ORIGINAL ARTICLE

Glycemic Indices of Enteral Feeding Formulas in Diabetics at The Dr. Cipto Mangunkusumo General Central National Hospital Jakarta

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ABSTRACT

Diabetics occasionally need enteral nutrition–either as supplement or in situations necessitating total dependency on enteral nutrition to fulfill their energy requirements. Enteral nutrition specifically designed for diabetics is not yet available in our hospital, as sugar is often added to enteral nutrition preparations, subsequently affecting the blood glucose profiles of the patients.

This study was done to determine the glycemic index of 4 kinds of enteral feeding formulas, conducted among ambulatory diabetics attending the Diabetic Clinic of the Dr Cipto Mangunkusumo General Central National Hospital.

Twenty samples were purposively chosen among the Diabetic Clinic attendees. They were well-controlled non-pregnant diabetics; none of them were having either kidney or liver problems, and were otherwise healthy. Each of the diabetic studied was given 50-g glucose syrup (200 Kcal) as a standard load. With a 3 to 4 days interval, the patients were consecutively given several enteral feeding formulas, i.e., the standard hospital enteral feeding formula (MC-FRS I), a newly developed diabetic formula (MC-FRS II), a frequently-used commercially available predigested/elemental enteral feeding formula (MC-FK I = Isocal), and a new predigested/elemental enteral feeding formula specifically designed for diabetics (MC-FK II=Diabetasol). All of the formulas tested contained energy equal to 50-g glucose (200 Kcal). Blood glucose was measured with an Accutrend-Ames® glucometer in fasting condition and subsequently 30, 60, 90 and 120 minutes after the load. Any glucose/enteral feeding loading was given 30 minutes after. Data were presented as a blood glucose curve and glycemic index were calculated as area under the blood glucose curve of each food load compared to the standard glucose load, presented as percentage.

In all the enteral feedings studied, the blood glucose response curves went up and the peaks achieved in 60 minutes, thereafter declined to points above the initial fasting blood glucose values. The glycemic index of the MC-FRS I, MC-FRS II, MC-FK I and MC-FK II were 39.6%, 25%, 45% and 52.1% respectively.

The sugar that was added to the MC-FRS I and MC-FK I did not give rise to higher blood glucose levels as compared to the other non-glucose-added food. All of the enteral feeding formula tested showed low glycemic index (Miller, less than 55%). The difference glycemic index among the formulas studied might be due to different food composition (predigested/elemental component in the commercial enteral feeding formula; no sugar added and higher fiber in MC-FRS II as compared to MC-FRS I; higher fat content in MC-FK I as compared to MC-FK II). Glycemic index of enteral feeding formula was particularly determined by the total carbohydrate, total fat and total protein content of the food, as well as the presence of fiber and antinutrient in the food studied.

Key words: Diabetes Mellitus, Hospital Enteral Feeding Formula, Commercial Enteral Feeding Formula, Glycemic Index

INTRODUCTION

Diabetics occasionally need enteral nutrition–either as supplement or in situations necessitating total dependency on enteral nutrition to fulfill their energy requirements[1] to prevent hospital malnutrition. Anthropometric evaluations in our hospital revealed that 30-50% of hos-

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pitalized patients were undernourished due to difficulties in their food intake.[2] Enteral nutrition without sugar specifically designed for diabetics is not yet available in our hospital before this study. Enteral nutrition preparations available in hospitals and in the market have added sugar, therefore having certain effects on the blood glucose profiles of the patients. Efforts should be taken to solve the feeding problems utilizing several available methods and technology.[3]

Enteral feeding comprise all the nutritional support delivered through the oral route, included normal food whether solid, liquid or given in other forms. Other definition includes only artificial feeding; some authors include tube feeding in their definitions.[4]

Enteral nutrition has been practiced by the ancient Egyptians. Tube feeding has been used since the 16th century, and recently well-developed due to the availability of elemental /predigested food in the market. However, nutritional support should be given as normal and as physiological as possible although there are some plausible obstacles hampering the enteral nutritional support, namely mechanical and metabolic problems.

