ABSTRACT

Diet has always played a major role in the management of diabetes. In the pre-insulin era diet played a dominant role in the management of diabetes. Even after the discovery of insulin and several oral hypoglycemic agents diet forms the sheet anchor of treatment. The dietary approaches have varied from time to time. The pendulum has swung from the starvation diets of Allen, to restriction of carbohydrates with liberal fat, to the modern high carbohydrate and high fiber diets.

The current concepts of dietary management of diabetes are based on the need to achieve glycemic control as well as to normalize the dyslipidemia which is commonly associated with diabetes. Such an approach aims at preventing the micro and macrovascular complication of diabetes. The amount of carbohydrate in the diet, the type of fat and quantity and type of protein has been altered to meet these needs.

Carbohydrate content of the diet has to provide 50-60% of the calories and most of this is to be in the form of complex carbohydrates with a high fiber content and low glycemic index.

Fat content of the diet should be 20-25% of the total calories distributed in the ratio of 1:1:1 among saturated fatty acids, MUFA and PUFA. PUFA content of <10% of the total calories and an EFA content of at least 3% of the total calories is advisable with the n-6/n-3 ratio being <10.

Protein intake of 0.8mg/kg is recommended, so as to contribute to 12-20% of the calories. Vegetable proteins are preferable due to their high fiber content and absence of saturated fat which is present in animal proteins.

Diet continues to be the sheet anchor of diabetes management and newer concepts are bound to come in future, based on experiences with current approaches and newer studies.

Both diet and exercise have been shown to improve the risk factors associated with macrovascular disease by improving the lipid profile, decreasing blood pressure and decreasing the body weight. Thus the role of dietary modifications should be emphasized to the patient.

In the last three decades a lot of changes have occurred in the concepts of dietary management of diabetes. The exact nature of the diet most appropriate for diabetic individuals remains a source of
controversy. The several issues involved are:

i. The composition of the diet
ii. Metabolic effects of high carbohydrate and low fat diets
iii. The types of fats and carbohydrates
iv. The role of fiber – its type and quantity
v. The use of food substitutes

Atherosclerosis is accelerated in diabetics and is a major cause of macrovascular disease resulting in an increased incidence of coronary artery disease, strokes and peripheral vascular diseases. The risk for CVD is 2-3 times greater in diabetics compared to non-diabetics. Hence a major concern of dietary therapy is metabolic normalization and reduction of cardiovascular risk factors. So the current focus is on the fat content and the type of fat, the fiber content and the carbohydrate content of the diet. The proportion of saturated fats MUFA and PUFA in the cooking oil has drawn attention. The fish oils and eicosanoids are being used to lower the atherogenic lipids. The role of micronutrients and antioxidants has also gained importance and the diet planning has to incorporate these.

The objective of dietary therapy is to provide a nutritious and balanced diet. In type 1 diabetes patients the total energy input has to be increased to ensure weight recovery and growth while in Type 2 diabetes patients the calories need to be restricted to decrease the weight and foods which promote vascular complications have to be avoided.

Obesity is not a major problem in our Type 2 diabetes patients compared to the west. Only about 30% of our Type 2 diabetes patients have a BMI >27. Majority of our patients have a BMI in the normal range). A subset of about 18-20% of our patients is underweight with a BMI of less than 19- they are labeled as the “lean Type 2 diabetes”. However some of these normal weight or lean type 2 diabetes have a waist hip ratio of >0.9 and they are labeled as the “lean obese”.

In prescribing a diet to a diabetic patient the following points have to be considered the type of diabetes type 1 diabetes or type 2 diabetes the weight of the individual in comparison to the ideal body weight, his occupation, activities, and the presence of any complication. In type 2 diabetes patients the first step would be dietary therapy along with exercise. About 50% of Type 2 diabetes patients achieve good glycemic control within 4 – 6 weeks. Proper patient education helps in better compliance and adherence to the diet over prolonged periods of time.

Total caloric requirement is assessed based on the ideal body weight of the patient and his activity level. The prescribed diet should contain 30Kcal/Kg of ideal body weight per day. (Ideal body weight = height in cms-100). In an underweight individual the diet should provide 35kcal/kg/day while in an obese individual calories should be reduced by 5 -10 kcal/kg/day. Additional allowances are required in case of pregnancy, lactation and for growing children. Total calories thus calculated should be evenly distributed into three principal meals and two snacks. These calories are derived from three principal sources – carbohydrates, proteins and fats. Each fraction has its own importance and should provide calories in proper proportion. 60% of the calories are to be provided by carbohydrates, 20% by proteins and the remaining 20% by fats.

