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Review Article

NUTRACEUTICAL SUPPLEMENTATION FOR DIABETES: A REVIEW

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ABSTRACT

In recent years there is a growing interest in nutraceuticals which provide health benefits and are alternative to modern medicine. Nutrients, herbals and dietary supplements are major constituents of nutraceuticals which make them instrumental in maintaining health, act against various disease conditions and thus promote the quality of life. Diabetes mellitus is one of them. This dreadful disease is found in all parts of the world and is becoming a serious threat to mankind health. There are lots of chemical agents available to control and to treat diabetic patients, but total recovery from diabetes has not been reported up to this date. Alternative to these synthetic agents, plants and nutrients provide a potential source of hypoglycemic drugs and are widely used in several traditional systems of medicine to prevent diabetes. The effects of these plants may delay the development of diabetic complications and correct the metabolic abnormalities using variety of mechanisms. This review attempts to display and remark some of the most popular nutraceuticals being use as antidiabetic.

Keywords: Nutraceutical, Diabetes Mellitus, Macronutrient, Micronutrient

INTRODUCTION

The quality of life in terms of income, spending and lifestyle has improved with economic development. However, it has also thrown up a major challenge in the form of `lifestyle diseases'. The first victim of this lifestyle change has been food habits. Consumption of junk food has increased manifold, which has led to a number of diseases related to nutritional deficiencies. Nutraceuticals can play an important role in controlling them. No wonder more and more people are turning to nutraceuticals.

A nutraceutical is a food with a medical-health benefit, including the prevention and treatment of disease. The term was coined in the late1980s by Stephen DeFelice, M.D., founder and chairman of the Foundation for Innovation in Medicine[1] (Figure-1). Nutraceuticals also refer to natural functional/medical foods or bioactive phytochemicals that have health promoting, disease preventing or medicinal properties. These nutraceuticals normally contain the required amount of vitamins, lipids, proteins, carbohydrates, minerals, or other necessary nutrients, depending on their emphases[2, 3].

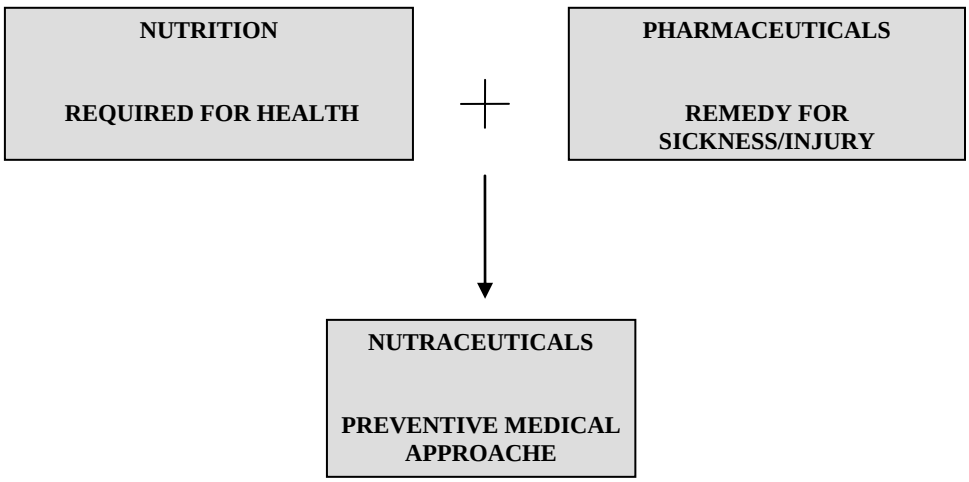

Fig. 1: Term, Nutraceutical was created from two words nutrition and Pharmaceutical by Stephan DeFelice in 1989

When food is being cooked or prepared using "scientific intelligence" with or without knowledge of how or why it is being used, the food is called "functional food".

Thus, functional food provides the body with the required amount of vitamins, fats, proteins, carbohydrates, etc. needed for its healthy survival. When functional food aids in the prevention and/or treatment of disease(s) and/or disorder(s) other than anemia, it is called a nutraceutical (Figure-2). Examples of nutraceuticals include fortified dairy products (e.g. milk) and citrus fruits (e.g. orange juice) [4].

