Chapter 5
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Diabetes mellitus is emerging as a chronic non-communicable disease of concern in developed and developing countries. With changing environment, urbanization and altered life style, diabetes is also increasingly identified as a major cause of mortality and morbidity in India. Furthermore Indians have high ethnic susceptibility for developing diabetes at a younger-age. As per the available data, there are atleast 20 million people with diabetes in India, which could also be a possible underestimate. The alarming rise in non-communicable diseases like diabetes, hypertension, lipid disorders warrants immediate attention of experts to develop better diabetes health care facilities and also plan preventive measures against diabetes. Dietary treatment is the oldest of the three-treatment modality recommended for diabetes. Since the days of charak nutritional defects have been implicated in the developing of diabetes, Yet diet therapy in diabetes mellitus even today leaves much more to be desired. At present we can not speak about the cure of diabetes. In dealing with this chronic disorder our goals are maintenance of the well being of the effected individual and minimization of long-term complications.

Recent work has suggested that the carbohydrate exchange lists that have regulated the diets of many diabetics for over four decades have not reflected the physiological effects of foods. Approach to dietary modification in the management of diabetes mellitus has changed in recent years. Such factors as dietary fiber and nature of carbohydrate have been shown to have a marked influence on the postprandial glycemia and allowance can not be made for these in lists, which take into account
The glycemic index (GI) is a classification of foods based on their blood glucose-raising potential. Glycemic index is based on blood glucose response to a food, in comparison with response to an equivalent amount of glucose or white bread. Glycemic Index describes the type of carbohydrate in foods and indicates their ability to raise blood glucose levels.

The research of glycemic index has turned some widely accepted beliefs down. Results are truly revolutionary. The first miracle was that the starch in foods like bread; potatoes and many types of rice are digested and absorbed very quickly, not slowly, as always has been assumed. Second, the scientists found that sugar in foods (like fruits, chocolates, ice cream and softdrink) did not produce more rapid rises in blood sugar, as had always been thought. The truth was that most of the sugars in foods, regardless of the source, actually produced quite moderate blood glucose response even lower than most starches. The present study also defends these findings. The glycemic index is a useful tool, which may have broad spectrum of applications, from the maintenance of fuel supply during exercise to the control of blood glucose level in diabetics. Low glycemic index foods may prove to have beneficial health effects for all in the long term.

Researches all over the world have been proved that glycemic index are useful in the management of diabetes mellitus, obesity, hyperlipidemia and certain kind of cancers. Though many studies conducted all over the world to study the glycemic Index of hundreds of foods, but not much work has been done in this field in India specially in northern part of India. Though the food habits of north Indians differs drastically from
The following objectives –

- To determine the glycemic index of various food articles commonly used in north India in diabetic and non-diabetic subjects.
- To recommend classification of food articles on the basis of glycemic index, particularly for the use of diabetic subjects.
- To find the utility of glycemic index in the management of diabetes mellitus.
- To establish a co-relation between various nutrients i.e. protein, fat, fiber with glycemic index.
- An attempt to change the glycemic index of food articles by combining them with other food articles.
- To develop a theory relating glycemic index with molecular parameters of food articles.

The present study was conducted in Bundelkhand area of Uttar Pradesh State. From this area M.L.B medical college Jhansi was chosen purposively. Type 2 Diabetic patients attending diabetes OPD randomly selected for the determination of Glycemic index of foods. All patients were between the age group of 30-50 years and their BMI was less than 25. They were free from any other metabolic disorder that could effect the digestion of foods. Total diabetic patients selected for the study were fifteen and finally they were divided into three groups, each of five patients. Five non-diabetic patients between the same age and body mass index were also selected for the study. So finally four groups were formulated for the study. After the selection of
of glycemic index. Finally selected food were divided into following sub groups

**Fruits:** In this category the selected fruits were mango, banana, Dashiari mango, pomegranate, muskmelon (300-g), grapes, lichi, and orange.