Depending on the food source and processing of the preparations, enteral feeding formulas are be grouped into:

1. Hospital enteral feeding formulas
2. Commercial/predigested-elemental enteral feeding formulas

Hospital Enteral Feeding Formula

Enteral feeding formula of this type is traditionally made from the non-elemental foodstuffs available in the hospital, such as flour, milk, eggs, oil and sugar.

1. Standard hospital enteral feeding formula
   The traditional source of this kind of hospital enteral feeding formula is flour, eggs, oil, milk and sugar. It is very easy to make and usually consist of 1 Kcal/mL.
2. Blended hospital enteral feeding formulas are made from a variety of foodstuffs commonly consumed in meals such as rice, meat, fermented soya bean cake, fruit juice, blended and can be administered orally or as tube feeding. This type of hospital enteral feeding is more physiological, and can be individually tailored to the patients' need. However it has a higher osmolarity and the composition is not consistent. By striving for a standard blended formula, consistency in food composition can be obtained.

Up to the present moment, blended hospital enteral feeding formula is not available in our hospital. As an innovation and maximizing the use of the present dietetic knowledge, as has been developed in Ramathibodi Hospital Bangkok,[7] we therefore developed a standard blended hospital enteral feeding formulas which have the above mentioned benefits, which were also included in this study.

Samples of Blended Hospital Enteral Feeding Formulas in Ciptomangunkusumo General Central Hospital (MC-FRS II)

Source	Weight (g) (per 1000 Kcal.)	Nutritional value
While rice	150 Calorie	1000 Kcal.
Fermented soya bean cake	100 Protein	53.2 g (21.3 %)
Corn oil	10 Fat	27 g (24.3 %)
Beef	125 Carbohydrate	130 g (54.4 %)
Pumpkin	200	
Orange	400	
Total fluid	100 mL	

Samples of Blended Enteral Feeding Formula in Ramathibo di Hospital Bangkok [7]

Source	Weight (g) (per 1000 Kcal – 100 mL)
Hog liver	100
Egg	200
Banana	100
Pumpkin	100
Sucrose	100
Vegetable oil	10

Commercial Enteral Feeding Formula

There are several commercial enteral feeding formulas using the predigested/elemental food designed only as general nutritional support (Isocal, Entrasol, Entramil, Protifar, Enercal, Enercal plus, Procal, Nutrison) as well as the specifically designed enteral feeding formulas for certain chronic diseases (Diabetasol, nefrisol, peptisol, pepti 2000). All of them are ready for use, with standard and consistent compositions and can be given through fine bore tube. However those are more expensive as compared to the hospital enteral feeding formulas.

In choosing and determining which enteral feeding to be used, the goals of nutritional support in diabetes mellitus should taken into account[8]:

1. Achieve the goal of nutritional management
2. Achieve sustainable blood glucose which is as normal as possible
3. Achieve normal lipid profile
4. Provide enough calories to maintain reasonable body weight; child and adolescence growth as well as the increasing calories need during pregnancy and

reconvalescence.

For diabetics in clinical practice, beside total calorie determination, it is also very important to take into account the effects of certain foods on blood glucose increment (glycemic index of food), the effect on profile lipid as well as the fiber content of each food. Diabetic who needs enteral feeding is usually given standard hospital enteral feeding formulas (MC-FRS I) or the commercially available enteral feeding formulas (MC-FK I=Isocal). A new standard blended hospital enteral feeding formula (MC-FRS II) and predigested/elemental enteral feeding formulas without sugar (MC-FK II = Diabetasol) have been specifically designed for the diabetics in our hospital just before this study.

GLYCEMIC INDEX

Up to the present moment, the glycemic indices of hospital enteral feeding formulas as well commercially available enteral feeding formulas have never been evaluated, while in clinical practice, it is very important for consideration in choosing the most appropriate enteral feeding for the diabetics.

