Some glycemic carbohydrate indices as alternative foods for people with diabetes mellitus (dm)

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Abstract. Diabetes mellitus (DM) is a metabolic disease that increases blood glucose levels above normal due to abnormal insulin secretion, insulin action, or both. The purpose of this study is to determine the glycemic index (IG) of several types of food. The method of this study was observational with cross-sectional study design. The results showed that the lowest GI was young corn (IG 34), kepok banana (IG 46), cassava (IG 46), Havermuth (IG 48), sweet potato (IG 51), and taro (IG 54). Head rice has a high GI, which is 78. This study concludes that the lowest GI is young IG 34 and the highest is rice, having IG 78. This study is expected as a strategy in the selection of low-GI food ingredients as a preventive measure dm.

1. Introduction
Diabetes mellitus (DM) is a metabolic disease that increases blood glucose levels above normal due to abnormal insulin secretion, insulin action, or both found with increasing age, lifestyle changes, and increasing obesity population. So, this disease tends to increase [1,2]. Diabetes mellitus is a public health problem because of its short-term and long-term complications. Long-term hyperglycemia affects the system of small blood vessels in the eyes, kidneys and nerves and arteries [3,4]. Based on data from the World Health Organization (WHO), around 347 million people worldwide suffer from DM; it estimated that deaths from diabetes would increase by two-thirds by 2030. The number of diabetics in the United States reaches 23.6 million (7.8% from the entire population). The number of people with diabetes worldwide is projected to increase from 171 million in 2000 to 366 million in 2030.

The prevalence of DM patients in Southeast Asia is expected to increase to 123 million by 2035, and in Indonesia in 2013 as many as 8.5 million and will increase to 14.1 million by 2035 [3]. Epidemiologically, it is estimated that in 2030 the prevalence of DM in Indonesia will reach 21.3 million people. Basic Health Research (Riskesdas) in 2013 showed the proportion of Southeast Sulawesi Diabetes Mellitus 16,934 people [5].

Based on the pattern of population growth in 2000 aged over 20 years of 125 million, assuming the prevalence of diabetes is 4.6%, the amount is 5.6 million. 2020 is estimated to be over 20 years old, around 178 million, and the prevalence is still 4.6%, so the number of diabetics is 8.2 million [3]. The increase in the prevalence of diabetes mellitus will develop into several complications, including stroke, vascular disease, kidney disorders, blindness [6,7].

One way to control blood sugar is by regulating the diet through the selection of the right number and type of carbohydrates using the concept of the Glycemic Index (IG). The glycemic index can
provide clues to the effect of food on blood sugar levels. Food with a high GI will increase blood sugar levels quickly, while low-GI foods raise blood sugar levels slowly [8].

The purpose of selecting food ingredients in diabetics is to reduce blood sugar to near normal. The choice of diabetic food ingredients usually uses a list of exchange food ingredients based on food groups. For example, to replace food ingredients, carbohydrate sources are used as food ingredients which are contained in the group 1 table, which per exchange unit contains 175 calories. Foodstuffs in group 1 include polysaccharides based on the division of carbohydrates chemically. The most recent division of carbohydrates is based on the glycemic index [9,10]. Based on the 2014 research, Enhas showed that white rice and fried rice carbohydrate groups had the highest glycemic index [11].

Sources of carbohydrates are rice, red sweet potato, taro, easy corn, cassava, some of these foods have different absorption which will affect the increase in blood glucose levels, so the glycemic index value of each food will be different [8].

2. Methods
This study was an observational study with a cross-sectional study design approach to determine the glycemic index of giving food and then measuring blood glucose levels [12]. Not performing Non Randomized form controls. The research/workflow design is as follows:

**Figure 1. Research design**

The population in the study were hospital employees with normal nutritional status. Determination of the sample was determined by porous sampling method according to the FAO study sample size of 6-8 people. Glycemic Index Measurement Procedure [12]:

- Subjects are required to fast for approximately 10-12 hours (from 20.00 - 08.00).
- In the morning the blood glucose level is taken through the fingertips and then given a load.
- Wait for the 15th minute, for blood to be taken without being given a load and then for the 30th minute, 45th minute, 60th minute, 90th minute and last 120th minute.
- Day I is given glucose in a glass of water 200-250 ml.
- Day 2 is given head rice; day three is given havermuth, day four is given sweet potato, day five is given taro, day six is given raw kepok banana, day seven is given cassava and the last day is day 8 given young corn.
• The same procedure also is done for taking blood on the first day.
• The results of blood glucose checks are recorded in the table provided.
• Average calculation is done to determine the glycemic index in the form of a percentage =

