DETERMINATION OF GLYCEMIC INDEX (GI) OF VARIOUS FROZEN DESSERT TYPES WITH ADDED SOLUBLE DIETARY FIBER IN VIETNAM

Pham Phuoc Thanh*, Lam Vinh Nien*, Tran Thi Tra Phuong**

ABSTRACT

Objective: To determine the glycemic index (GI) of various frozen dessert types with added soluble dietary fiber. ***Methods***: The study followed the method of determining the GI of food according to the National Standard TCVN10036: 2013. 11 subjects were served with 125 ml glucose 20% on three occasions, with 4 different frozen dessert types with added soluble dietary fiber (ice cream, gelato, vegan gelato and sorbet) providing an equal amount of available carbohydrate of 25 g, in every two days. Blood glucose levels are monitored continuously with Freestyle Libre 2. ***Result:*** The glycemic index of vegan gelato chocolate was 30±5,7; GI of coconut sorbet is 18±5; GI of black sesame ice cream is 14±3,5 and GI of mango gelato is 30±6,0; all of which are categorized as low GI food. ***Conclusions***: This is useful both to health professionals advising individuals on their diets, and to improving the quality of life of diabetic people, people at risk of diabetes or in need of blood glucose control.

I. INTRODUCTION

Diabetes mellitus is a chronic disease with many serious health consequences affecting working capacity, quality of life, family economy and society. Type 2 diabetes is increasing rapidly in Vietnam.

There is currently much scientific and popular interest in developed countries in the role of low glycaemic index (GI) foods in the management of weight and metabolic disease risk [8]. The GI concept can be utilized to help with the food selection in a healthy diet. Continuous Glucose Monitoring (CGM) evaluated postprandial glycemic excursions which had comparable results compared to standard blood glucose measurements under real-life conditions [6]. Addition of purified fiber to carbohydrate test meals has been shown to flatten the glycemic response in both normal and diabetic volunteers, reduce the insulin requirement in patients [8]. The efficacy of soluble dietary fiber (SDF) in glucose and insulin metabolism seems to be proportional to the viscosity of hydrated fiber [4].

Several studies have been reported on diabetic or low-calories ice cream. Whelan *et al*. (2008) [7] revealed that the low GI ice cream containing tagatose (6%), polydextrose (6%) and maltitol (3%) or maltitol (15%) and trehalose (2.5%) in a formulation with milk, cream and milk protein concentrate (MPC) showed satisfaction in both physicochemical and sensory requirements, therefore diabetic people could enjoy these frozen desserts without negative impacts on their quality of life.

In Vietnam, we could not find any study of glycemic index of any frozen dessert types yet. The goal of this research is to determine to GI of the frozen desserts with added soluble dietary fiber by using the 25 g portion of carbohydrate for the control and

the food products, so that the volunteers can consume comfortably within 15 minutes.

II. MATERIALS AND METHODS

2.1. Study design: Clinical trial.

According to TCVN10036:2013 [2], which is equivalent to international standard ISO26642:2010, the standard method of determining the GI of foods in Vietnam is about collecting venous blood or capillary blood. With the recent validity of Continuous Glucose Monitoring (CGM) [6], our study applies Freestyle Libre 2 from Abbott as CGM device for monitoring.

2.2. Study population:

Inclusion criteria: healthy adults from 20-35 years old, who do not have blood sugar disorders (fasting blood glucose level < 100 mg/dL), not allergic or intolerant with cow milk, do not have blood lipid disorders (serum cholesterol < 5,2 mmol/L and triglyceride < 1,7 mmol/L and LDL-cholesterol < 3,4 mmol/L and HDL-cholesterol > 1,03 mmol/L), do not have liver or kidney dysfunctions, have a normal BMI (18,5≤BMI≤23), and do not use medicines that have effect on glucose tolerance.

Exclusion criteria: adults with these problems were not included in the research: mental health problems, chronic diseases, pregnant women, lactating women, and using stimulation drugs.

