Diabetes is defined as a disorder of carbohydrate metabolism caused by absence or deficiency of insulin, insulin resistance, or both, ultimately leading to hyperglycemia. People with diabetes cannot properly process glucose, a sugar the body uses for energy. As a result, glucose stays in the blood, causing blood glucose to rise. At the same time, however, the cells of the body are starved for glucose. Diabetes mellitus is typically classified into two subtypes: type-I or insulin-dependent diabetes mellitus (IDDM), and type-II or non-insulin-dependent diabetes mellitus (NIDDM). Type-I is called juvenile onset diabetes, and type-II is called adult-onset diabetes. In IDDM, the pancreas cannot make the insulin needed to process glucose as a result of destruction of islet cells of the pancreas which secretes insulin. With NIDDM, the pancreas makes enough insulin, but the body has trouble using it. Type-I and II are differentiated on immunological-etiologial grounds with type-I referring to an immune-mediated condition, whereas type-II is non-immune-mediated. Diabetes mellitus (DM) is a common disease affecting an estimated 4% of the population of which 90% of them are NIDDM, and is highly associated with Western, industrialized cultures in which the refined and processed, rich, fiber-depleted diets are found there. Although hereditary predisposition, viral and bacterial afflication of the pancreas, and auto-antibodies have their effect on the pancreatic islets and contribute to the development of this disease, diet, lifestyle, and obesity are by far the most significant risk factors for the development of diabetes.

Signs and symptoms of DM – Frequently asymptomatic; polyuria, polydipsia, weight loss, glycosuria, and dehydration. The serious complications include diabetic nephropathy leading to kidney failure and need for dialysis, retinopathy leading to blindness and poor healing of ulceration of the feet leading to gangrene and amputations.

Treatment – In treatment of type-II DM diet is of utmost importance and can be very successful in its control. The focus is on eating High Complex Carbohydrate, High Fiber diet (HCF). The HCF recommends 70-75% of calories come from complex carbohydrate, 15-20% from protein, and 5-10% from fat. The carbohydrate portion of this diet must be very well balanced and does not include sugar or processed starches. This high fiber diet is highly recommended for diabetics. Guar gum and pectin fiber has also been shown to have a positive effect on blood sugar control. One study found consuming up to 26 grams of guar gum per day resulted in a lowered insulin requirement and a reduced amount of sugar spilled over into the urine.

Dietary Recommendation
- Increase cereal grains like oats that are high in soluble fiber
- Increase legumes like lentils, peas, and navy beans which are high in soluble fiber
- Increase root vegetables like yams
- Increase fresh organic vegetables
- Include onions and garlic on a daily basis
- Avoid simple sugars, but whole organic fruit like pears and green apples are good
- Decrease fat, avoid margarine because of trans fatty acids
- Avoid highly processed foods and flours

Specific nutrient supplementation
- Chromium – An essential micronutrient that functions as a cofactor in all insulin-regulating activities. Despite 40 years of research on the potential role of chromium in carbohydrate and lipid metabolism, significant progress has only recently been made regarding the mode of action of chromium at a molecular level. The oligopeptide low-molecular-weight chromium-binding substance (LMWCr) may function as part of a novel insulin-signaling autoamplification mechanism. This proposed mechanism sheds some light on the potential of chromium in the treatment of NIDDM. Chromium is part of the glucose tolerance factor. Double blind research shows that chromium supplements improve glucose tolerance in people with both NIDDM and IDDM, apparently by increasing sensitivity to insulin.
- Niacin – Is a component of the glucose tolerance factor.
- Selenium – May protect against retinopathy. Maintaining proper selenium levels appear to be especially important as the antioxidant enzyme glutathione peroxide requires selenium to detoxify free radicals. It has been shown that patients with diabetes have pronounced decreased selenium concentrations in erythrocytes as compared to controls.
- Magnesium – Is essential for glucose homeostasis, and it is a co-factor in glucose transport and regulates energy production in liver mitochondria. A tendency for magnesium deficiency in patients with diabetes mellitus is well-established. The plasma magnesium level has been shown to be inversely related to insulin secretion in patients with type II diabetes. Hypomagnesemia is most pronounced in patients with the most severe retinopathy.
- Vitamin B6 – As the coenzyme pyridoxal phosphate, B6 plays an important role in the metabolism of carbohydrates, therefore B6 has been associated with impairments in gluconeogenesis and abnormal glucose intolerance. B6 prevents diabetic neuropathy and inhibits glycosylation. Many diabetics have low blood levels of B6. Levels are even lower in diabetics with nerve damage. The clinical response to therapeutic doses of B1 and B6 were determined in diabetic patients with clinical symptomatic peripheral neuropathy after four weeks of treatment. The results showed that pain reduced in 88.9%, numbness in 82.5%, paresthesia in 89.7% and signs of peripheral neuropathy decreased in 48.9% of patients.
- Vitamin B12 – Prevents and treats diabetic neuropathy.

