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A Study of Glycemic Index of Ten Indian Fruits by an Alternate Approach

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Abstract:

Fruits should form an essential constituent of every diet, more so in a diabetic. Most of the diabetic patients do not consume fruits because they are sweet and they feel that sweetness is directly correlated to increase in blood sugar.

The primary objective: To determine the glycemic index of commonly available and consumed fruits in this area by an alternate method and to know whether the results obtained are comparable to the GI obtained by conventional method in other studies
The secondary objective: To use the results to convince the diabetics to consume fruits.

Conventional method of testing GI of any food stuff compares the elevation of blood sugar with 50 gms of glucose with that of 50 gms of available carbohydrate in the food being tested. Large quantities have to be consumed for the test when their available carbohydrate is low. To circumvent this we have used an alternate method where in the amount of fruit consumed was constant at 120 g. The available carbohydrate in each of the fruit was noted, and the rate of rise of blood glucose levels at various intervals was recorded .Glucose was used as the control. The calculated amount of glucose equal to the available carbohydrate in the fruit and the amount of blood sugar it rises was arrived at by simple regression analysis. AUC was drawn comparing the values..

The Glycemic Index of Chikku(73), Guava(78), and Jack fruit(63) were higher than the other fruits, Banana(43), Papaya(42), watermelon(37), orange(52), mango(35), apple(45) and Pineapple(19), The GI of First three fruits were higher compared to conventional method. The blood glucose levels after consumption of some fruits do not sustain even for 45 minutes.

The method that we have employed is less cumbersome and easy. The results are similar. Since the blood sugars after the consumption of the fruit do not sustain, diabetics can be convinced to use the fruits in their diet.

Key Words: *Glycemic Index, Indian Fruits, GI Methodology*

Introduction

The concept of Glycemic Index (GI), pioneered by Jenkins et al (1981), describes the blood glucose response after consumption of carbohydrate containing food, compared to a reference food, usually glucose. GI has proven to be a more useful nutritional concept than the chemical classification as simple or complex, as sugars and starches, or as available and non-available. Despite controversial beginnings, GI is widely recognized as a reliable, physiologically based ranking and classification of foods according to their post prandial glycemic effect and is used in the management of diabetes. (Foster-Powel et al 2002) Jenkins (1981) was of the opinion that the ability to prescribe a diabetic, a varied diet of low GI foods was especially appropriate at a time when more emphasis was being placed on tight Glycemic control. Use of GI has been endorsed by WHO/FAO and numerous other international health related organizations (Ludwig et al 2002)

Fruits have a lower GI even though they are sweet to taste (Jenkins et al 1981, Foster-Powel et al 2002).In spite of this; there is widespread misconception amongst most diabetic patients, which makes them to avoid fruits in their diet. It is a myth, that a diabetic should not consume fruit as they increase blood sugar. Fruits are the only food group that are eaten raw and in their natural form, rich in fiber, vitamins, minerals and anti oxidants. Fruits should be consumed on daily basis in moderation. (Jaya Dewan et al 2005) Most of the literatures on GI are from western sources and Indian studies on GI of fruits are sparse.

The conventional method of calculating Glycemic Index consists of giving fruits with 50g of Carbohydrate content, and comparing it with 50g of glucose. This is inconvenient for certain fruits, which have low carbohydrate. Hence we have used an alternate approach of calculating the area under the curve for glucose and fruit where in we have compared the blood glucose response of the amount of carbohydrate present in the fixed amount of serving of the fruit with that of blood glucose response to equal amount of glucose.

This study was done with two objectives. The primary objective was to study the GI of ten fruits commonly available and consumed locally by the alternate approach, and to know whether the response differed when compared to that of conventional method and the secondary objective was to use the data to convince diabetics to use fruits in their diet.

Material and Methods

This was a cross sectional, observational study done at two centers, JSS Hospital, Mysore and Prem Health Care, Mysore. JSS Medical college institutional ethical committee approved the study. The study was done in the period of April 2009 and August 2009. 150 healthy volunteers were recruited. Informed consent was obtained from all of them. Those aged less than 20 years,

obese (BMI >30), those with FBS>100mg% and pregnant women were excluded. 50 volunteers were in the control group and 100 were in the test group. Ten fruits used for the evaluation of Glycemic Index were1.Banana (yallakki), 2.Mango (Raspuri), 3.Papaya, 4.Orange, 5.Guava, 6.Chikku, 7.Jack fruit, 8.Watermelon, 9.Pineapple, 10.Apple. Ten volunteers were tested for each fruit.