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\text{Glycemic index} = 100 \times \frac{\text{Added area under the blood glucose response (IAUC) curve of food ingredients}}{\text{Added area under the blood glucose response (IAUC) curve of pure glucose}}
\]

3. Results and Discussions
Based on the results of anthropometric measurements of 8 people who were sampled in this study, the average value is presented as follows:

Table 1. Characteristics of samples based on average values of anthropometry, age.

| Characteristics | n  | Mean + SD | Min | Max  |
|-----------------|----|-----------|-----|------|
| Height          | 8  | 154.38 ± 5.999 | 146 | 165  |
| Weight          | 8  | 51.688 ± 6.081  | 45.4 | 6.0552 |
| IMT             | 8  | 21.063 ± 1.3147 | 19  | 22.6 |
| Age             | 8  | 40 ± 7.568     | 22  | 40   |

In table 3 it can be seen that the average nutritional status of the sample based on the Body Mass Index (BMI) is 21 kg / m² from an average height of 154.38 cm and body weight of 51.6 kg. In this study, the average age of the sample was 40 years old.

Food Provided. The food used is 50 grams of carbohydrates from several carbohydrate sources. Glucose solution is used as a comparison in determining the glycemic index. Food requirements are calculated using a list of food ingredients. The glucose solution consumed in the form of drinks dissolved in 200 ml of boiled water is then given to all samples after fasting. The food that will be studied is processed by boiling while Havermuth is cooked for 5 minutes.

Table 2. Food items provided

| No. | Food material | Amount of Carbohydrates / 100 (g) | Sample Needs (g) | Need for BM (g) For research = (50 / carbohydrate amount) x 100 g |
|-----|--------------|----------------------------------|-----------------|---------------------------------------------------------------|
| 1.  | Pure glucose | 50                               | 50              | 50                                                            |
| 2.  | Head rice    | 79                               | 50              | 63                                                            |
| 3.  | Havermuth    | 68.2                             | 50              | 73                                                            |
| 4.  | Sweet potato | 35.4                             | 50              | 141                                                           |
| 5.  | Taro         | 28.2                             | 50              | 177                                                           |
| 6.  | Kepok        | 26.8                             | 50              | 186                                                           |
| 7.  | banana       | 36.6                             | 50              | 134                                                           |
| 8.  | Cassava      | 30.3                             | 50              | 165                                                           |
Blood Glucose Levels. Blood glucose levels after loading are as follows:

Table 3. Average blood glucose levels

| No | Food material       | Average blood glucose level (mmol) |
|----|---------------------|-----------------------------------|
|    |                     | t.0     | t.15    | t.30    | t.45    | t.60    | t.90    | t.120   |
| 1. | Glucose             | 6.6     | 7.8     | 9.9     | 10.6    | 10.3    | 9.0     | 7.4     |
| 2. | Head Rice           | 5.8     | 6.4     | 8.8     | 9.4     | 8.6     | 7.5     | 7.0     |
| 3. | Havermuth           | 6.2     | 6.7     | 8.2     | 8.6     | 7.8     | 7.1     | 6.7     |
| 4. | Sweet potato        | 6.0     | 6.3     | 8.6     | 9.2     | 8.5     | 6.1     | 5.3     |
| 5. | Taro                | 6.4     | 6.8     | 8.9     | 9.3     | 8.8     | 7.1     | 5.7     |
| 6. | Kepok banana        | 6.6     | 7.2     | 9.0     | 9.1     | 8.6     | 7.2     | 5.9     |
| 7. | Cassava             | 6.1     | 7.0     | 8.8     | 9.0     | 7.8     | 6.4     | 5.4     |
| 8. | Young corn          | 6.1     | 6.8     | 8.4     | 8.1     | 6.9     | 6.3     | 5.6     |

Table 3 shows the blood glucose response given by the glucose solution at fasting 6.6 mmol. Then, the 15th minute blood glucose level increases 7.8 mmol, means an increase of 1.8%, the 30th minute increases 9.9 a 5% increase, then slowly increases - the time to peak 45 minutes to 10.6 mmol means a 6% increase, the 60th minute blood glucose decreases to 10.3 mmol decreasing 0.28%, the 90th minute decrease in 9.0 mmol means a decrease of 1.5%, and minute 120 decreased by 7.4 mmol a decrease of 3%. At 2 hours after eating blood glucose becomes normal 7.4 mmol (133 gr/dl).

