Determination of the Glycemic Response of Healthy Individuals to a Developed Dragon Fruit Snack Bar

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ABSTRACT

Studies of glycemic response to snack foods are limited. Furthermore, a dragon fruit snack bar was developed previously but not tested for glycemic response. Its development includes the usage of dragon fruit with pulp (110 g), rice pop (pinipig;76 g), rolled oats (15 g), almonds (15 g), cashew nut (15 g), sesame seed (8 g), raisin (12 g), honey (70 g), rock salt (8 g), and water 25 ml which yielded 6 servings. The purpose of this study is to determine the glycemic response of healthy individuals to a developed dragon fruit snack bar. This descriptive study utilized 50 g of carbohydrates (1 serving) from the developed dragon fruit snack bar (50 g per serving). Eleven individuals with no medical and family history of diabetes and had normal Body Mass Index completed the study. The participants fasted for eight hours prior to blood collection. A glucometer was used to measure the blood glucose of the participants. Blood glucose level was tested with 15-minutes interval for the first 1 hour and another two 30-minute intervals for the next hour (i.e. interval time of 15, 30, 45, 60, 90 and 120 minutes). This procedure was done twice; at baseline using 50g carbohydrates D-glucose and; using 50 g of dragon fruit snack bar. The results showed that the blood sugar level of the participants increased within the time range of 15 to 30 minutes and started declining within 45 to 120 minutes. The baseline procedure that had used 50g carbohydrates D-glucose served as the basis of the results. The glycemic index of the dragon fruit snack bar is low compared to the glucose powder (the reference food), but its glycemic load is high. Thus, one serving of the dragon fruit snack bar should only be 25 g to prevent too much increase in blood sugar level. Therefore, the amount of carbohydrate should be considered in the selection of food to help manage blood sugar.

Keywords: dragon fruit, glycemic response, snack bar

INTRODUCTION

Dragon fruit is one of the medicinal plants which has been reported to have a potential in diabetes mellitus treatment; it is a rich source of natural antioxidants including betacyanin, flavonoid, phenolic acid, ascorbic acid, and fiber. Its fruit has been studied to have a high antioxidant and free radical scavenging activity. It preventively affects the histopathological image of pancreatic β cells in alloxan-instigated diabetes rodents by decreasing responsive oxidative species. Clinical investigations affirmed the pattern towards increasingly significant

blood glucose decrease with a higher portion of mythical beast natural product (Poolsup et al., 2017).

A snack bar in replacement for a complete meal is sometimes preferred, especially in a busy modern world. As a means to a quick and convenient meal, snack bars have been produced and developed to meet the demand of modern-day humans. Over the years, the sales of snack bars have risen to the point that its almost everywhere. The challenge is that many commercial products, such as snack bars, perceived as healthy by the consumer, don't meet the necessary nutrient profiling score (NPS) criteria for wellbeing claims. However, the health properties of snack foods such as glycemic impact and satiety have limited studies (Mary et al., 2017).

Glycemic response is the alteration of the blood glucose concentration influenced by ingested food. The attributes of the food can affect the glycemic response, such as; the volume of the food, the total cooking time, it's ripeness, the quantity of fat, and protein in the food (Jones, 2007). Studies about the glycemic response to snack foods are unexplored and are only a few. Moreover, a dragon fruit snack bar was developed previously but not tested for the glycemic response. This study aims to determine the effect of the dragon fruit snack bar on the blood glucose level of healthy individuals and further determine its glycemic response.

The study aimed to determine the glycemic response of the dragon fruit snack bar among healthy individuals with normal fasting blood glucose levels and normal body mass index (BMI). Specifically, this study sought to answer these questions: What is the glycemic index of the dragon fruit snack bar? How much is the glycemic load of the dragon fruit snack bar?

LITERATURE REVIEW

Dragon Fruit

Dragon fruit (Pitaya Roja) is commonly known as 'Pitaya,' 'Pitahaya' (Choo et al., 2018). A group of Nutrition and Dietetics students developed a snack bar from dragon fruit and peel. Dragon fruit is not produced by a tree but rather from a fruit-bearing species of cacti, which is local to Central and South America, but today it is commercially produced in Southeast Asia. It has a unique appearance, having a bright pink or yellow skin, and consists of overlaid leaves that look like scales, giving the dragon-like appearance (Aloba, 2015). It was introduced in the Philippines and is cultivated in Malaysia, Vietnam, Taiwan, Thailand, and Southeast China. It is sweet, juicy, crispy and tastes like a pear, kiwi, and a watermelon (SunStar Philippines, 2018). It was studied that dragon fruit has excellent nutritional, antioxidant, and anti-inflammatory content. Sugar contents of the fruit include glucose, fructose, and sucrose. The sugars increased during fruit maturation, reaching its highest levels in the pulp at the mature point (Hua et al., 2018). Subandi et al. (2018) mentioned that dragon fruit sugar content has prebiotic properties.