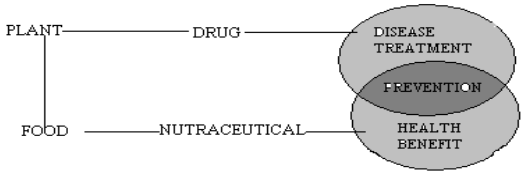

Fig. 2: Nutraceutical Inhabit a Grey Area between the Food and Drug

Nutraceuticals and Diabetes

Diabetes mellitus is characterized by abnormally high levels of blood glucose, either due to insufficient insulin production, or due to its ineffectiveness. The most common forms of diabetes are type1 diabetes (5%), an autoimmune disorder, and type2 diabetes (95%), which is associated with obesity. Gestational diabetes occurs in pregnancy[5]. As a result of elevated levels of blood glucose, two problems occur: body cells become starved for energy, and, over time, the high glucose levels can damage the nerves, eyes, kidneys, heart and blood vessels. Globally the total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2003[6]. Several medicinal plants have found potential use as hypoglycemic in the Indian system of medicines, including ayurveda[7].

Nutraceuticals have the capability to control diabetes. Nutraceuticals denote foods having medicinal effect on the health of human beings. According to the American Diabetes Association, if you have the symptoms of developing diabetes then appropriate change in diet will certainly do wonders for you. Research is also supportive of the benefits of diets high in certain types of fiber for promoting improved post-prandial glucose and insulin responses in normal individuals and in individuals with type 2 diabetes, dyslipidemia, and insulin resistance[8]. The types of dietary fiber that appear to be most significant with respect to insulin resistance include oat fiber and guar gum, while psyllium has produced mixed results[9-17]. Coffee is another great nutraceutical. It comprises of chlorogenic acid which act as an antioxidant. After having food, it aids in slowing down the release of glucose in our blood stream. A few more popular nutraceuticals include magnesium, chromium piccolinate, conjugated linoleic acid, bitter melon and our beloved cinnamon. These nutraceuticals effectively enhances glucose tolerance as well as insulin sensitivity[18].

Traditional plant medicines are used throughout the world for a range of diabetic presentations. Herbal drugs are prescribed widely because of their effectiveness, less side effects and relatively low cost[19]. Therefore, investigation on such agents from traditional medicinal plants has become more important[20]. The present review, deals with some selective Indian medicinal plants having pharmacologically established hypoglycemic potential.

Categories of nutraceuticals and their role in diabetes

Nutraceuticals are non-specific biological therapies used to promote wellness, prevent malignant processes and control symptoms. These can be grouped into the following three broad categories[21].

1. Substances with established nutritional functions, such as vitamins, minerals, amino acids and fatty acids - ***Nutrients***

2. Herbs or botanical products as concentrates and extracts - ***Herbals***

3. Reagents derived from other sources (*e.g.* pyruvate, chondroitin sulphate, steroid hormone precursors) serving specific functions, such as sports nutrition, weight-loss supplements and meal replacements – ***Dietary supplements***.

Nutrients

Apart of choosing herbs as part of natural army against diabetes, vitamins and minerals are also an essential and balancing factor. There is mentioning below the basic vitamins and minerals that our needs especially in case of diabetes. These nutrient classes can be categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients include carbohydrates, fats, protein, and water. The micronutrients are minerals and vitamins.