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used as treatment in 1,149 patients with polyneuropathy, neuralgia, radiculopathy and neuritis associated with pain and paraesthesia, were observed. Under treatment, there was a clear improvement in these symptoms observed in 69% of the cases.\textsuperscript{11}

Manganese – An important co-factor in the key enzymes of glycolysis. Deficiency can lead to glucose intolerance.\textsuperscript{14}

Vitamin C – May prevent sorbitol accumulation and inhibits glycosylation of proteins.\textsuperscript{19} Glucose competes with ascorbic acid for absorption, therefore tissue levels are often lower in diabetics, but high dose vitamin C is contraindicated in patients with kidney failure.

Vitamin E – Is an antioxidant that has been demonstrated to improve insulin action.\textsuperscript{18} Vitamin E may control blood sugar and decrease glycosylation of proteins.\textsuperscript{17} Vitamin E also reduces cellular damage through its antioxidant property and reduces cardiac diseases.\textsuperscript{16} The dosage of vitamin E must be slowly increased in diabetics on insulin because it may reduce insulin requirements.

Zinc – Has an antihyperglycemic effect.\textsuperscript{19} Zinc may enhance insulin synthesis and increase insulin binding. Diabetics excrete more Zinc than non-diabetics do.\textsuperscript{19} Wang P and Yang P concluded at the end of their research that “zinc supplementation should be used as an important adjunctive therapy for NIDDM.”\textsuperscript{20}

Inositol – Improves diabetic neuropathy.\textsuperscript{21} Inositol is needed for normal nerve function. Diabetes can cause nerve damage or diabetic neuropathy, which may be reversed by inositol supplementation.

Potassium – Improves insulin response to glucose.\textsuperscript{22} Insulin administration often causes potassium deficiency.\textsuperscript{23}

Biotin – Mediates phosphorylation of glucose, may improve glucose tolerance and lowers insulin resistance. When people with IDDM are given 16 mg of biotin per day for just one week their fasting blood glucose level drops by 50%.\textsuperscript{24}

Copper – Deficiency may impair glucose intolerance, which results in elevation of glucose.\textsuperscript{25}

Bioflavonoids – May enhance insulin secretion.\textsuperscript{26}

In addition to the above supplements there are a few other supplements that deserve mentioning. These additional supplements are: Vanadium (vanadyl sulfate) reduced glutathion, alpha-lipoic acid, coenzyme Q10, fish oils, flaxseed oil, and the amino acid taurine.

**Specific Botanicals in treatment of diabetes**

*Allium sativum / Allium cepa* (Onions and garlic) – Blood sugar lowering action; Onions and garlic have several sulfur-containing constituents that compete with insulin for binding sites in the liver which results in increased insulin in free circulation.\textsuperscript{27} S-allyl cystein sulfoxide (SACS), a sulfur containing amino acid of garlic, which is the precursor of allicin and garlic oil, has been found to show significant effects in diabetic rats. Administration of SACS decreased significantly, the concentration of serum lipids, blood glucose and activities of serum enzymes like alkaline phosphatase, acid phosphatase and lactate dehydrogenase and liver glucose-6-phosphataase.\textsuperscript{28} In one study researchers showed that feeding onions for 8 weeks to diabetic rats had a significant reduction in excreting albumin, urea, creatinine and inorganic phosphorus in addition to significant reduction in hyperglycemic status and cholesterol level. Thus, the study reveals that onion feeding improves the metabolic status in diabetic condition, probably because of its hypoglycemic as well as hypocholesterolemic effect.\textsuperscript{29}