A study compared the betacyanin content of red dragon fruit in its flesh and peel. They found out that the content in peel was 1.35 higher than flesh, which leads to the enzyme breaking down of cellulose into glucose, cellobiose, and higher glucose polymers. Dragon fruit is rich in nutrients and low in calories. It is high in fiber as well as various vitamins and

minerals, including manganese and iron may be beneficial for fighting chronic illnesses, improving gut health, and boosting immunity (Hui et al., 2014). Health benefits of dragon fruit include its capacity to aid in weight loss, control diabetes, improve digestion, lower cholesterol, and boost energy levels. It might likewise be defensive against certain malignant growth and heart illnesses, shield against microbes and organisms and upgrade the general working of the body (Staughton, 2019).

Dragon Fruit Snack Bar

Its development includes the usage of dragon fruit with pulp, rice pop (pinipig), rolled oats, almonds, cashew nut raisin, and honey. As stated by the researchers, one serving of their developed product contains 200 kilocalories, 1.14 grams of total fat, 41.4 grams of carbohydrates, 3.16 grams of protein, 59.75 milligrams of calcium, 2.59 milligrams of iron, 56 milligrams of potassium, 0.59 milligrams of vitamin C, 0.02 milligrams of thiamin, 0.14 milligrams of riboflavin, 0.88 milligrams niacin, 0.03 milligrams of vitamin E, 59.31% milligrams of magnesium, 0.24 milligrams of zinc and 4.17 grams of fiber (Ocampo et al., 2019).

Snack Bar

Various definitions explain snack bar in many ways, but in this study, it means a simple, ready-to-eat, and nutritious and healthful kind of bar-shaped snack; A study investigated glycemic response and satiety effects of the snack bars. The result showed that the snack bar made up of; rolled oats, oat bran, almonds, apricots, cranberries, dates, raisins, apple puree, banana, manuka honey, sunflower oil, egg white, cinnamon (ground), ginger powder, and gelatin, had lower than 30% blood glucose response over two hours among the three snack bars (Yan, 2017).

Glycemic Response

Glycemic response has no proper definition, but it commonly refers to the changes in blood glucose after ingesting a carbohydrate-containing food. Blood glucose testing requires the use of a small electronic device, and it is called a glucometer. A glucometer is gradually modern nowadays; it requires less blood and is more convenient than before. It is small enough to take anywhere and anytime. Blood glucose testing is an essential part of diabetes care and using glucometer can be an essential tool, and it can now test blood glucose at home with a small drop of blood. The meter of the tool reads the amount of glucose in the small amount of blood. In using Glucometer, it needs a test strip to be inserted in the meter. Prick the side of the fingertip with the needle and gently squeeze it until a drop of blood forms. Hold the edge of the test strip and let the drop of blood touch the tip of the test strip then the meter will read and display the result of blood glucose (Mayo Clinic, 2019).

Glucose is a major source of energy for most cells of the body, including brain cells. Glucose is a building block of carbohydrates. A hormone called insulin helps move glucose from the bloodstream into cells. Too much or too little glucose in the blood can be a sign of serious medical condition. High blood glucose levels (hyperglycemia) may be a sign of diabetes, a disorder that can cause heart disease, blindness, kidney failure, and other complications. In normal fasting with no food for eight hours would result in a blood sugar

level between 70 and 99 mg/dl. The normal blood sugar level for two hours after eating is less than140 mg/dl (Virginia Mason Medical Center, 2019).

Glycemic index (GI) measures the ability of a food to cause an increase in the blood sugar level of an individual. Foods' glycemic index are ranked through a food scale of 0 – 100. High glycemic index foods that are easily digested and absorbed usually are highly processed carbohydrates and sugars. On the other hand, low GI foods are those hardly absorbed by the digestive organs. These are typically rich in fiber, protein, and fat. It is applied only to an unfilled stomach (Kimbal, 2017). A low range of glycemic index 55 or less, a medium-range of glycemic index 56-69, and the high range of glycemic index 70 or higher (Oregon State University, 2019).