Glycemic index is the ratio (in percentage) between blood glucose response after ingestion of certain foodstuff or food and blood glucose response after ingestion of standard food, which is usually glucose or standard amount of bread. Glycemic index reflects the combined/net effect of glucose and insulin after ingestion and metabolism of certain food.[9] In clinical practice glycemic index depicts the increment of blood glucose after ingestion of certain kind of food as well as the body capacity to return the blood glucose level toward normal.[9]

Glycemic response of food is determined by calculating the area under the blood glucose curve after ingestion of certain kind of food given to the patients. The glycemic index is the ratio in percentage between the areas under the curve of certain food and the standard food.[9]

Studies on glycemic indices of foodstuff as well as food have been conducted in Dr. Cipto Mangunkusumo General Central National hospital.[10-14] All of them were done to find out the food that have low glycemic index to be recommended for the diabetics. There are many factors which might have some effects on the blood glucose increment, namely fiber content, methods of cooking, type of starch component in the food; protein, fat and carbohydrate interaction, physical condition of the food, antinutrients etc.[15-18] Jenkins in his studies found that leguminous has low glycemic index, and so are food containing fat such as milk and ice cream. Fruits, which have high glucose content, have also high glycemic index.

Jenny Miller classifies the glycemic index into 3 groups [cited by 9]

1. Low Glycemic index: < 55%
2. Moderate glycemic index: between 55-70%
3. High glycemic index: > 70%

While Wolever et al. have different methods of grouping[9]:

1. Low glycemic index: < 70%
2. Moderate glycemic index: between 70-90%
3. High glycemic index: > 90%

The aim of this study is to determine the glycemic indices of standard hospital enteral feeding formula (MC-FRS I), blended hospital enteral feeding formula (MC-FRS II), commercially available enteral feeding formula (MC-FK I=Isocal) and predigested/elemental enteral feeding formula specifically designed for diabetics (MC-FK II=Diabetasol).

The available glycemic index of food might help the dieticians as well diabetics in choosing the appropriate food for the daily meal of the diabetics.

MATERIAL AND METHODS

The population studied comprised diabetics attending the Diabetic Clinic Dr. Cipto Mangunkusumo General Central National Hospital. Samples were purposively chosen. They were healthy diabetics without apparent kidney and liver dysfunction, were not anemic and nonpregnant for the female respondents. Data collected were: Personal data: name, age, gender, diabetic diet, duration of diabetic treatment and drug(s) consumed if any, blood pressure, and height as well as body weight. Laboratory data: Sample criteria: fasting and 2 hrs post prandial blood glucose, HbA1c, SGPT, serum creatinine, leucocyte count, hemoglobin, serum albumin and globulin. Studied data: fasting blood glucose and subsequently blood glucose on 30 minutes, 60, 90 and 120 minutes after the food load.

Glycemic index data were manually calculated as the ratio of AUC of food studied and the standard glucose, using the following formula:

$$\text{Glycemic Index} = \frac{\text{Area Under the Curve of Food Studied}}{\text{Area Under the Curve of Standard Glucose}} \times 100\%$$

$$AUC = \frac{\Delta 30\, t}{2} + \Delta 30\, t + \frac{(\Delta 60 - \Delta 30)\, t}{2} + \Delta 60\, t + \frac{(\Delta 90 - \Delta 60)\, t}{2} + \Delta 90\, t$$

t = Time in minutes
AUC = Area under the curve of glucose of food studies
1 = The increment of blood glucose in minutes 30, 60, 90 and 120 in mg/dL as compared to the fasting blood glucose level.