**Beverages:** beverages selected for the estimation of glycemic index were sucrose solution, sugarcane juice, mirinda, pepsi and orange juice. Due to large volume of mirinda, pepsi and orange juice (which could have been difficult, if consumed 50-g carbohydrate portion), 300-ml volume was given by considering it one serving.

**Sweets:** selected sweets were gulab-jamun, chenna rasgulla, motichoor ladoo, ice cream (100 g) and chocolate (40 g).

**Breakfast snacks:** consisted samosa, potato bonda, and bread roll.

**Cereal preparations:** was Puri and potato sabzi and bread butter.

**Rice preparations:** Dal chawal (rice and red gram dal) and khichadi (rice and green gram dal) were selected for the study in this category.

Reference food was glucose (50-g glucose dissolved in 200 ml of water). All the selected food was measured for 50-g total carbohydrate. Mixed meals were measured for 50g carbohydrate as combination of all major ingredients. All the fruits were purchased in bulk from local market to maintain the uniformity of samples. Among
mirinda and pepsi was purchased from local market. Breakfast food, sweet, cereals and rice preparations all were prepared at home. Bread preparations were made using white bread. Foods were purchased and prepared time to time as required for the study.

The GI of different test meal was determined by comparing their glycemic response with that of glucose, in twenty selected volunteers. Their dietary pattern was elicited by a 24-h recall questionnaire on the day prior to each test day. Selected volunteers than were divided in 4 groups of 5, 3 diabetic and 1 non-diabetic group. Each group consisted 3 males and 2 females. On the first test day of each group, 50-g glucose dissolved in 200 ml of water was given as reference food. The test meals were given within 4 weeks of a reference food administration, with atleast 3 days interval between feeding of 2 test meals with each group. The meals were served at a set time in the morning after a 12-h overnight fast to eliminate the effect of previous meal. Each recipe was given separately on a second occasion. The subjects were instructed not to perform any heavy activity 1-day prior to the test and were made to rest for 30 min before being given the test meal. They were also instructed to finish the meal within 10-15 min with proper chewing. They remained on rest and refrained from eating or drinking during the test period of 2-h. Finger prick samples was obtained with softstick lancets at 0, 30, 60, 90 and 120 min after the reference glucose and each test meal. The blood glucose was estimated using glucometer (Reflolux R S by boehringer). A pretest was carried out indicated no difference and a high degree of correlation between this and the traditional method. These values for reference and each test meals were plotted for each subject and incremental area under curve was
method suggested by Jenkins et al that is

\[ GI = \frac{\text{incremental area under curve of test food}}{\text{incremental area under curve of reference food (50-g glucose)}} \times 100. \]

Mean of glucose tolerance (GTT) of reference food and each test meal was calculated and used for the calculation of area under curve. Statistical tools applied to determine the correlation and significance of results obtained was ANOVA, Spearman's and Pearson rank correlation, Mean with standard errors.

Major findings and conclusions:

- All the selected recipes were well tolerated by the subjects. GI of all the test recipes was ranged from 56-95 with lowest for chocolate and highest for sugarcane juice.

- GI tested in diabetic and non-diabetic subjects were comparable (P<0.02). It indicated that GI tested in non-diabetic might be applied to diabetic subjects and vice versa.

- GI of Test fruits ranged from 64-94 with lowest in muskmelon and highest in grapes. It may be due to difference in fiber contents.

- GI of test beverages ranged from 65-95 with lowest in pepsi and highest in sugarcane juice.
highest in samosa. On the basis of these results, it is concluded that glycemic index of individual food articles can be changed when they are combined with other low glycemic index food. Such as glycemic index of both white bread and potato are high but in this study as bread rolls when they combined together and deep fried in oil showed significant low glycemic index that is only 56.

- GI of test sweets ranged from 56-74 with lowest in chocolate and highest in chenna rasgulla. Same conclusions can be drawn with sweets as breakfast snacks that, if foods high in glycemic index are consumed as mixed foods. It can significantly lower the glycemic index of that meal and can be the part of diabetic diet without compromising their glycemic control.