In getting the GI value of food, ten or more consumers must be provided with food amounting to 50 grams of carbohydrate minus the fiber. Then the effect of blood glucose levels would be measured over the next two hours. The area under the two-hour blood glucose response (glucose AUC) for this food is then measured for each person, and in another instance, another set of consumers, preferably ten or more will consume an equal amount of carbohydrates, and their two-hour blood glucose response will also be measured (Glycemic Index Foundation, 2017). The formula of the glycemic index is:

$$\text{GI.} \quad \frac{\text{incremental area under the curve (IAUC)}_{\text{test food}}}{\text{incremental area under the curve}_{\text{glucose}}} \times 100 \quad \ldots\ldots(1)$$

Glycemic load. It is a measure of the degree of glycemic response and insulin demand evoked by a given amount of a certain food. To get the glycemic load combine the GI and the total carbohydrate content of an average serving of food. (Glycemic Index and Glycemic Load, 2019). The normal range of glycemic load (GL) is between 1-10, medium range of GL is 11-19, and the high GL is 20 or higher. The formula of glycemic load is calculated from the glycemic index value:

$$\text{GL} = (\text{GI x amount (g) of available carbohydrate per serving}) \div 100 \ldots..(2)$$

Fasting blood sugar. There are several ways on how to compute the blood sugar level. This study will require fasting blood sugar test which is typically done through attaining blood sample from the participant who fasted for 8 hours with constant intervals of 15 minutes for the first four bloodletting – 15, 30, 45, 1hour, and then extending to 30 minutes for the following last procedure – 1 and 30 mins, 2 hours (to plot the rise and fall of BGL), (Gangoso &Wesley, 2018). The normal level of measuring the fasting blood sugar ranges to less than 100 mg/dL (5.6 mmol/L) while exceeding that level is considered prediabetic, ranging from 100 to 125 mg/dL (5.6 to 6.9 mmol/L). If it reaches 126 mg/dL (7 mmol/L) or higher on two distinct tests, the person will be considered having diabetes (Mayo Clinic, 2019).

METHODS

Research Design

A descriptive research design was used in this study. Descriptive research is from the root word describe, which usually relates to situations, behavior, or phenomenon. It is also commonly described as something concerned about finding out what is.

Population and Sampling Techniques

Out of 14 who responded from the initiation of the study, 13 volunteers were qualified. However, only 11 completed the study. Purposive sampling method was used in the selection of the participants of the study. Purposive sampling because the researcher chose the participant with normal BMI, normal blood glucose, and do not have any sickness. This purposive sampling method is a non-probability sample that is selected based on the characteristics of a population (Crossman, 2018).

Instrumentation

The instruments used were a researcher-made assessment form, an informed consent form, and a glucose-response datasheet. The subjects were given the full details of the study protocol and the opportunity to ask questions regarding the procedure. The AUP-URC Ethical Review Board gave ethics review board approval. The researchers used the World Health Organization (WHO) classification for BMI. To compute for the BMI, an adult's weight measured in kilograms divided by the height in meters squared. The ideal BMI for most adults ranges normally from 18.5 to 24.9. The researchers also utilized the most recent medical certificates of the participants and their medical history to determine if they have no family history of diabetes. The table 1 explains the ranges of the value of the fasting blood glucose level that indicates normal, prediabetes, and diabetes.

Table 1

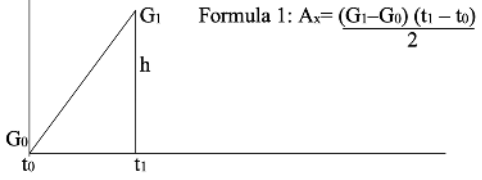
Interpretation of Fasting Blood Sugar

Classification	Values
Normal	<100mg/dl (5.6 mmol/L)
Prediabetes	100-125 mg/dl (5.7-6.9 mmol/L)
diabetes	126 mg/dl (>7 mmol/L)

Source: The Global Diabetes Community (diabetes.co.uk)

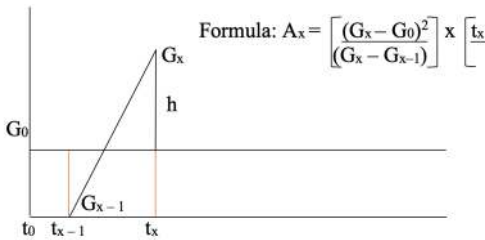
The following formulas were used to compute for the incremental Area Under-curve (iAUC) of each subject, where A pertains to Area of each glucose interval shape:

Scene I:



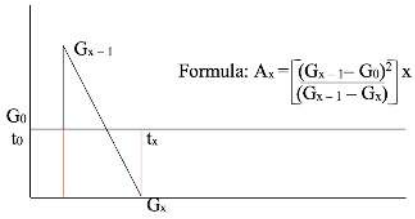
$$\text{Formula 1: } A_x = \frac{(G_1 - G_0)(t_1 - t_0)}{2} \quad (3)$$

Scene II:



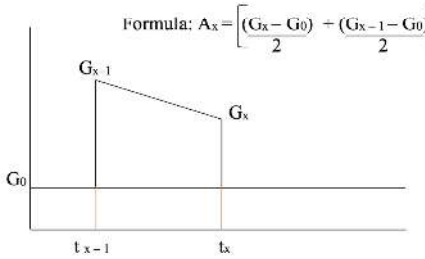
$$\text{Formula: } A_x = \left[\frac{(G_x - G_0)^2}{(G_x - G_{x-1})}\right] \times \left[\frac{t_x - t_{x-1}}{2}\right] \quad (4)$$

Scene III:



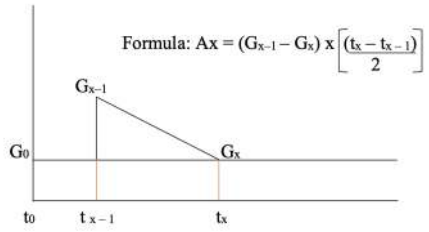
$$\text{Formula: } A_x = \left[\frac{(G_{x-1} - G_0)^2}{(G_{x-1} - G_x)}\right] \times \left[\frac{(t_x - t_0)}{2}\right] \quad (5)$$

Scene IV:



$$\text{Formula: } A_x = \left[\frac{(G_x - G_0)}{2} + \frac{(G_{x-1} - G_0)}{2}\right] \times \frac{(t_x - t_{x-1})}{2} \quad (6)$$

Scene V:



$$\text{Formula: } Ax = (G_{x-1} - G_x) \times \left[\frac{(t_x - t_{x-1})}{2}\right] \quad (7)$$

Table 2 reflects the range levels of glycemic index and glycemic load respectively. Referencing the glycemic index and glycemic load is classified as low, moderate and high, based on the following array. This reference range explains the value indicator of the results that were discussed in chapter 4 computations of the glycemic index and glycemic load.

Table 2

Glycemic Index and Glycemic Load Reference Ranges

Relative Level	Glycemic Index	Glycemic Load
High	>70	>20
Moderate	56-69	11-19
Low	<55	<10

The Glycemic Index (GI) is computed as the incremental area under the glucose curve (IUAC) after the test food is eaten, divided by the equivalent IAUC of the control food, which is the dissolved D-glucose. The value is multiplied by 100 to signify as percentage of the control food. Glycemic Load (GL) of a food is computed by multiplying the GI of that food by the amount of carbohydrate in the actual serving of the food divided by 100.

Materials

Dragon fruit snack bar is a developed product and standardized snack bar which utilized dragon fruit pulp and peel. It was consumed by the participants for the glucose response test. D-glucose, a monosaccharide served as a reference food. Glucometer is a portable machine that was used to measure how much glucose is in the blood. Isopropyl alcohol was used to sanitize the hand before the preparation of the test. Lancing device is designed to grip the lancet

firmly and is operated by simply clicking a button and was used to hold the lancet. Micro lancet is a small, broad two-edged surgical knife or blade with a sharp point. This was used to puncture the skin to release the blood. Strip test was used in blood glucose meter to test the blood glucose level. It was used to contain the blood needed for glucose level testing. Cotton was used to absorb the blood after the puncture of the skin.

Standardized Recipe

Table 3 shows the standardized recipe of the dragon fruit snack bar. The carbohydrate content of 1 serving of the Dragon Fruit Snack Bar is 50g. The carbohydrate needed for the glucose test is 50 g of the sample food. Blood samples for the determination of glucose concentrations are taken before eating and at regular intervals after eating.