Study Procedures

- Respondents should come in the morning after ± 10 hrs fasting.
- Fasting blood glucose was determined.
- Hypoglycemic drug(s) if any were given after the fasting blood glucose determination.
- Respondents were given 50-g glucose load (200 Kcal.), or enteral feeding studied (200 Kcal.) after fasting blood glucose determination. For respondents who need hypoglycemic agents, the load was given approximately 30 minutes after the hypoglycemic agents.
- Blood glucose were determined every 30 minutes for 2 hours (on minutes 0, 30, 60, 90, 120).
- During the study period the respondents remain seated, and smoking was prohibited.
- Duration of each food load study was 3-4 days.

RESULTS

Respondents included in this study were 20 healthy well-controlled type 2 diabetics attending Diabetic Clinic Dr. Cipto Mangunkusumo General Central National Hospital, consisting of 8 (40%) male and 12 (60%) female diabetics, with the age ranged between 41-80 years old, and the peak age group between 61-70 years (50% of both male and female respondents).

Sixty percent of the respondents were normoweight; the remaining 25% and 15% were underweight and overweight respectively. Some of the respondents (15 respondents) were using hypoglycemic agent (11 sulphonylurea, 3 biguanide and 1 intermediate acting insulin) while 5 respondents were on diet and exercise only. Among 20 respondents the recommended diet were 1500–2300 calories.

HOSPITAL ENTERAL FEEDING FORMULA (MC-FRS)

Hospital Enteral feeding formulas in this study were standard hospital enteral formula (MC-FRS I) and blended hospital enteral formula specifically designed for diabetics (MC-FRS II).

1. Mean Blood Glucose with MC-FRS I and MC-FRS II

Mean blood glucose in fasting and studied time after glucose as well as MC-FRS I and MC-FRS II load are as follows:

Table 1. Mean Samples' Blood Glucose with Glucose, MC-FRS I and MC-FRS II Load

Food Load	Mean Samples' Blood Glucose (mg/dL)				
	Fasting	30 min.	60 min.	90 min.	120 min.
Glucose	117.6	248.1	286	272.5	218.4
MC-FRS I	115.5	189.9	202	161.2	126.6
MC-FRS II	113.7	159.3	181.4	133.7	91

It is obvious that glucose load caused rapid increase of blood glucose level. In 30 minutes after the glucose load the blood glucose level increased 110% (from 117.6-248.1 mg/dL) and gradually increased toward the peak level (286 mg/dL) in 60 minutes (increase 143.2%). Thereafter the blood glucose decreased gradually toward the 120 minutes' level, which is still higher than the initial fasting level (218.4 mg/dL).

After the standard hospital enteral feeding formulas (MC-FRS I) load, the mean samples' blood glucose increased 64.4% in 30 minutes, reaching the peak in 60 minutes (increase 74.9%) and thereafter decreased gradually toward the level which is still slightly higher (9.6% higher than the initial fasting level) in 120 minutes.

After the blended hospital enteral feeding formulas (MC-FRS II) load, in 30 minutes, the blood glucose increased 40.1%, and peaked in 60 minutes (increase 59.5%), thereafter decreased toward the 120 minutes' level (91 mg/dL), which is 20% lower compared with the initial fasting level.

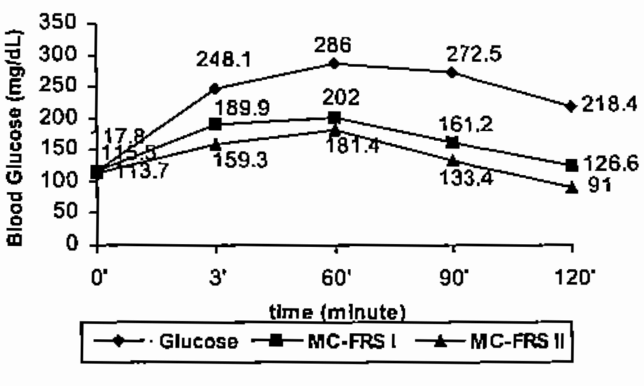

Figure 1. Blood Glucose Increment After Glucose and Enteral Feeding Load (MC-FRS I and MC-FRS II)