All volunteers were physically examined for their health status. Their age, sex, heights, weight, BMI, BP were recorded in the proforma. Capillary blood sample was used for testing. The same make of Glucometers (Accu-Chek, Sensor, Manheim, Germany) were used. These glucometers were evaluated for their accuracy, in a standard laboratory, and all showed similar values when tested on the same sample of blood.

Glucose was used as control. The volunteers had an overnight fast. Their fasting blood glucose was recorded. 50 g of glucose dissolved in 200 ml of water was given to 32 volunteers and their blood sugars were recorded at 15,30,45,60, 90 and 120 minute intervals. 12 volunteers had 25 g of glucose in 100 ml of water and their blood glucose was recorded at the same intervals. 6 volunteers were given 12.5 g of glucose in 50 ml of water and their blood sugars were obtained and recorded at the same intervals.

A standard serving of 120 g of each fruit was used. The fruits were weighed in an electronic balance with LED display for accuracy. Fruits with unpalatable skin were peeled before being weighed and given for consumption. The volunteers were asked to consume the fruits within a period of 3 minutes. As each fruit contained different amount of available carbohydrate which was also low, to give the amount of fruit containing carbohydrate equivalent to 50 g would have been very high and difficult to consume,(example : Water melon had 5 g of available carbohydrate in 100 g, and to give 50 g of available carbohydrate from that fruit, 1000 g of fruit had to be given) The same was the case with Pineapple(10 g), Orange(11 g), Guava(11.5 g) and Mango(15 g). Hence the standard serving of 120 g was used and the amount of available carbohydrate in each serving was noted. Ten healthy volunteers for each fruit, who were on overnight fast, ate the fruit after their fasting blood sample was taken and recorded. Their blood sugars were recorded at the interval of 15, 30,45,60,90 and 120-min intervals. The method of evaluating the GI of fruits in this study differs from the conventional method of evaluation in the following respects.

1. In the conventional method 50 g of glucose or even 25 g are used as control against which fruits having similar amount of available carbohydrate are compared. This study has used a fixed quantity of fruit which is routinely consumed; (Foster-Powel et al 2002) and the available quantity of carbohydrate in the serving is compared with equal quantity of glucose.
2. In the conventional method both the glucose and the fruit are given to the same volunteer where as we have used different healthy volunteers both for control and to the test sampling.
3. The alternate approach that we have used has avoided large quantities of fruit being consumed.
4. The method used in this study has used the statistical method of simple regression analysis to arrive at the response of a particular amount of glucose. The available

carbohydrate in each fruit sample was noted and its blood glucose response was plotted against that of equivalent amount of glucose and its response in the controls.

Statistical analysis

Mean age with STD deviation was calculated both for controls and fruit participants. Mean values for increments of glucose at each interval from the fasting glucose were calculated for controls that had 50, 25 and 12.5 g of glucose. Mean values of increments in blood sugar for each interval for each fruit was also calculated. A statistical method of simple linear regression was used to predict the glucose values of controls, for each interval depending on the available carbohydrate for each fruit. The data were analyzed using the software SPSS 15. All the assumptions of the simple linear regression were satisfied. The mean increments of glucose values predicted for the amount of carbohydrate in the fruit was plotted on a graph and the mean fruit values were plotted below the glucose values and AUC and GI were calculated for each fruit. .

Results

The mean values for age with standard deviation of volunteers and sex distribution are given in table- 1. Table -2 shows the comparison of GI values of the present study with that of International studies done by conventional method. The GI values of Apple, Banana, Mango, Orange and Papaya in the present study are similar to the GI values of international studies. The GI values of Chikku is higher when compared to conventional method. The GI values of Jack fruit and Guava are also higher, but could not be compared to, as there were no studies on these fruits. The GI of watermelon and Pine apple are much lower in our study when compared to studies by conventional method.