Table 3

Standardized Recipe

Ingredients	Grams	Household Measurement
Dragon Fruit-pulp	85	¼ cup
Dragon Fruit-peel	25	¼ cup
Fresh Pinipig	76	1 cup + 3 tbsp
Almond	15	2.5 tbsp
Cashew Nuts	15	2.5 tbsp
Rolled Oats-Roasted	15	¼ cup
Honey	70	5tbsp
Rock Salt	8	1/8 tsp
Sesame Seed	8	1 tbsp
Raisins	12	1.5 tbsp
Water	22 (ml)	1.5 tbsp

Data Gathering Procedure

Recruitment was announced during the class of Nutrition and Dietetics seniors. They were advised about the requirement for the study. At the start of the research 14 participants were enrolled in the study. They were assessed for normal BMI and were asked to submit their medical certificate for the verification of no diabetes cases and no family background of diabetes. After the screening, fasting blood glucose (FBS) procedure was conducted. However, only 11 were able to finish due to the unforeseen and inevitable circumstances. The participants were instructed to consume food before 11:00 p.m. The researchers together with the medical

laboratory scientist students supervised by a registered medical technologist collected blood samples at 7:00 a.m. to 9 a.m. using OneTouch glucometer to measure the blood glucose response of 1 serving of dragon fruit snack bar and the participants were pricked to extract blood with 15-minutes of interval for the first 1 hour and another two 30-minutes intervals for the next hour (i.e., interval time of 15, 30, 45, 60, 90 and 120 minutes, (Gangoso & Wesley, 2018). Another set of procedure was done after a week wherein the participants were tested again for blood glucose response of 50-grams carbohydrate of D-glucose, with the same procedure mentioned above.

The two testing for fasting blood glucose determined the glycemic index in the dragon fruit bar from fasting blood glucose with the interval time. According to the Glycemic Index Foundation (2017), ten or more healthy individuals can determine the GI value containing 50 grams of carbohydrates and measure the blood glucose level within two hours.

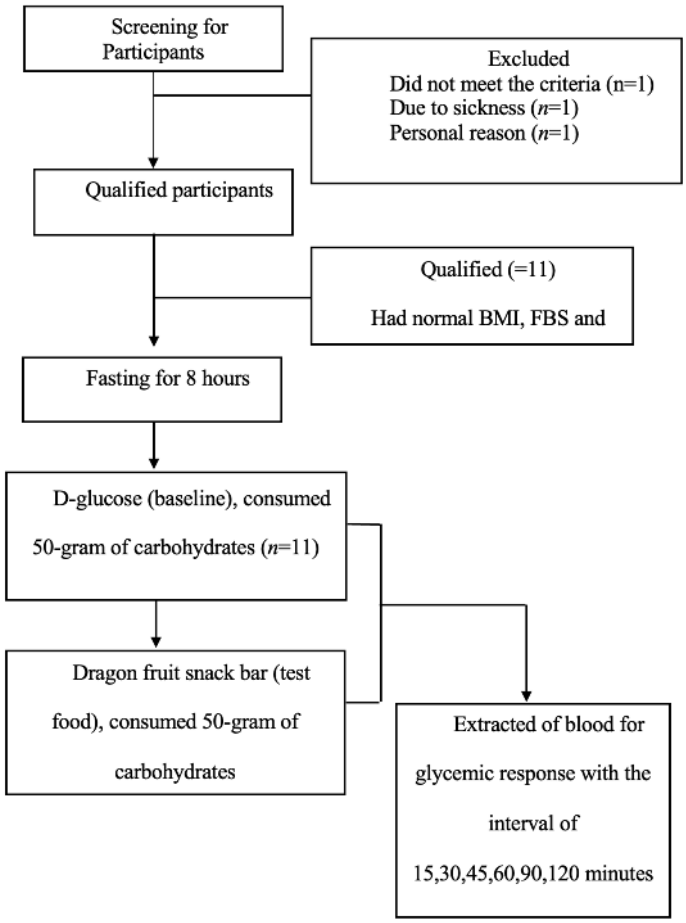


Figure 1. **Flow Diagram of Recruitment, Retention, and Data Gathering**

RESULTS AND DISCUSSION

Baseline Glucose Response of the Healthy Individuals

Figure 2 presents the glucose response of each respondent to diluted D-glucose within the time range of 15-120 minutes interval. It shows that there was a higher increased on the fasting blood glucose level after the consumption of D-glucose. It can be observed that after 45 minutes, the glycemic response was steadily declining, and most of the participants' glucose levels did not descend to the baseline level.