Response of blood gluconate levels of fasting rice head 5.8 mmol, 15 minutes increased 6.4 mmol means 1% increase, 30 minutes increased to 8.8 mmol 5.1% increase, 45 minutes increased 9.4 mmol 6% increase, 60th minute decreased 8.6mmol 0.8% decrease, 90th minute decreased 7.5moles 2% decrease, then the last drop in 120th minute to 7.0mmol 2.5% decrease.

Example: Response of blood glucose levels to rice food ingredients
Figure 2. Area under the head rice blood glucose response curve

Area of triangle A = 4
Trapezoidal area B = 27
Area of trapezoid C = 48
Trapezoidal area D = 46
Area of trapezoid E = 66
Trapezoidal area F = 42
IUAC = 233
IG = 78

Glycemic Index. The calculation of the glycemic index value of food in this study is as follows:

Table 4. Area and glycemic index of foodstuffs researched

| No | Food studied | Area | The glycemic index = (food area / area of glucose) x 100 |
|----|--------------|------|--------------------------------------------------------|
| 1  | Glucose      | 298  | 100                                                   |
| 2  | Head Rice    | 234  | 78                                                    |
| 3  | Havermuth    | 142  | 48                                                    |
The glycemic index = (food area / area of glucose) x 100

| No | Food studied   | Area | The glycemic index |
|----|----------------|------|--------------------|
| 4  | Sweet potato   | 153  | 51                 |
| 5  | Taro           | 166  | 54                 |
| 6  | Kepok banana   | 136  | 46                 |
| 7  | Cassava        | 138  | 46                 |
| 8  | Young corn     | 100  | 34                 |

Carbohydrate sources are head rice, sweet potatoes, taro, bananas, corn. Cassava and Havermuth have different glycemic indices. As in Figure 2 below:

Figure 3. Glycemic index of various foods to be researched

Glucose is used in this study is a glucose solution given in the form of a drink dissolved in a glass of boiled water. The advantages of glucose solutions are cheaper, easier because there are no other influences that occur in food ingredients. The glucose solution in this study is a standard according to the FAO study to determine the glycemic glucose index as a standard with a value of 100 [13,14].

Rice Head (Oryza Sativa Glutinosa / Rice) is used in this study is head rice. The results showed that head rice had a high glycemic index of 78. Factors affecting the high glycemic index of head rice were due to high amylopectin content. Amylopectin is a simple sugar having branches that have a larger and more open molecular size, making amylopectin easier to gelatinize so that it is easily digested. The results of the study of determination of head rice IG according to the results of research conducted by Marry S. Doddard, rice that has high amylopectin levels turns out that the area under the blood glucose response curve is higher, this study shows that the area under the sample curve given higher head rice (235,7) [15]. With the high area under the curve, the glycemic index value of the food
is also high. The rice used in this study came from the Sidrap area of Makassar with the specifications of shiny white, processed by cooking 10 minutes and then steamed for 30 minutes.

Havermuth is a packaged food circulating in supermarkets. Havermuth / oatmeal is obtained from processed wheat seeds. Based on the results of the study Havermuth has a low glycemic index that is 48, which is not different from the table [16]. Foster Powell (2002) which has a glycemic index 49. The results of the Havermuth IG study have a low glycemic index compared to GI rice head. This is because Havermuth contains soluble fiber. Soluble fiber slows glucose (sugar) in the body because when the fiber is eaten, it takes place gel formation in the stomach. The rate of food in the stomach leading to the intestine will be slowed so that the absorption of sugar does not occur quickly. The results of the study in overweight adults with BMI 27-36 found that consuming oats increased insulin sensitivity by 10%. Insulin sensitivity is the ability of the insulin hormone to reduce blood glucose levels by suppressing hepatic production and stimulating glucose utilization in skeletal muscle and adipose tissue [17].