**CARBOHYDRATES**

Carbohydrates (CHO) constitute a major proportion of human diet. CHO rich food items are easily digested, relatively inexpensive, provide ready energy and sense of filling. These are also considered more suitable for the sick and at the extremes of age.

For several decades it has been appreciated that all carbohydrate containing food items do not raise blood glucose to a similar extent within the same period of time. Ingestion of simple sugars raises plasma glucose faster and higher than food consisting of complex CHO such as starch. Even among starchy food distinction has been made between refined raw rice and potato on one hand and whole mill wheat flour and pulses on the other. Quantification of these differences has been possible following introduction of procedures for estimate of glycemic index (GI) by Jenkins et al (1981).

**GLYCEMIC INDEX (GI):**

GI is meant to measure the change in blood glucose following the ingestion of food containing a specific amount of CHO and compare it with a reference standard such as glucose or white bread. GI is ratio between the increase in blood glucose over the fasting levels observed for 2-hour, following ingestion of a set amount of carbohydrate (50g) in the test food and the response to glucose or white bread containing similar amount of carbohydrate in the same individual. The increments are calculated from the measurement of area under the curve (AUC) in the graph drawn as in glucose tolerance test GI = ACU following the test meal/AUC after 50g of glucose or equivalent amount of white bread x 100.

**GLYCEMIC LOAD (GL):**

The overall blood glucose response is determined not only by the GI value of a food but also by the amount of carbohydrate in the food. Thus the concept of glycemic load (GL) has been developed. The product of Glycemic index and value of its carbohydrate content is the glycemic load. This represents both the quantity and quality of carbohydrate consumed.

Food prepared from whole grains products as whole meal wheat (flour), oats, Jowar, Rai and Ragi have low glycemic index. In addition these are rich in fiber, antioxidants and
was noticed that there was remarkable improvement in their belief that such a diet would worsen metabolic control. It intake and avoidance of pure sugars contrary to the general their usual diet pattern with restriction of the total calorie patients. It was suggested that the patients may continue a diet 70-80% of the total calories were from carbohydrates. markedly different from the normal diet patterns of Indians, from proteins and 50% from fats. This diet pattern was 1960's the diet advice was similar to that followed in western restriction. This practice was followed in our country till principle in the diet for diabetes should be carbohydrate For a long time it was generally believed that the fundamental cause important decrement in several classes of lipoproteins rate of absorption of carbohydrate and high fiber diets usually carbohydrate diets will have profound beneficial effect on the reduction in total and LDL cholesterol and also plasma triglycerides return to the baseline and glycemia is unaffected. So they suggest that gradual replacement of fat with carbohydrates may be a better strategy. Garg and associates compared a high carbohydrate (60% carbohydrates, 25% fat) with low carbohydrate diet (35% carbohydrate and 50% fat, enriched in monounsaturated fat) compared with the baseline ADA diet (50% carbohydrate diet). Both diet induced striking reduction in total and LDL cholesterol and also plasma triglyceride levels. However greater triglyceride reduction was noted in the high fat diet. The fiber content in the high carbohydrate diets will have profound beneficial effect on the rate of absorption of carbohydrate and high fiber diets usually cause important decrement in several classes of lipoproteins as well.

For a long time it was generally believed that the fundamental principle in the diet for diabetes should be carbohydrate restriction. This practice was followed in our country till 1960’s the diet advice was similar to that followed in western countries providing 33% calories from carbohydrates, 17% from proteins and 50% from fats. This diet pattern was markedly different from the normal diet patterns of Indians, resulting in a poor compliance. An average Indian diet is cereal based it consist of either rice, wheat or Jowar in such a diet 70-80% of the total calories were from carbohydrates. In order to obtain a better compliance and adherence from patients. It was suggested that the patients may continue their usual diet pattern with restriction of the total calorie intake and avoidance of pure sugars contrary to the general belief that such a diet would worsen metabolic control. It was noticed that there was remarkable improvement in their glucose tolerance (Vishwanathan). The usefulness of such a high carbohydrate diet was also reported by Singh. Patel et al. Gulati and Vaishnav Tripathy.