2.3. Time of study: September 2023

2.4. Sample size and sampling method:

According to TCVN10036:2013 and ISO 26642:2010, choosing at least 10 healthy adults based on inclusion and exclusion criteria [2]. Anticipating the dropout rate was 20%, in total, there were 15 eligible individuals included in the study.

2.5. Nutritional values of tested products:

Performed by Eurofins Sac Ky Hai Dang, accredited according to ISO/IEC 17025:2017

Value per 100g	Black sesame ice cream	Coconut Sorbet	Vegan Gelato Chocolate	Mango Gelato
Calories	298	107	166	92
Total carbohydrate	23,3	18,7	22,3	21,5
Dietary fiber	5,52	1,76	6,13	2,43
Total sugar	9,97	9,30	12,5	15,8
Protein	4,67	0,35	1,75	0,63
Total fat	9,55	3,47	7,70	0,40
Saturated fat	1,92	3,20	3,14	0,24
Unsaturated fat	7,63	0,27	4,56	0,16

2.6. Core ingredients of tested products listed on label: inulin, acacia fiber, fructo-oligo-saccharide, xylitol, allulose, invert sugar, water.

All tested products are manufactured following Food Safety regulation and distributed by GOURMED VN Ltd. Company, Vietnam.

Glucose 20% 125ml is from Fresenius Kabi, Vietnam.

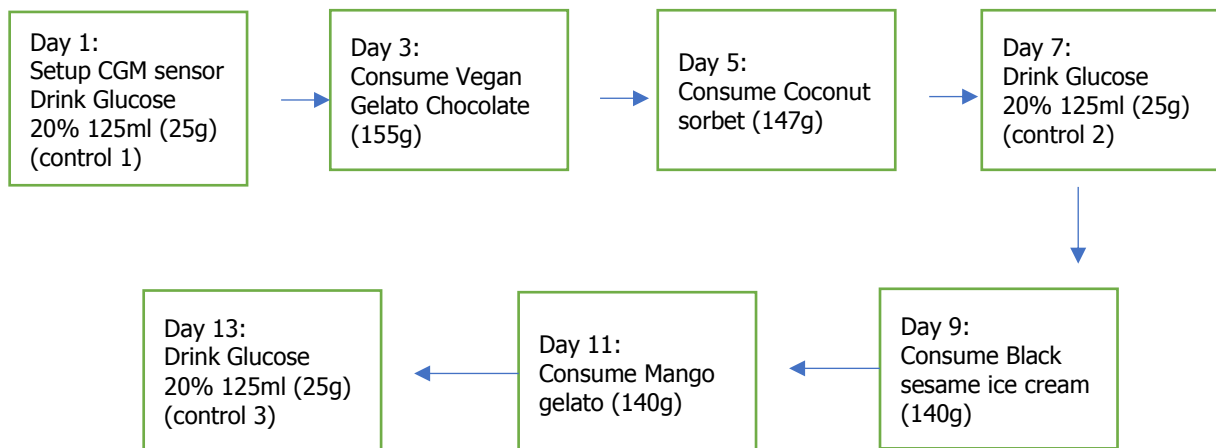**2.7. Calculation of 25g carbohydrate equivalent in test food:**

100g of mango gelato contains 21,5g total carbohydrate and 2,43g dietary fiber. So available carbohydrate equals total carbohydrate minus dietary fiber [1], which is 19,07g. So the equivalent amount of mango gelato to be consumed is: (100 x 25)/19,07 = 131g.

Applying the method mentioned above, the equivalent amount of food to be consumed is as follow: Coconut sorbet: 147g

Vegan gelato chocolate: 155g

Black sesame ice cream: 140g

2.8. Study progress:

An online form was available for volunteers to register. Based on the inclusion and exclusion criteria, 15 eligible individuals were chosen. Each volunteer was tested every two days, including 03 times with 25 g glucose as control and once with 04 tested products, in total 7 test times within 14 days so is the battery life of the Freestyle Libre 2 sensor.

