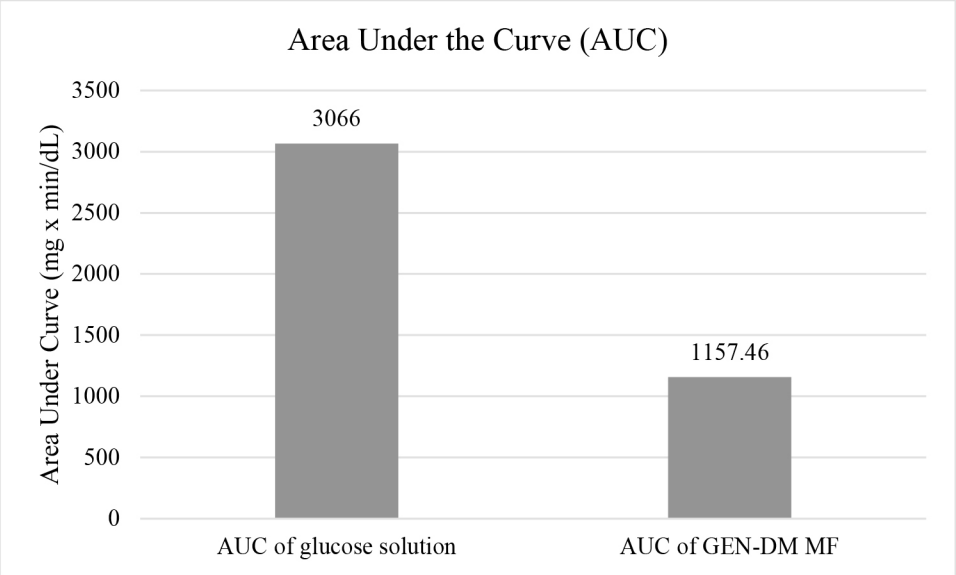

Figure 1. Area Under the Curve of Glucose Solution and GEN-DM MF

Table 2. Baseline characteristics of 10 subjects

Characteristics	Mean ± SD
Age (years)	35.8 ± 6.9
Male (N, %)	6 (60%)
Body weight (kg)	64.0 ± 8.8
Height (cm)	166.2 ± 7.2
BMI (kg/m^2)	23.1 ± 1.7
Laboratory blood tests	
Hematocrit (%)	42.3 ± 4.3
Two hour-Oral Glucose Tolerance Test (mg/dL)	80.0 ± 11.4
Creatinine (mg/dL)	0.9 ± 0.2

Table 2. Baseline characteristics of 10 subjects (Cont.)

Characteristics	Mean ± SD
Albumin (g/dL)	4.5 ± 0.3
SGOT: Aspartate transaminase (AST) (U/L)	21.2 ± 8.1
SGPT: Alanine transaminase (ALT) (U/L)	23.0 ± 12.0
Total bilirubin (mg/dL)	0.6 ± 0.2
Direct bilirubin (mg/dL)	0.2 ± 0.1
Thyroid Stimulating Hormone (mIU/L)	2.2 ± 1.3

Data are presented in mean ± SD.