Vishwanathan et al noted that the protein content was not sufficient in these diets in order to make the diet more balanced, the protein content was raised while keeping the carbohydrate content constant resulting in reduction of fat content. This was called high carbohydrate high protein date. Experience with high carbohydrate high protein diet showed that the diet helped in achieving rapid and effective control of diabetes. Such diets also contributed to increase in the fiber content which is about 26gm in 1000Kcalories. Hence it was labeled High CH, High Protein and High Fiber diet.

The American Diabetic Association and the European Diabetic Association study groups have also altered their dietary recommendations. In an attempt to reduce the cardio vascular morbidity and mortality they now recommend a liberalized use of carbohydrate in the diet upto 50-60% of the calories. This helps in reducing the intake of saturated fats.

Simple carbohydrates such as glucose and sucrose with a high glycemic index are to be replaced by complex carbohydrates with a lower glycemic index in order to reduce the hyperglycemia. Modifications in the type of carbohydrate can be achieved by increasing the intake of legumes and pulses, green leafy vegetables which increase the content of complex carbohydrates and fiber.

**FATS**

The fat content of the diet should be 20-25% of the total calories. The distribution of the types of fat should be equal i.e. one third each from saturated fats, monounsaturated and polyunsaturated fatty acids. The total dietary cholesterol should be less than 300mg/day. Invisible fat is derived in a fair amount from cereals, legumes and seeds and contributes to 5-10% of the total energy intake. Milk and milk products contribute approximately to 40-50% of the total fat content in vegetarian diets. Milk fat is saturated fat.

Dietary saturated fats down regulates hepatic LDL receptors and therefore reduce receptor mediated clearance of LDL particles from circulation. Replacement of saturated fats with carbohydrates or with unsaturated fats such as MUFA/PUFA may unregulate hepatic LDL receptors and thereby reduce LDL cholesterol levels. Thus there is a general consensus about the importance of reducing the cholesterol raising saturated fats in the diets of individuals with diabetes.

IT is recommended that PUFA comprise <10% of the total calories, because of concern over the effect of PUFA on serum HDL cholesterol levels and their possible carcinogenic effects. The remainder of fat energy should be provided by MUFA.

Our body requires two essential fatty acids – linoleic acid (18:2, n-6) and alpha linolenic acid (18:3, n-3) fatty acids.
as they are not synthesized in the body. These fatty acids play an important role in the body as they are precursors for prostaglandins and other biologically active long chain PUFA. It is recommended that the ratio of n-6/n-3 fatty acids should be below 10 and 3% of the energy should be derived from EFA. Therefore intake of fat should also meet the requirements of these essential fatty acids.

Fish oils are rich in Omega – 3 polyunsaturated fatty acids (ω3PUFA) in contrast to the vegetable oils which contain ω6PUFA. They are more effective triglyceride lowering agents than vegetable oils.

**PROTEINS**

Protein intake has been recommended as 0.8gm/kg of ideal body weight and should contribute to 12-20% of the total caloric intake. Proteins from vegetable sources are thought to be better than those from animal sources.

Animal protein is rich in saturated fats and tends to increase cholesterol and triglycerides. Lean meat and fish are to be preferred in order to minimize the risk. Vegetable proteins are incomplete proteins as they are deficient in certain amino acids. They can be made complete proteins by suitable combinations of cereals and pulses as is commonly done in traditional diets. The proteins of cereals and pulses complement each other in such a way that amino acid deficiencies are overcome. Vegetable proteins have the major advantage of being free of saturated fat and dietary cholesterol and also have high fiber content.

Protein in Indian Diets is very different as the regular protein intake is usually from vegetable sources and the daily consumption is about 0.60m/kg body weight.

The protein requirements are enhanced in growing children and during pregnancy. Protein will have to be restricted in nephropathy.

Ingested protein stimulates insulin secretion in people with Type 2 diabetes. There appears to be a synergistic effect when protein is ingested with glucose. Since the dietary protein does not raise the blood glucose concentration and stimulates insulin secretion some workers suggest increasing the protein content of meals for people with Type 2 diabetes if lower post meal glucose levels are a treatment goal. Therefore, in lean body weight individuals a modest increase in proteins may be desirable. Arginine and leucine improve insulin secretion and lead to a better metabolic control.

**CONDIMENTS**

In India, while cooking condiments are added to food items. They have a high fiber content of 5-10% are rich in micronutrients and some have essential oils that tend to modify the absorptive function of the intestines. Fenugreek seeds commonly used as condiments have been shown to reduce blood glucose, serum cholesterol and triglyceride levels.