As far as rise of blood sugar (BS) after consumption of fruit is concerned, the rise is linear to glucose in the first 15 minutes. Blood sugar levels start to fall and by the end of 60 min, their levels are low (Graphs – 1,3,5,6 8,9 and 10). The blood sugars after consumption of Mango, watermelon and Pine apple tend to show negative values at the end of 120 min (Graphs – 5, 9,& 10) Even with Guava(Graph-4) and Jack fruit(Graph-2) where the GI values are high, the BS start falling after 60 min. It is only with Chikku(Graph-7) the BS remain high until 90 min.

Discussion

This study is one of the large studies in India on Glycemic Index of fruits(Robert et al 2008, Reddy et al 2009) in this study we have used an alternate approach for calculating Glycemic Index. GI testing requires that portion of both reference foods and test foods; contain the same amount of available carbohydrate(Foster-Powel et al 2002) .The first question that would arise would be, the reason as to why we have tried an alternate approach instead of following the time tested conventional method. We wanted to evaluate the GI of fruits in the quantity that they are consumed daily, which is more physiological rather than giving large quantities. The second question that would be asked would be the reasons as to why we have not used the same volunteer as the control as well as for test, which would avoid inter individual variations. The variability could be both intra as well as inter. Ten healthy volunteers have been used for each

fruit and the mean values of the results have been taken for evaluation which probably would suffice to circumvent the inter individual variations, The same is the case with glucose too. We have used the method wherein the serving sample size of the fruit was the same for all the fruits. This was 120 g as per the International study on GI (Foster-Powel et al 2002) and the available carbohydrate in the sample was noted. The data pertaining to Guava and Jackfruit were obtained from another source (Gopalan et al 1989) .The advantages of this method were that 1.large quantity of fruit was not needed to be consumed by the volunteers 2. Once the control values are worked out, the same can be used for future studies without being repeated every time. The limitation of this method is that the values obtained by regression analysis may not reflect the exact value of glucose but nearer to it.

The GI of Apple, Banana, Mango, Orange and papaya are comparable to the GI values from the International studies (Foster-Powe et al 2002).Chikku and Pineapple had GI which showed variance with the values from the international table. Guava, which was not so sweet to taste showed a higher GI of 78 where as pine apple which was much sweeter than guava had a GI of 19. This only showed that sweetness had nothing to do with GI.

The differences in the values of Glycemic Index of the same fruit obtained by different studies could be due to a number of reasons like geographical changes in the cultivation, methods of storage and harvesting and variations in the degree of ripeness of fruits (Xavier P Sunyer 2002). The variations in the GI could also be due to the reference food used as well as the time interval. It can be observed from the table-2, that bread has been used as reference food for some fruits and the time interval has varied from 2-3 hours.

Even different types of blood samples can vary the GI (capillary vs venous). Capillary samples are preferred to venous samples for the reliability of testing, as after the consumption of food, glucose concentration changes to a greater extent in the capillary blood samples than in venous samples. Therefore capillary blood may be more relevant indicator of the physiologic consequences of high GI foods. (Foster-Powel et al 2002) The glycemic response to food depends not only on the amount and type of carbohydrate but also on other variables, like ripeness or maturity, presence and type of fiber, resilience of cell structure and variable rates of digestion and absorption (Chalmers 2005)

This study has taken care of these aspects. Glucose is the reference food for all the fruits and the time interval was 2 hours for all the fruits. Only capillary blood samples have been used. How much the above said variations have affected the values in our study is difficult to say as the methodology itself is different.

Since the primary objective of this study has been fulfilled, let us examine whether the secondary objective can met with the findings of the study. The blood glucose levels after consumption of every foodstuff would increase over a period of time but whether they are sustained is the point. Higher BS levels over longer period of time will have insulinogenic effect. The present study has clearly shown that BS levels do not sustain even for 45 min with most of the fruits, with Chikku being an exception. (see graphs) The blood sugar excursions after fruit consumption do not sustain as compared to glucose hence there would be no insulinogenic effect at all.(Foster-Powel et al 2002) The GI of fructose, which is the main sugar of fruit, itself is 33 which is low(Rekha