*Momordica charantia* (Bitter melon) – Has been used in many cultures for centuries to treat diabetes. One isolate of Momordica, charantin, compares favorably to Tolbutamide, an allopatic drug commonly used as an oral hypoglycemic agent. Momordica contains insulin-like polypeptide, which lowers the blood glucose.\textsuperscript{30} Effect of Momordica on fasting and post-prandial serum glucose levels were studied in 100 cases of moderate NIDDM subjects. Drinking of the aqueous homogenized suspension of the vegetable pulp led to significant reduction of both fasting and post-prandial serum glucose levels. This hypoglycemic action was observed in 86% cases; 5% showed lowering of fasting serum glucose only.\textsuperscript{31} An investigation was made of the effect of Momordica fruit juice on the distribution and number of alpha, beta and delta cells in the pancreas of the diabetic rats immunohistochemical methods. The results indicated that there was a significant increase in the number of beta cells in Momordica-treated animals with untreated diabetics, however, their number was still less than that obtained for normal rats. There was also a significant increase in the number of delta cells in diabetic rats compared to non-diabetic rats.\textsuperscript{32}

The hypoglycemic influence of Momordica is claimed to be mediated through an insulin secretagogue effect or through an influence on enzymes involved in glucose metabolism.\textsuperscript{33}

Gymnema sylvestre – The leaves of Gymnema have been used in Ayurvedic and folk tradition as a therapy to improve diabetes for centuries. Gymnema decreases blood sugar and glycosylated hemoglobin while increasing free insulin. The active component GS4 may enhance endogenous insulin production in both type I and type II DM. It may also increases the number of islets of Langerhans and beta cells.\textsuperscript{34} In another study GS4 was administered for 18-20 months as a supplement to the conventional oral drug. During GS4 supplementation, the patients showed a significant reduction in blood glucose, glycosylated hemoglobin and glycosylated plasma proteins, and conventional drug dosage could be decreased. Five of the 22 diabetic patients were able to discontinue their conventional drug and maintain

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**TOWNSEND LETTER for DOCTORS & PATIENTS – JANUARY 2002**

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Diabetes

their blood glucose homeostasis with GS4 alone. These data suggest that the beta cells may be regenerated/ repaired in type II diabetic patients on GS4 supplementation. This is supported by the appearance of raised insulin levels in the serum of patients after GS4 supplementation. To confirm this finding researchers at the University of Madras extracted two soluble components GS3 and GS4 from Gymnema sylvestre to test in diabetic rats. In the diabetic rats, fasting blood glucose levels returned to normal after 60 days of GS3 and after 20 days of GS4 oral administration. GS3 and GS4 therapy led to a rise in serum insulin to levels closer to normal fasting levels. In diabetic rat pancreas, GS3 and GS4 were able to double the islet number and beta cell number. So, it appears that Gymnema sylvestre brings about blood glucose homeostasis through increased serum insulin provided by repair/regeneration of the endocrine pancreas.