Discussion

The GI of GEN-DM MF was 37.75, indicating that it constitutes a low-glycemic food. The carbohydrate components include 34% maltodextrin, 9% fructose, 9% maltitol, 6.25% fructo-oligosaccharides (FOS) and 1% oat fiber. Most of the ingredients have slow absorption and low GI. A related GI study of the GEN-DM old formula among ten healthy participants revealed a low GI of 50.2.[10] The reduced GI value is believed to have resulted from a change in the carbohydrate composition of the formula. GEN-DM formula has been modified to the GEN-DM MF formula by reducing high glycemic carbohydrates, specifically maltodextrin and incorporating carbohydrates with lower glycemic indices, such as maltitol. FOS and oat fiber have been implemented as replacements for polydextrose. However, quite notably, protein, fat, vitamin and mineral levels remain consistent. Maltitol constitutes a sugar alcohol (polyol) used in the food industry as a sugar substitute. It tastes 80% as sweet as sucrose but contains fewer calories, 2.4 kcal per gm, than 4 kcal per gm for sucrose, and causes a slower rise in blood sugar and insulin levels than D-glucose or sucrose. From 15 to 90 minutes after ingestion, maltitol substantially reduced mean blood glucose and insulin levels compared with those glucose.[11] FOS is an alternative sweetener substitute with a sweetness level of around 30% compared with sucrose. FOS are categorized as dietary fibers that resist hydrolysis by endogenous enzymes in the small intestine but are fermented by colonic microflora. FOS does not significantly impact postprandial glycemia when incorporated in food and beverage products.[12, 13] A related study assessed healthy individuals' glycemic response and tolerance to a sugar-free diet containing both maltitol and FOS, reporting that the combination reduced the postprandial blood sugar response. Therefore, the study suggests that maltitol and FOS can reduce glycemic response in sugar-free foods.[14] Incorporating oat fiber in the formula could reduce the resulting food's GI. Based on the formulation, the quantity of oat fiber present is anticipated not substantially to impact the formulation's overall GI.[15] Fructose, a low GI sugar, has been used in exchange for other carbohydrates to improve long term glycemic control.[16] The WHO recommends a sugar intake level of 10% of the body's total energy requirements.[17] Regarding the advice for fructose intake, many studies have indicated a suggested level of fructose consumption. One study examining the relationship between dietary fructose and metabolic syndrome discovered that consuming more than 51.4 gm of added fructose daily is strongly related to an increased risk of metabolic syndrome.[18] However, GEN-DM MF contains 20 g of fructose per 1,000 kcal, not more than that intake. A related study of GEN-DM MF was carried out to examine the dietary regimen of ten individuals with type 2 diabetes receiving nutrition via enteral feeding tubes. It revealed that the patients could maintain average plasma glucose and mean blood glucose amplitude over 36 hours within the range of a diabetic recommendation without any adverse events.[19]

The Standards of Care in Diabetes 2023 by the American Diabetes Association provide

recommendations highlighting the importance of personalized medical nutrition therapy to promote healthy eating patterns, emphasizing nutrient-dense foods and portion control. Evidence suggests that reducing overall carbohydrate intake can improve blood sugar levels, and thisapproach can be applied to various eating patterns based on individual needs and preferences.[20] Carbohydrate count, GI and GL are essential considerations for patients with hyperglycemia when selecting food, as they significantly impact glycemic regulation. DSNFs with low GI and GL values and comprehensive nutrients can be convenient and effective dietary support for blood glucose management.

Carbohydrate count, GI and GL should be considered when selecting foods, as these can affect glycemic control among people with diabetes. DSNFs with low GI and GL values may be an option for patients with hyperglycemia requiring nutritional support to control blood sugar. Further research is needed concerning postprandial insulin response and increased effectiveness in managing diabetes.[21] For study limitations, GI is one of the tools for guiding diabetic patients' food choices, but it could not predict glycemic response well within individuals.

Conclusion

This study demonstrates that GEN-DM MF has a low glycemic index. The formula consists mainly of slow-digested and absorbed carbohydrates and dietary fiber. This product can potentially support individuals with type 2 diabetes in making appropriate dietary choices as part of their nutritional plan.