Day 1: Setup CGM sensor Drink Glucose 20% 125ml (25g) (control 1)	→	Day 3: Consume Vegan Gelato Chocolate (155g)	→	Day 5: Consume Coconut sorbet (147g)	→	Day 7: Drink Glucose 20% 125ml (25g) (control 2)

Day 13: Drink Glucose 20% 125ml (25g) (control 3)	←	Day 11: Consume Mango gelato (140g)	←	Day 9: Consume Black sesame ice cream (140g)

Scheme 1. *Procedure of blood glucose measurement using CGM*

The subjects had to fast for 8-10 hours the night before tested day, having been instructed not to consume unusually large meals, drink alcohol or exercise vigorously on the previous day, and to avoid cycling or walking to the laboratory. Then they came to study location in the next morning, taking fasting blood glucose measurement by scanning their phones to the sensor and using products according to the study plan. The product had to be consumed within 10-15 minutes. The starting point of time to consume was recorded to calculate the time of subsequent blood glucose measurement.

On testing day, the individuals had blood glucose measurement taken 7 times: prior to product consumption, after 15 minutes, 30 minutes, 45 minutes, 60 minutes, 90 minutes, and 120 minutes. The individual was in resting state for 120 minutes while waiting to scan the sensor. Other food was not allowed as subjects were only allowed to drink extra water (150-200 ml).

The postprandial glucose levels were automatically recorded every 15 min via the real time CGM (rtCGM) sensor worn by the participants. A nutritionist monitored the participants, ensuring all test foods were consumed accordingly. They were then allowed to carry on with their normal daily routine.

Once the consumption of all the frozen desserts and reference drink is completed, the glucose data that were displayed in the form of a line graph indicating the postprandial glucose levels, were explained to the participants. The participants were able to observe the differences in postprandial glucose levels in response to the consumption of the tested food. They were educated on low GI and GL diets and how rtCGM can provide real-time information of their glucose levels in response to their dietary carbohydrate intake.

2.9. Data analysis: the data analysis included only individuals who participated in all tested days and had taken blood glucose measurement in each day (07 times per day)**.** Data is then coded, cleaned, and analyzed by Microsoft Excel 365 software. The area under curve (AUC) and the GI was calculated according to instructions of TCVN10036:2013.

III. RESULTS

At the end of the study, there were 11 individuals who completed the tests. Characteristics of subjects were shown in the table below.

Index	Mean	Standard deviation
Age	23,7	3,8
BMI (kg/m2)	21,3	1,2
Fasting blood glucose (mg/dL)	75	3,2
HbA1C (%)	5,2	0,2
Urea (mmol/L)	4,1	0,7
Creatinine (mg/dl)	71,6	15,6
AST (UI/L)	17,9	7,3
ALT (UI/L)	22,3	6,4
GGT (UI/L)	19,7	7,7
Cholesterol (mmol/L)	4,0	0,6
Triglyceride (mmol/L)	1,1	0,4
HDL (mmol/L)	1,4	0,4
LDL (mmol/L)	2,0	0,5