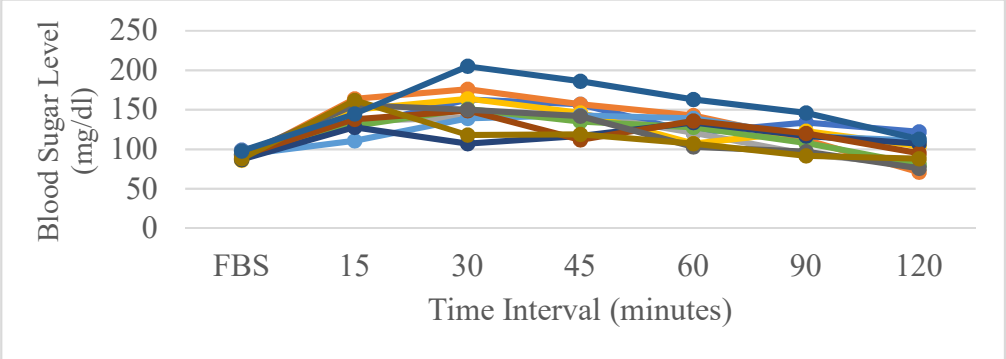


Figure 2. **Glucose Response of Participants to D-glucose**

Test Food Glucose Response of the Healthy Individuals

Figure 3 presents the test food glucose response of the healthy individuals within the time range of 15-120 minutes.

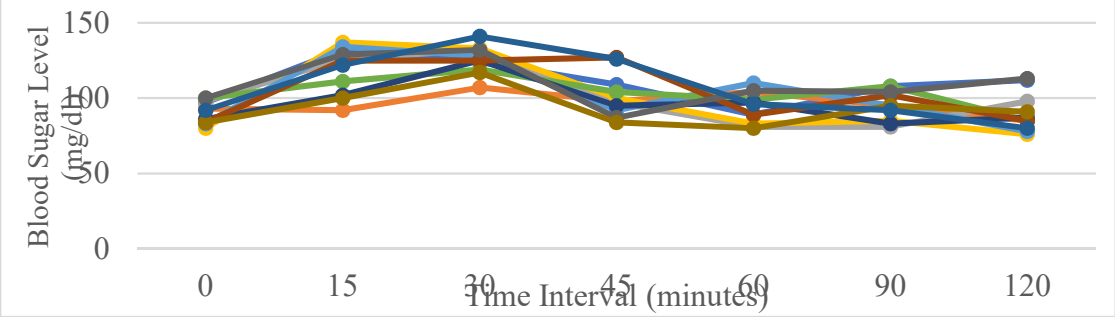


Figure 3. **Glucose Response of Participants to Dragon Fruit Snack Bar**

As shown in figure 3, the blood glucose levels increased within the time range of 15-30 minutes. The average increase in sugar level (15-30) minutes interval is 122.41 (31.95). Therefore, it can be observed that the glycemic response of healthy individuals to the dragon fruit snack bar was not too high. Likewise, it is in the normal phase, and their range is adjacent to each other. Changes in the blood glucose response over time are known as a curve.

Table 4 shows the GI of the Dragon fruit snack bar. It indicates a low glycemic index, related to D-glucose as a basis. The result indicates low GI (41.69) of the respondents after eating the dragon fruit snack bar. The result of this study agrees with the study of Reddy et al. (2009), which also resulted to the low GI (36.64) of respondents after consuming their Naturo fruit bar containing fresh fruits without added artificial supplementary additives. Another study of a snack bar is called Nothing Else Bar. It is a nutritious combination of oats, dates, almonds, oat bran, makuna honey, sunflower oil, flaxseed, and cinnamon which resulted to it containing low GI (30) (Yan at al., 2017). Foods containing low GI bring benefits for persons with risk factors of CVD and diabetes.