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References

1. International Diabetes Federation [Internet]. IDF Diabetes Atlas, 10th ed. Brussels, Belgium: 2021. [cited 2023 5 December]. Available from: https://diabetesatlas.org/
2. Asif M. The prevention and control the type-2 diabetes by changing lifestyle and dietary pattern. J Educ Health Promot 2014; 3: 1.
3. Villegas R, Liu S, Gao YT, Yang G, Li H, Zheng W, et al. Prospective study of dietary carbohydrates, glycemic index, glycemic load, and incidence of type 2 diabetes mellitus in middle-aged Chinese women. Arch Intern Med 2007; 167: 2310–6.
4. Riccardi G, Rivellese AA, Giacco R. Role of glycemic index and glycemic load in the healthy state, in prediabetes, and in diabetes. Am J Clin Nutr 2008; 87: 269S-74S.
5. Noronha JC, Mechanick JI. Is there a role for Diabetes-Specific Nutrition Formulas as meal replacements in Type 2 diabetes? Front Endocrinol (Lausanne) 2022; 13.
6. Alish CJ, Garvey WT, Maki KC, Sacks GS, Hustead DS, Hegazi RA, et al. A diabetes-specific enteral formula improves glycemic variability in patients with type 2 diabetes. Diabetes Technol Ther 2010; 12:419–25.
7. Mechanick JI, Marchetti A, Hegazi R, Hamdy O. Diabetes-Specific Nutrition Formulas in the management of patients with diabetes and cardiometabolic risk. Nutrients 2020; 12: 1–16.
8. Carbohydrates in human nutrition. Report of a Joint FAO/WHO Expert Consultation. FAO Food Nutr Pap 1998; 66:1-140.
9. Jenkins DJA, Dehghan M, Mente A, Bangdiwala SI, Rangarajan S, Srichaikul K, et al. Glycemic index, glycemic load, and cardiovascular disease and mortality. N Engl J Med 2021; 384: 1312–22.
10. Samaisong N. Effects of diabetic diets supplemented with medical food fructose formula on nutritional status in patients with Type 2 diabetes mellitus. [Thesis]. Nakhon Phatom: Mahidol University; 2009.
11. Saraiva A, Carrascosa C, Raheem D, Ramos F, Raposo A. Maltitol: Analytical determination methods, applications in the food industry, metabolism and health impacts. Int J Environ Res Pub Health 2020; 17: 1–28.
12. Costa GT, Guimarães SB, Sampaio HA de C. Fructo-oligosaccharide effects on blood glucose: an overview. Acta Cir Bras 2012; 27: 279–82.
13. Shah P, Wolever TMS, Jenkins AL, Ezatagha A, Campbell J, Zurbau A, et al. Acute

glycemic and insulin response of Fossence TM alone, or when substituted or added to a carbohydrate challenge: A three-phase, acute, randomized, cross-over, double-blind clinical trial. Heliyon 2021; 7: e06805.
14. Respondek F, Hilpipre C, Chauveau P, Cazaubiel M, Gendre D, Maudet C, et al. Digestive tolerance and postprandial glycaemic and insulinaemic responses after consumption of dairy desserts containing maltitol and fructo-oligosaccharides in adults. Eur J Clin Nutri 2014; 68: 575–80.
15. Chen V, Zurbau A, Ahmed A, Khan T, Au-Yeung F, Kendall C, et al. Effect of oats and oat-fiber on glycemic control in diabetes: A systematic review and meta-analysis of randomized controlled trials. Curr Dev Nutr 2021; 5(Suppl 2): 489.
16. Cozma AI, Sievenpiper JL, De Souza RJ, Chiavaroli L, Ha V, Wang DD, et al. Effect of fructose on glycemic control in diabetes: A systematic review and meta-analysis of controlled feeding trials. Diabetes Care 2012; 35: 1611–20.
17. Guideline: Sugars intake for adults and children [Internet]. Geneva: World Health Organization; 2015. Executive summary. [cited 2023 5 December]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK285538/
18. Aoun R, Chokor FAZ, Taktouk M, Nasrallah M, Ismaeel H, Tamim H, et al. Dietary fructose and its association with the metabolic syndrome in Lebanese healthy adults: a cross-sectional study. Diabetol Metab Syndr 2022; 14: 29.
19. Tiyapanjanit T, Boonyavarakul A. Comparative study between the Phramongkutklao's diabetic blenderized diets and commercial diabetic diets on glycemic variability in continuous tube-fed patients with type 2 diabetes. J Med Assoc Thai 2014; 97: 1151–6.
20. Elsayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. 5. Facilitating positive health behaviors and well-being to improve health outcomes: standards of care in diabetes-2023. Diabetes Care 2023; 46 (Suppl 1): S68–96.
21. Yari Z, Behrouz V, Zand H, Pourvali K. New insight into diabetes management: from glycemic index to dietary insulin index. Curr Diabetes Rev 2020; 16: 293–300.