The results of the study on sweet potato (Ipomoea Batatas / Yam) study have a glycemic index value of 51. The results of the sweet potato study have an index having a low glycemic index compared to the glycemic index of head rice. This is likely that sweet potatoes contain high fiber, which is 1.1 grams. The fiber content in sweet potatoes in the small intestine can slow glucose absorption and increase the viscosity of intestinal contents, which can indirectly reduce the speed of diffusion of the small intestinal mucosa. Blood sugar levels decrease slowly, so the need for insulin decreases. Fiber is a part of food that cannot be digested enzymatically (an enzyme produced by humans) so that it is not a source of nutrients. Included in the fiber categories are cellulose and hemicellulose, pectin, lignin, and gum. Sweet potatoes also contain phytochemicals that function as antioxidants. Watzi, Bernhard from Karlshure Institute of Nutritional Physiology (FRCN), Germany stated that phytochemistry has a biological effect that effectively inhibits cancer growth, as an antioxidant, has the properties of inhibiting microbial growth, decreases blood cholesterol, lowers blood glucose levels, is antibiotic and causes the effect of increasing immunity [18,19].

The results of the study of young Kepok Banana (Musa Paradisiaca Forma Typical) have a low glycemic index of 46. The results of research on bananas have a low glycemic index compared to the glycemic index of head rice; possibly Taro has a fiber content of 0.9 grams. The role of fiber in food is to help speed up food debris through the digestive tract to be excreted out. Also, foods containing high fiber will provide a sense of satiety, thereby reducing food consumption. The taro used is from the Gowa area of the brownish-black Makassar skin, which is processed by boiling.

The results of the study of young Kepok Banana (Musa Paradisiaca Forma Typical) have a low glycemic index of 46. The results of research on bananas have a low glycemic index compared to the glycemic index of head rice that has been studied. Young bananas contain fiber so that it thickens the density of food in the digestive tract. This will slow the passage of food in the digestive tract and inhibit the movement of enzymes so that the digestive process becomes slow. The result is the area under the low blood glucose response curve (136). With a low area, the blood glucose response curve means a low glycemic index. Fiber is a part of food that cannot be digested enzymatically (an enzyme produced by humans), so it is not a source of nutrients.

The results of the study on cassava (Manihot Utilissima) have a glycemic index value of 46. The results of research that have been conducted that cassava has a low glycemic index compared to the glycemic index of head rice. Cassava has a high fiber content. Fiber can increase viscosity can also reduce the increase in blood sugar levels and insulin. The glycemic index is a number that states the speed of food raises blood glucose levels after consuming it. Foods that have a high glycemic index increase blood sugar levels quickly and vice versa. Furthermore, it is known as slow release carbohydrate. Namely carbohydrates from food that is digested slowly and hence absorbed slowly. As a result, blood sugar levels rise slowly. This is what is known as good carbohydrates, whereas high-release carbohydrate (bad carbohydrate) is a carbohydrate that is digested and absorbed quickly, so that blood sugar levels rise quickly. In this study, the cassava used originated from the area of Antang,
Makassar, the contents are white, the processing process is done by peeling the skin and boiling [20,21,22].

Then results of research on young corn (Zea Mays / Maize / Corn). The obtained a low glycemic index value of 35. The results of research on young corn have a low glycemic index compared to the glycemic index of rice, corn containing fructose absorbed does not need a carrier. There is a difference in the glycemic index between corn and other foods; this is because fructose metabolism does not require insulin so that it can be directly used. The glycemic index is related to the blood glucose response of the food in question, while the glucose response is related to food digestibility, so it can be stated that the low glycemic index is generally due to the low digestibility of the food. Yellow young corn comes from the Limbung area of Makassar, around three months old, yellow seeds taste sweet after boiling, processed from the cob and then corn seeds boiled. The glycemic index is beneficial for the management of diabetics' diets. Generally, food handling is based on the portion of food (especially carbohydrates). This is done because of the assumption that every carbohydrate, in the same amount, has the same effect on increasing blood sugar levels. Research shows that different carbohydrates will have different effects on blood sugar levels even though they are given the same amount. Heather, et al. 2001, stated that the amount of carbohydrates is not an adequate basis for controlling blood sugar levels [23,24,25].

4. Conclusion
The results of the study of determining the glycemic index of several carbohydrate-based food ingredients can be known to the glycemic index. Overall the lowest glycemic index is IG 34 young corn, kepok banana IG 46 raw, cassava IG 46, havermuth IG 48, IG 51 sweet potato, IG 54 taro. Rice has high IG 78.

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