Vaccinium myrtillus (Bilberry) and blueberry leaves appear useful in controlling hyperglycemia. Anthocyanosides in the Vaccinium family have a stabilizing effect on capillaries, inhibits free radical damage, and prevents damage to vascular walls. Therefore, anthocyanosides help treat and prevent diabetic retinopathy and nephropathy by improving the integrity of the vasculature. Vaccinium myrtillus anthocyanosides are effective in promoting and enhancing arteriole rhythmic diameter changes, that play a role in the redistribution of microvascular blood flow and interstitial formation. Alterations in the capillary filtration of macromolecules are well documented in diabetic patients and experimental diabetes. Various flavonoids including anthocyanosides and ginkgo biloba extracts have been shown to be effective against experimentally induced capillary hyperfiltration. In one experiment Vaccinium myrtillus leaf infusions were given to diabetic rats for 4 days. Plasma glucose levels were consistently found to drop by about 26% at two different stages of diabetes and plasma triglyceride were also decreased by 39%. Trigonella foenum-graecum (Fenugreek) – Improves glucose tolerance, reduces fasting blood sugar, decreases 24-hour urinary glucose output and serum cholesterol. Trigonella also improves postprandial glucose, insulin response, and general blood sugar control. One study showed that fenugreek diet significantly reduced fasting blood sugar and improved the glucose tolerance test. There was a 54% reduction in 24-hour urinary glucose excretion. Serum total cholesterol, LDL, and VLDL cholesterol and triglycerides were also significantly reduced. These results indicated the usefulness of fenugreek seeds in the management of diabetes. The effect of fenugreek seeds on antioxidant status in rats has been studied. The study showed that the level of antioxidants were higher in rats which were fed with the fenugreek supplemented diet compared with control animals which were fed commercial rat chow. The study shows that disrupted free radical metabolism in diabetic animals may be normalized by fenugreek seed supplementation in the diet.

Pterocarpus marsupium – A traditional Indian botanical that is used in treatment of diabetes. Epicatechin, a flavonol glycoside found in the bark has been shown to prevent beta cell damage to the pancreas, and is also reported to have insulin-like activity. Epicatechin also increases the cAMP content of the islets which is associated with increased insulin release, conversion of proinsulin to insulin and cathepsin B activity. Also, it is has been experimentally proven that epicatechin has insulogenic as well as insulin-like properties. Pterocarpus also has other flavonoids such as marsupin, pterosupin, and pterostilbene. In experimental studies marsupin and pterostilbene have been shown to significantly lower the blood glucose level of hyperglycemic rats, which was comparable to metformin. In a separate study 93 patients with NIDDM were treated with Pterocarpus for 12 weeks. The result showed that both fasting and postprandial blood glucose levels fell significantly, by 32 and 45 mg/dl at 12 week from initial means of 151 and 216 mg/dl respectively. Mean HbA1c decreased significantly to 9.4% at 12 week from the initial mean of 9.8%. Also, no side effects were reported. Epicatechin also can be found in green tea, which is used in diabetes.

Galega officinalis (Goat’s rue) – Contains alkaloid galeine that is reported to have hypoglycemic properties by enhancing glucose utilization. Galega is well known for its hypoglycemic action and has been used as part of a botanical mixture in the treatment of diabetes mellitus. During pharmaceutical investigations of an ethanolic extract of a powdered mixture of equal proportion of Galega officinalis, Syzygium jambolanum and two other herbs, a weight reducing effect of Galega was discovered. In this study post-mortem examination of all galega-treated mice revealed a striking absence of body fat. Serum glucose was significantly reduced in mice receiving galega for 28 days.

Catharanthus roseus (Madagascar periwinkle) – Is widely used as an anti-diabetic botanical. Cantanarthus contains many alkaloids including vindoline, which have anti-diabetic activity. A commercial preparation, “Vinculum,” has been marketed in Great Britain as an anti-diabetic agent. A comparison of blood sugar lowering activity of four important medicinal plants such as Catharanthus and Gymnema sylvestre were carried out against normal and diabetic rats. The result showed that Catharanthus and Gymnema had potent blood sugar-lowering activity.

Syzygium jambolanum (jambol) – Used in India in treating diabetes, and other diseases of the pancreas.

Inulin-containing botanicals – Articium lappa, Taraxacum officinalis, Inula racemosa, and Helianthus tuberosa all contain Inulin, which can lower hyperglycemia.

Exercise program
Maintain a regular exercise program such as aerobic exercise for 30 minutes at least 3-4 times a week. Exercise is necessary to reduce obesity, which is common in type II diabetes. Exercise also enhances insulin sensitivity, improves glucose tolerance, increases HDLs, improves chromium metabolism, and decreases cholesterol.

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