Table 4

Incremental Area Under the Glucose Curve of Each Respondent Based on Baseline and Food Test

Code	IAUC Index	
	D-glucose	Dragon fruit snack bar
A1	2227.75	981.00
A2	2929.79	332.75
A3	1475.14	690.21
A4	2681.25	1301.67
A5	1935.00	1499.56
B1	1736.39	453.66
B2	1965.00	714.64
B3	2032.50	1425.00
B4	1607.62	750.78
B5	1593.75	713.50
C1	3555.00	1035.00
TOTAL	**23739.19**	**9897.77**

GI = (9897.77 ÷ 23739.19) x 100 = **41.69**

Studies also confirm that low-GI carbohydrates are digested and absorbed slowly with a low glycemic response, whereas high GI carbohydrates are rapidly digested and absorbed that relates to high glycemic response. With the result obtained, examples of foods containing low GI are sweet potatoes, yam, all bran type cereal, popcorn, milk, yogurt, chickpeas, lentil, and apple. Medium GI foods include brown rice, wheat bread, quick oats, soda, ice cream, black bean soup, and raisin. High GI foods are French fries, white rice, instant rice, and white based on the Canadian Diabetes Association (2018).

GL = (41.69 x 50g of dragon fruit snack bar per serving) ÷ 100 = **20.85**

As seen in a computation, the glycemic load of the dragon fruit snack bar was high (20.85) because of the high amount of carbohydrates that contains 50-gram. According to Venn and Green (2007). Foods with a low glycemic load maintain blood sugar levels stable and prevent experiencing the highs and lows that can be caused by blood sugar that jumps too elevated and quickly drops. A low GL diet could be attained by choosing small servings of foods relatively high carbohydrates having a low GI. Otherwise, a low GL diet could contain

foods having high fat, high protein, and low carbohydrate content. For example, boiled carrots, watermelon, plain popcorn, they contain high GI but low GL. Based on UW Integrative Health (2018), GL is a more accurate way to predict the impact of the different types and amounts of food on blood glucose. Generally, selecting foods low on the glycemic load level system can be helpful, however, these foods are ranked as individual foods only. Addition of other foods changes the rank.

Mean Blood Glucose of Healthy Individuals

Figure 4 illustrates the mean blood glucose concentration in healthy individuals after intake of the D-glucose and consumption of the dragon fruit snack bar containing 50 grams of carbohydrates. The result illustrates that the elevation of D-glucose is higher than the test food which is a dragon fruit snack bar.

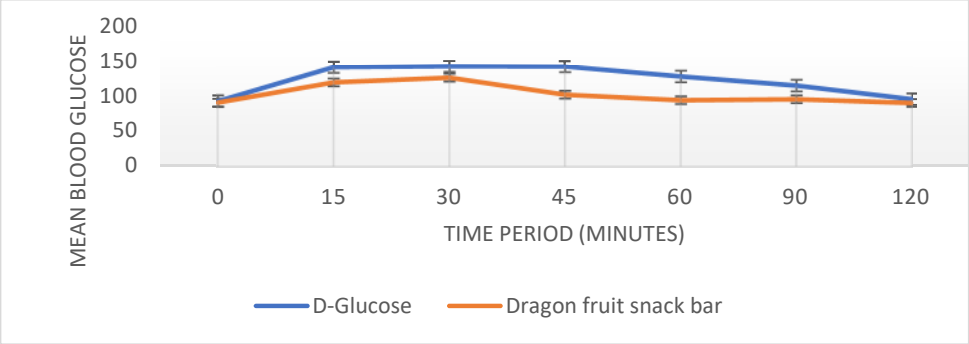


Figure 4. **Mean Blood Glucose Concentration**

CONCLUSION, IMPLICATION, SUGGESTION, AND LIMITATIONS

Considering the prevalent consumption of snack bars as an alternative food for typical meals in the Philippines, it is useful to obtain information regarding the glycemic response of the Dragon fruit snack bar. Based on the result, the glycemic index of the Dragon Fruit Snack Bar is low, but the glycemic load is high. Thus, one serving of the dragon fruit snack bar should only be 25 grams to prevent too much increase in blood sugar level. Therefore, not only the GI but also the amount of carbohydrates in the food should also be considered in the selection of food to help manage blood sugar.

GI reflects how fast carbohydrates would be absorbed. With the low GI it means that eaten with the large amount will not cause a spike into the blood glucose it will not lead to hyperglycemia and the high GL is not necessarily bad.

The researchers recommend that consumers should eat half the amount (25g) of the standardized serving. While to the future researchers, it is recommended that the developed dragon fruit snack bar should undergo objective examination such as proximate analysis of carbohydrates, to specify its nutrient contents. Also, it is recommended that future studies may compare the GI and GL of the dragon fruit snack bar to any snack bar available in the market.

The researchers recommend considering snack bars and other foods with a low glycemic index. Because it is important, such information will be beneficial for the consumers' health status.

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