2. Glycemic Index of MC-FRS I and MC-FRS II

Glycemic indices of the hospital enteral feeding formulas studied among 20 healthy well controlled type 2 diabetics can be seen in the following table:

Table 2. Mean Glycemic Indices of Glucose and Hospital Enteral Feeding Formulas

Food Studied	Glycemic Index (%)
Glucose	100
MC-FRS I	39.6
MC-FRS II	25

Predigested Enteral Feeding (Commercial) Formulas

1. Mean blood glucose with commercial enteral feeding formulas

The mean samples' blood glucose after glucose, and enteral feeding commercial formulas load can be seen below:

Table 3. Mean Samples' Blood Glucose with Commercial Enteral Feeding Formula

Food Studied	Mean Samples' Blood Glucose (mg/dL)				
	Fasting	30 min	60 min	90 min	120 min
Glucose	117.6	248.1	286	272.5	218.4
Isocal	123.0	199.4	227.7	183.8	141.5
Diabetasol	108.1	164.6	202.4	184.8	145.2

Soon after the commercial enteral feeding formula (MC-FK I=Isocal) load, the blood glucose increased, reaching its peak in 60 minutes (increase 85.1 %), thereafter declined toward the 120 minutes level, which is 15 % higher than the initial fasting level. On commercial enteral feeding formula II (MC-FK II = Diabetasol), the peak level was achieved in 60 minutes (increase 87.2 % from the initial fasting level), and then declined toward the 120 minutes level (145.2 mg/dL), which is 34.3 % higher as compared to the initial fasting blood glucose level.

2. Glycemic Index of the commercial enteral feeding formulas

The glycemic indices of the healthy 20 well-controlled type 2 diabetics after the ingestion of the studied commercial enteral feeding formulas are as follow:

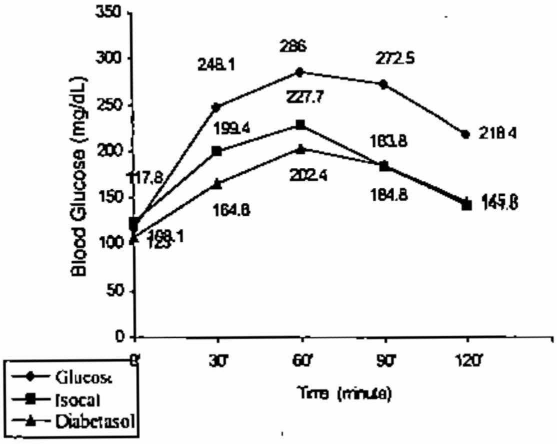

Figure 2. Blood Glucose Increment After Ingestion of Glucose and Predigested Enteral Feeding Formulas (Isocal and

Table 4. Mean Glycemic Indices of Isoca and Diabetasol among Diabetics

Food Studied	Glycemic Index (%)
Glucose	100
Isocal	45
Diabetasol	52.1

DISCUSSION

After the glucose load, it is obvious that among diabetics, the blood glucose soon increased and reached the peak level in 60 minutes, then returned back toward levels, which is still higher than the initial fasting level in 120 minutes. This is a common and physiologic response among diabetics after the ingestion of glucose or foodstuff. [9]

On enteral feeding, both with the hospital enteral formulas and commercially available enteral formulas the blood glucose increased, but the increment was lower than the increment after the glucose load. After the ingestion of standard hospital enteral feeding formula (MC-FRS I) similar response to the response after glucose load were documented, with a lower blood glucose increment, although in preparing the standard hospital formulas sugar (sucrose) is added. The addition of sugar did not have significant effect on the blood glucose elevation. This fact support the recommendation that the meals for the diabetics should not be prepared and served separately from the other member of the family meals, since small amount of sugar as spices is allowed. This finding support and was in accordance with the American Diabetes Association recommendation for the diabetics in general.[19]