- GI of test cereals and pulses preparations ranged from 68-85 with lowest in bread butter and highest in dal chawal. In this study fat is found to show the glycemic index at significantly lower level (GI of Puri and sabzi + potato veg.67, and bread butter only 68). No significant change is seen with rice preparations when they are combined with pulses like Red gram dal and Green gram dal. So it is concluded on the basis of these results of rice preparations, that more research is needed to reach on any final conclusion.

- GI of bread butter and Puri sabzi was found to be same as 68. It is concluded that fat is the strong factor to reduce the glycemic index of these food articles. These foods are very popular among selected population and as they are mostly farmers
Peak plasma concentrations of test food articles have found strong positive correlation with glycemic index (P<0.0001). It is concluded that glycemic index is directly related to peak plasma concentration of particular food. And peak plasma concentration can predict the glycemic index of that food.

Area under curve and glycemic index was also having direct relationship. Area under curve may also predict that whether the food will be high or low in glycemic index.

Glycemic index of mixed food articles was lower than the glycemic index of individual food article in it. For example glycemic index of potato and bread is as higher as 80 as revealed by hundreds of studies conducted around the world (new glucose revolution 2003), but bread roll (combination of potato and bread) found to have much lower glycemic index that is 56 and samosa, aloo bonda, Puri sabzi also showed lower glycemic index than potato alone. In this study fat also found to be a strong factor to reduce the GI as it delays the gastric emptying.

Glycemic index of rice also found to be changed when used as mixed meals (Dal chawal and khichadi), but it was not low with red gram dal as compared of green gram. Lentil and chana dal can be better alternative to be used with rice due to its very low glycemic index (28, 20 respectively) for the use of diabetic subjects.
Fruits and beverages have shown their peak plasma concentration at one hour and after one hour they have found to flatten the blood sugar response curve.

All mixed test preparations have shown their peak plasma concentration at 1.5 hour. In this study strong positive correlation was observed between Peak plasma concentration and GI (P < 0.0001)

GI and protein: In this study no significant correlation was found between protein and glycemic index of test foods. Though the it was showing negative relationship between protein and GI, but it was not found statistically significant (P =NS).

GI and sugar: No significant relationship was observed between amount of carbohydrate of test foods and its glycemic index. (P = NS). It indicates that amount of carbohydrate is not responsible for overall glycemic response, but it is the type and nature of carbohydrate. Method of food preparation also effects the GI of particular food article.
- GI and fat: A significant negative correlation was seen between fat and glycemic index of test preparations. (P<0.01). It is revealed by several studies that fat slows the gastric emptying so that the GI of the particular food.

- GI and fiber: No significant relationship was seen between fiber and glycemic index of tests preparations, especially cellulose and hemicellulose fiber present in most test fruits and cereal preparations (P= NS), but relation was significantly positive in preparations containing soluble fiber such as fiber present in legumes and pulses preparations.

- Lowest Peak plasma concentration was seen with Motichoor laddoo and highest was with sucrose. These results show that sweets can be included in the diet of diabetic patients and provide some sort of satisfaction to diabetics in contest of diet flexibility.

- Mixed foods have shown lower peak plasma concentration than fruits and beverages. Fruits should be used with meal to reduce the overall glycemic index instead of using it alone.

- Results of this study indicate that all fruits containing simple carbohydrate are not same, neither all foods containing complex carbohydrate acts same on blood sugar levels. Glycemic index of individual food is altered when it is consumed as mixed meal.
potatoes and sweets when they are being consumed as mixed foods. Glycemic index of high glycemic index food also can be reduced by combining with other foods and by using as mixed meal. It can make diabetic diet more pleasant without causing any negative effects on blood sugar levels. Results of this study are also evidence that, it's not the amount of carbohydrate in food but nature of carbohydrate that is responsible for glycemic response of particular food. Low glycemic index foods may be very useful tool for blood glucose control of diabetic patients without compromising metabolic control as well as taste of effected individual.