Table 1. *Characteristics of subjects at the beginning of the study*

The mean age of 11 subjects was 23,7±3,8 years old. All of them had normal BMI (from 18,5 to 23 kg/m2; mean BMI: 21,3± 1,2 kg/m2). None of them had abnormal results regarding liver and kidney function, blood glucose, AST, ALT, creatine, or urea index.
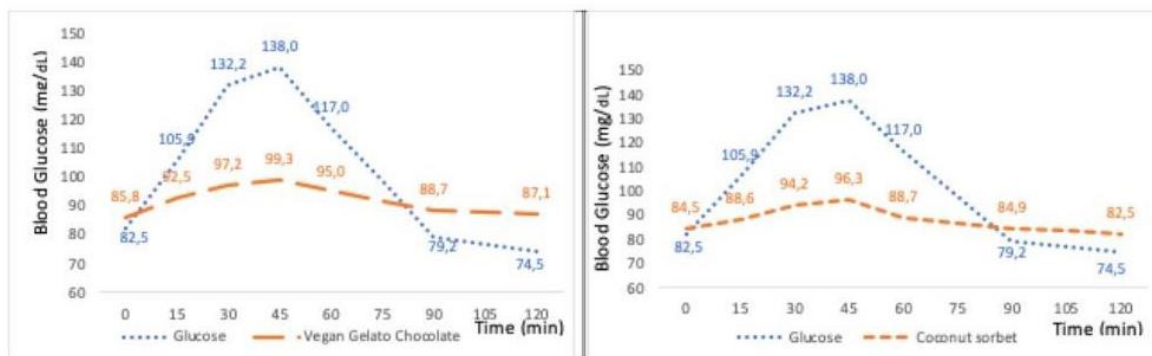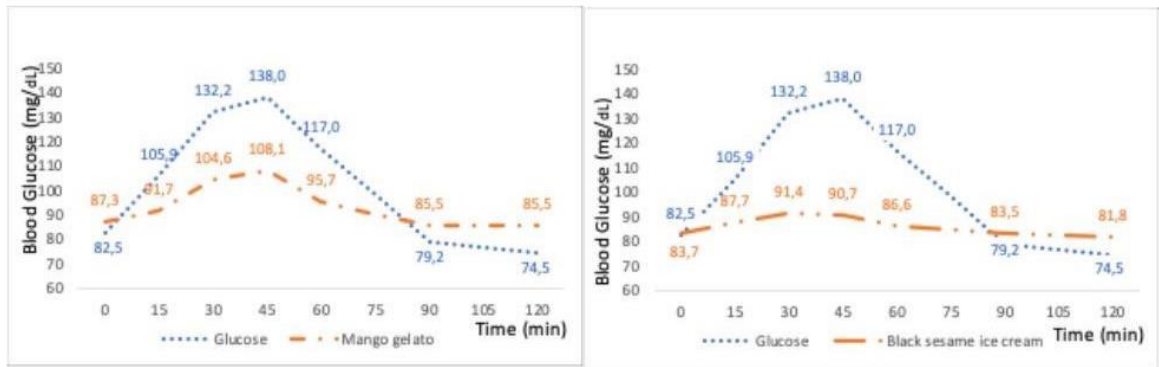
Figure 1. *(a-d) showed the changing of blood glucose levels after using 25 g glucose as control and tested products within 120 minutes. The results represent the average for 3 times with the glucose (control) and once with the test products. The units are expressed as mg/dL.*

The mean fasting blood glucose of 11 subjects was 82,5 mg/dL. After using glucose, the mean blood glucose increased and reached 138 mg/dL after 45 minutes, then decreased. At the end of the test, the mean blood glucose was 74,5 mg/dL, lower than that at the starting time 8 mg/dL. There was a significant difference between the blood glucose values at 45 and 90 minutes.

After consuming vegan gelato chocolate, the blood glucose of all subjects was increasing and reached 99 mg/dL after 45 minutes. Although the blood glucose was decreasing at the 45 minute mark, it was still higher than the starting point (87 mg/dL compared to 86 mg/dL)