The blood glucose increment pattern on commercial/predigested enteral feeding was similar with the general pattern of blood glucose increment after food ingestion (the hospital enteral feeding formula MK-FRS I and MK-FRS II), although the blood glucose increment is higher. The more refined and elemental foodstuff content in the commercially available enteral feeding formulas caused the higher blood glucose increment.[19]

The glycemic index of standard hospital enteral feeding formula (MC-FRS I) was 39.6%, while the blended hospital enteral feeding formula (MC-FRS II) was 25%. The nutrient composition of MC-FRS I were 62.6% carbohydrate, 7.5% protein and 29.9% fat. Besides, MC-FRS I use sugar as it's constituent and has a higher percentage of fat (29.9 %) as compared to the recommended daily fat allowances for the general population (20-25 % of total calorie as fat). The higher fat content might also cause lower blood glucose response, since high fat food might cause delayed gastric emptying time. This finding is in accordance with studied reported by American Diabetes Association (ADA), in which modified enteral feeding (changing/replacing some of the carbohydrate component with saturated or monounsaturated fat) can cause significantly lower blood glucose response as compared to the enteral food with higher carbohydrate content.

MC-FRS II (blended hospital enteral feeding formulas) consisted of blended rice, fried fermented soya bean cake, meat, pumpkin and orange. This standard blended formula give a nutrient composition of 55.9% carbohydrate, 27.1% fat and 17% protein, with 7.9 g fiber. The low glycemic index (25%) of this standard blended enteral feeding formula (MC-FRS II), beside due to the higher than recommended fat content (27.1%) might also due to the fact that its fiber content is the highest among the enteral feeding formula studied (MC-FRS II 1.92 g dietary fiber/100 g, MC-FRS I 1.68 g dietary fiber/100 g, Isocal 1.53 g dietary fiber/100 g and Diabetasol 1.56.g dietary fiber/100 g), and also the availability of antinutrient in fermented soya bean cake. Dietary fiber has a significant effect on the glycemic index of food.[16,18,20]

Diabetasol consist of 68.6% carbohydrate, 10.5% protein and 20.9% vegetable fat, without sucrose, but use aspartam as sweetener, while Isocal consist of 54.7% carbohydrate (sucrose and maltodextrine), 34.9% fat (elemental medium chain triglyceride) and 10.3% protein. Wolever consider a low glycemic index for foods if the glycemic index is less than 70%, while Miller classify food as low glycemic index food if the glycemic index is lower than 55%. Both the elemental enteral feeding formulas have low glycemic index, Isocal 45% and Diabetasol 52.1% respectively, although as expected they were higher than the glycemic indices of the hospital enteral feeding formulas (standard hospital enteral feeding formula MC-FRS I 39.6% and blended hospital enteral feeding formula MC-FRS II 25%). Predigested elemental enteral feeding formulas are more readily digested as compared to the natural non-elemental foodstuff content found in the hospital enteral feeding formulas.

The low glycemic index of diabetasol (52.1%) might be due to the non-caloric sweetener component, while Isocal although contains sucrose, it has a slightly higher fat content (34.9%) as compared to diabetasol (20.9%). Glycemic index of fat containing food is lower than food containing more carbohydrate.

CONCLUSION

Study conducted on 20 healthy well-controlled type 2 diabetics in Dr. Cipto Mangunkusumo General Central National hospital showed that:

Glucose load caused the increment of blood glucose level, which peaked at 60 minutes and thereafter decreased to the level, which is still higher than the initial fasting level.

Hospital enteral feeding formulas as well as the commercial elemental enteral feeding formulas caused similar pattern of glucose increment, although the increment was lower as compared to glucose.

The glycemic index of standard hospital enteral feeding formula is 39.6%, while the blended hospital enteral feeding formula has the lowest glycemic index (25%).

Both the predigested enteral feeding formulas (Isocal and Diabetasol) have low glycemic index, Isocal 45% and Diabetasol 52.1% respectively.

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