**SALT INTAKE**

Salt content of the diet should be less than 6gm/day. In the presence of hypertension or renal failure is to be reduced to around 3gm/day.

**ALCOHOL**

Alcohol intake increases the risk of hypoglycemia, may induce ketoacidosis, lactic acidosis and may contribute to peripheral neuropathy. Liberal intake of alcohol also induces hypertriglyceridermia and hyperuricemia. Alcohol is also and additional source of calories each ml providing 7Kcal. Alcohol intake should therefore be avoided, as far as possible. If consumed it should be taken in moderate quantities (1-2 pegs).

**FIBER**

Dietary fiber is derived from plant cell components and is composed of several complex polysaccharides. It is resistant to the digestive secretions of the gastrointestinal tract and is considered as unavailable carbohydrate. Depending on its solubility in hot water, dietary fiber is grouped into two categories: Water soluble (Pectins, gums) and water insoluble (Cellulose, hemicelluloses). Generally, soluble fiber present in fruits, oats, barley, and legumes is more effective in controlling blood sugar and serum lipids than insoluble fiber present in cereals and millets. An intake of 25g/1000Kcal or 40g of dietary fiber per day is desirable.

The fiber content of some of common Indian foods is given in Table 3

**ARTIFICIAL SWEETENERS:**

Non nutritive artificial sweeteners of not add to the caloric

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### Table 1: Fatty Acid Composition of Commonly Used Oils

<table>
<thead>
<tr>
<th>Oil</th>
<th>Saturated</th>
<th>MUFA</th>
<th>PUFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut oil</td>
<td>86.5</td>
<td>5.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Palm Oil</td>
<td>49.3</td>
<td>37.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Rice Bran Oil</td>
<td>24.4</td>
<td>38.4</td>
<td>36.6</td>
</tr>
<tr>
<td>Groundnut Oil</td>
<td>18.0</td>
<td>48.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Sun Flower Oil</td>
<td>11.0</td>
<td>20.0</td>
<td>69.0</td>
</tr>
<tr>
<td>Safflower Oil</td>
<td>9.1</td>
<td>12.1</td>
<td>74.5</td>
</tr>
<tr>
<td>Mustard Oil</td>
<td>6.8</td>
<td>55.5</td>
<td>33.3</td>
</tr>
</tbody>
</table>

### Table 2: Rich Sources of Alpha – Linolenic Acid

<table>
<thead>
<tr>
<th>Source</th>
<th>Cereals and millets</th>
<th>Pulses and legumes</th>
<th>Vegetables</th>
<th>Spices</th>
<th>Oils</th>
<th>Animal foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, Bajra</td>
<td>Blackgram, Cowpea, Rajmah, Soya</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Green leafy</td>
<td>Fenugreek, Mustard</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mustard, Soyabean</td>
<td>Fish</td>
<td></td>
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</tr>
</tbody>
</table>
intake and can be used in small quantities by diabetic patients. The commonly available ones are saccharin and aspartame. Saccharin is 30 times sweeter than sucrose, is heat stable and can be used in cooking but it leaves a bitter after taste. An intake of 500mg/day is acceptable. Aspartame is 180 times sweeter than sucrose, not stable in liquids and is destroyed by heating. The acceptable intake is 2-3 gm/day.

The role of diet in the management of diabetes remains crucial. The concepts continue to change with newer information gathered from metabolic studies. Some of the current views require further scrutiny and hence newer concepts will continue to be evolved. The current approaches have looked at the macronutrients content of the diet in achieving glycemic control as well as preventing the vascular complications of diabetes. The role of micronutrients and anti-oxidants in the management of diabetes is being examined in some recent ongoing studies. The development of newer compounds for the management of insulin resistance and hyperglycemia may bring in further changes. Thus the process of learning in this area will continue—controversies will promote further studies which will help us in improving our approach to the dietary management of diabetes.

**REFERENCES**


<table>
<thead>
<tr>
<th>Table 3: Total Fiber content of Common Goods (g/100g)</th>
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</thead>
<tbody>
<tr>
<td><strong>High (&gt;10)</strong></td>
</tr>
<tr>
<td>Wheat</td>
</tr>
<tr>
<td>Jowar</td>
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<tr>
<td>Bajra</td>
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<td>Ragi</td>
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<td>Maize</td>
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<td>Legumes</td>
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<tr>
<td>Dals</td>
</tr>
<tr>
<td>Fenugreek</td>
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