Sharma et al 2008).Hence fruits can safely be advised for diabetics. ADA technical review also stated that the total amount of available carbohydrate in meals or snaks is more important than the source.(Chalmers 2005) Hence the concept of Glycemic Load(GL). The higher the GL, the greater the expected elevation of blood glucose and the insulinogenic effect of the food(Foster-Powel 2002) Seven of the ten fruits tested have a GI of less than 50, considered to be having low GI. The GL of the fruits that we have tested in the fixed serving are 1.Apple(7.2),2.Banana(10.75)3.Mango(5.25)4.Chikku(21.17)5.Orange(5.2)6.Papaya(12.18)7.Pineapple(1.9)9.Watermelon(2.22)10.Jackfruit(18.1). As it can be seen that the GL of most of the fruits are very low and even fruits like chikku, Guava and Jack fruits which have higher GI when compared to other fruits have GL which are much lower than other foods. Hence there would be no insulinogenic effect and are safe for consumption in diabetics.

Even though lot of scientific studies have examined the application of GI or GL to DM, obesity, CV disease, even when GI has been endorsed by FAO/WHO and numerous other international health related organizations, there is by no means a consensus regarding the utility of GI to human health and nutrition (Ludwig et al 2002) In spite of this diabetic patients should be encouraged to include more unprocessed, high fiber foods for which lower GI has been generated. Fruits are an example (Franz 2003)
Finally, questions will be asked as to why we approached this subject by an alternate route, instead of following the conventional methodology. This study, by the conventional method, would have been another study like others, except that this was a larger one. We wanted to explore an alternate methodology and have shown that it is feasible to arrive at the conclusions. This methodology may not appear to be valid at present, but more number of studies, using the approach that we have used, would bring out the advantages and limitations of this method and would validate it for further use.

Conclusions

Fruits should be an essential component of the diabetic diet. Just because fruits are sweet, diabetics need not avoid them. 100 to 150 gms of fruit can safely be consumed per day. Chikku, guava and jackfruit have to be consumed in a lesser quantity.This information has to be widely publicized in the media for the public in general and diabetics in particular to adopt in their food habits. It has been shown by this study that the alternate approach used for finding the GI is equally useful as compared to the conventional method.We hope this study would remove the prejudice some doctors have, regarding consumption of fruits and make them to advice fruits to their diabetic patients.

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Table-1 Mean age of controls and fruit volunteers and sex distribution

Controls/Fruit	Mean Age+/- STD (years)	Mean Age +/- STD(years)
	Male(N)	Female(N)
Controls	32.4 +/-7.8(30)	32.0 +/-10.8 (20)
Apple	38.0+/-7.6(7)	36.0+/-9.8(3)
Mango	34.6+/-12.5(3)	43.2+/-6.7(7)
Orange	32.2+/-13.3(4)	37.16+/-12.12(6)
Watermelon	39.6+/-6.0(3)	37.0+/8.12 (7)
Banana	25.7+/-4.4 (9)	20.0+/-0 (1)
Jackfruit	26.7+/-7.8 (4)	28.3+/-10.8 (6)
Guava	31.8+/-9.1 (6)	26.0+/-2.4 (4)
Pineapple	25.0+/-3.0 (2)	42.7+/-8.3 (8)
Chikku	31.3+/-8.5 (6)	25.2+/-1.4 (4)
Papaya	25.4+/-4.0 (10)	----------
Total	54	46

Table-2 Comparison of GI of the fruits of the present study with other international studies

Fruit	GI-(International table/No. of studies)	Present study	Reference food and time	Reference food (present study)	Serving size	Available CHO gms
Apple	28-44/ 6 studies	45	Glu/2hrs	Glu/2hrs	120 gm	16
Banana	30-58/10 studies	43	Glu/2hrs	Glu/2hrs	120 gm	25
Mango	41-60/3 studies	35	Glu/3 hrs	Glu/2hrs	120 gm	15
Chikku	40 /	73	Bread /3hrs	Glu/2hrs	120 gm	29
Orange	31-56/6 studies	52	Glu/2hrs	Glu/2hrs	120 g	10
Papaya	44-76/3 studies	42	Glu/3hrs	Glu/2hrs	120 gm	29
Pineapple	46-73/2 studies	19	Bread /2hrs	Glu/2hrs	120 gm	10
Watermelon	59-85/	37	Bread/2hrs	Glu/2hrs	120 gm	06
Guava	NA	78		Glu/2hrs	120gm	11.5
Jackfruit	NA	63		Glu/2hrs	120 gm	28.8