For coconut sorbet, mango gelato and black sesame ice cream, the mean value of blood glucose at 120th minute is smaller only 1-2 mg/dL comparing to fasting blood glucose.
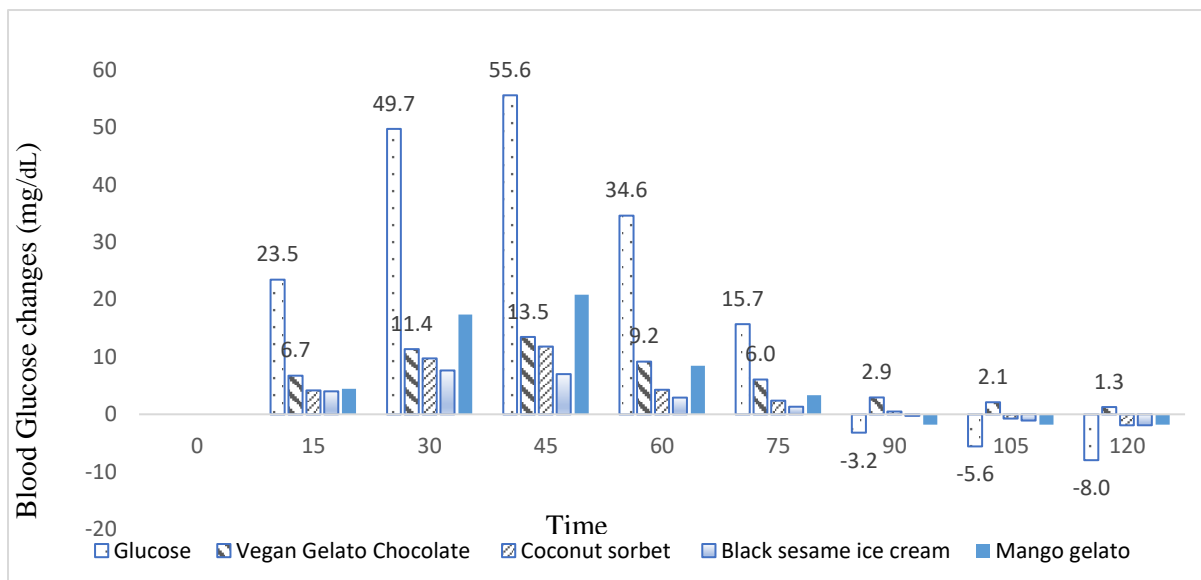

Figure 2. *Changes in blood glucose of tested products at each test time comparing to fasting blood glucose level.*

Figure 2 shows the change of blood glucose concentration after taking Glucose and the test products over a period of 120 minutes for 11 subjects. In general, for either glucose or the test product (except for black sesame ice cream, its peak is at 30 minutes), blood glucose levels peak at 45 minutes and decrease gradually from 45 minutes to 120 minutes.

However, when taking 25 g glucose (control), blood glucose concentration decreased rapidly after 45 minutes. From 90 minutes, the blood glucose concentration has decreased lower than the baseline, and significantly lower than the blood glucose concentration at the same time when taking the test products. When the test products were taken, blood glucose levels decreased slowly after 45 minutes. At the 90-minute and 120-minute time points, blood glucose concentration differs around ± 1-3 mg/dL than at baseline.

Table 2. *The glycemic index of tested products*

Subjects	mean *iAUC* *Glucose*	Standard Deviation	CV glucose	*iAUC* product 1	GI 1	*iAUC* product 2	GI 2	*iAUC* product 3	GI 3	*iAUC* product 4	GI 4
1	2.012	152	8%	953	47%	470	23%	382	19%	725	36%
2	2.718	147	5%	593	22%	430	16%	492	18%	840	31%
3	2.458	285	12%	583	24%	400	16%	378	15%	755	31%
4	2.087	632	30%	630	30%	435	21%	431	21%	540	26%
5	4.198	420	10%	975	23%	725	17%	345	8%	1.448	34%
6	2.103	181	9%	863	41%	413	20%	378	18%	753	36%
7	4.003	104	3%	893	22%	783	20%	345	9%	891	22%
8	2.760	241	9%	743	27%	410	15%	492	18%	840	30%
9	2.618	321	12%	900	34%	458	17%	238	9%	645	25%
10	2.571	334	13%	638	25%	380	15%	245	10%	755	29%
11	2.630	416	16%	806	31%	428	16%	245	9%	730	28%
Mean	2.742	722	26%	780	**30%**	485	**18%**	361	**14%**	811	**30%**
Standard deviation				148,5		136		90,9		232	
CV				19%		28%		25%		30%	

* *GI were* expressed to the nearest whole number

Product 1: Vegan gelato chocolate. Product 2: Coconut sorbet. Product 3: Black sesame ice cream. Product 4: Mango gelato

Table 2 showed the result of the iAUC after using the tested product compared to glucose. The mean iAUC after using glucose as control 3 times ranged from 2.012 to 4.198, with mean SD is 722, and CV glucose ranging from 5% to 30%. While the iAUC of product 1 - vegan gelato chocolate ranged from 583 to 975, mean is 780, SD is 148,5, CV is 19%, so the GI of vegan gelato chocolate is 30±5,7. For product 3 – black sesame ice cream, the iAUC ranged from 245 to 492, SD is 90,9, CV is 25%, so the GI of black sesame ice cream is 14±3,5. Similarly, the GI of product 2 – coconut sorbet is 18±5 and GI of mango gelato is 30±6.

Result: The glycemic index of vegan gelato chocolate was 30±5,7; GI of coconut sorbet is 18±5; GI of black sesame ice cream is 14±3,5 and GI of mango gelato is 30±6.

IV. DISCUSSION

Among 4 people dropped out of the study (2 men and 2 women), 2 women and 1 man get a common cold due to actual raining season in HoChiMinh City, they did not feel well and missed test day 5. The other man

dropped out due to familial reason, and discontinued from test day 9. All 11 subjects (6 men and 5 women) completed the study highly appreciated the usage of CGM sensors, they would not enroll the study if they had to be taken capillary/venous blood, they are willing to participate to similar studies in the future with theses sensors. Although it is known that gender is not an important factor in the glycemic index calculations we took care to ensure that the number of male and female participants in this study was balanced as much as possible [1].

The glycemic index of various frozen dessert types with added soluble dietary fiber was calculated using standard protocol. The result showed that these products have the glycemic index of 30±5,7 for vegan gelato chocolate; 18±5 for coconut sorbet; 14±3,5 for black sesame ice cream and 30±6 for mango gelato, which all are categorized as low GI food according to TCVN10036:2013 and ISO 26642:2010. The cause that makes the blood glucose of subjects decrease after using the tested products might be due to the product's contents including fiber and protein, which prevent blood glucose from raising significantly after usage.

The dietary fiber level of the products used in the study ranged from 1,76 g to 6,13 g per 100g of product, which was quantified, compared to most frozen desserts products in Vietnam which are not mentioned. The fibers used as ingredients are inulin, acacia fiber, fructo-oligo-saccharide (FOS). These fibers slow glucose absorption and delay gastric emptying. It also increases satiety by prolonging meal retention time in the stomach. So that fiber helps to manage blood glucose levels, blood lipids, prevent overweight, and obesity [8]. The 4 tested products have a combination with xylitol,

inulin, acacia fiber, FOS and invert sugar (containing glucose and fructose); xylitol – a sugar alcohol, and allulose – a sugar with GI = 0 [3] helped decrease the GI of the products even more.

Most studies of glycemic index sampled capillary blood or venous blood wash-out periods from five to seven days [5], but glycemic response testing on consecutive days does not seem to influence thevariability of glycemic response tests compared with longer intervals and it does not cause any data drift under conditions of earlier diet and habitual exercise control [5], and an ideal set-up may be to test three test foods, along with three control-reference trials, in a period of 2 weeks, allowing to test on Monday, Wednesday and Friday [1], therefore we plan to test 4 various frozen dessert types (ice cream, gelato, vegan gelato and sorbet) and 3 times with glucose as reference.

V. CONCLUSION

The glycemic index of vegan gelato chocolate was 30±5,7; GI of coconut sorbet is 18±5; GI of black sesame ice cream is 14±3,5 and GI of mango gelato is 30±6, which are categorized as low GI food. These products can be used with a balanced diet for people with diabetes, at risk of diabetes or in need of blood glucose control.

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