Macronutrients

Carbohydrates

Dietary carbohydrates from cereals, breads, other grain products, legumes, vegetables, fruits, dairy products and added sugars should provide 50–60% of the individual's energy requirements[22]. Both the source and the amount of carbohydrate consumed influence blood glucose and insulin responses[23, 24]. When a carbohydrate food is eaten there is a corresponding rise and subsequent decrease in blood glucose level known as the glycaemic response. This response is relevant, for example, to appetite control, sports nutrition and those with diabetes. A number of factors influence the rate and duration of the glycaemic response. It depends on:

The specific food

- The type of the sugar that forms the carbohydrate
- The nature and the form of the starch as some are more digestible than others
- The cooking and processing methods used
- Other nutrients in the food such as fat or protein

Weight reduction is usually necessary and is the primary dietary aim for people with non-insulin dependent diabetes. Consuming a wide range of carbohydrate foods is an acceptable part of the diet of all diabetics, and the inclusion of low glycaemic index foods is beneficial as they help regulate blood glucose levels. Most recommendations for the dietary management of diabetes allow a modest amount of ordinary sugar as the inclusion of sugar with a meal has little impact on either blood glucose or insulin concentrations in people with diabetes[25].

Protein

Current evidence indicates people with diabetes have similar protein requirements to those of the general population — about 0.86 g/kg per day[22]. Although protein plays a role in stimulating insulin secretion[26, 27] excessive intakes should be avoided as it may contribute to the pathogenesis of diabetic nephropathy[28]. Some evidence suggests eating vegetable protein rather than animal protein is better for reducing serum cholesterol[29] and managing nephropathy[30, 31]. There are a number of different types of protein supplements include liquid protein supplements, protein powders and liquid protein shots. There are a number of sources for protein supplements. Some of these sources include: Whey, Casein, Soy, Rice, and Egg[32].

Fats

Numerous studies indicate high-fat diets can impair glucose tolerance and promote obesity, dyslipidemia and atherosclerotic heart disease. Research also shows these same metabolic abnormalities are reversed or improved by reducing saturated fat intake. Current recommendations on fat intake for the general population apply equally to people with diabetes: reduce saturated fats to 10% or less of total energy intake and cholesterol intake to 300 mg/d or less[33]. Scientific debate continues over which alternative is preferable to saturated fat polyunsaturated fat, monounsaturated fat or carbohydrate calories[34, 35]. Research suggests monounsaturated fat such as canola, olive and peanut oils may have beneficial effects on triglycerides and glycemic control in some individuals with diabetes[36], but care must be taken to avoid weight gain. Omega-3 fatty acids, found in fish such as salmon and mackerel, may reduce serum triglycerides without impairing glycemic control[37].

Micronutrients

Minerals

Chromium

Chromium (Cr+3) is an essential trace element required for normal glucose metabolism [38-41]. It appears to act by enhancing insulin's actions, with increases in the number of insulin receptors, increased binding of insulin to the insulin receptor and increases in activation of the insulin receptor reported[42-45]. Because chromium is a nutrient, supplements are likely to be beneficial only in those people with chromium deficiencies. Chromium levels in the body tend to decline with age, which may be one factor affecting older people's risk of developing Type II diabetes. Dosage levels between 100-500 mcg/day have been shown to reduce blood glucose, insulin and cholesterol[46].

Vanadium

Research indicates that this mineral acts similarly to insulin in transporting glucose into the cells, and is therefore valuable for both Type I and Type II diabetics. Vanadium supplementation also decreased fasting blood glucose levels[47-49], Hemoglobin A1c levels[47, 48] and cholesterol levels [50]**.** Dosages ranging from 45-150 mg/day can be useful for improving fasting glucose levels (how much sugar is in the blood when one wakes up in the morning). Toxicity studies show these dosage levels to be safe and well tolerated by most people. Some individuals experience mild gastrointestinal distress, either during the first week of use or at higher dosage levels (up to 400 mg/day) [46].

Magnesium

The mineral magnesium functions as an essential cofactor for over 300 enzymes in the body. It is essential for all energy dependent transport systems, glycolysis, oxidative energy metabolism and biosynthetic reactions[51, 52]. While this mineral is not directly implicated in the mechanisms of diabetes, it helps to protect patients from complications of the disease. For people with diabetes or heart disease, the recommended daily intake level of magnesium is 1000 mg/day. However, because the actions of calcium and magnesium are so strongly connected, one needs an intake ratio of 2:1 or more—for each 1000 mg of calcium, one should also get 500-1000 mg of magnesium[46].

Vitamins

Vitamin E

Vitamin E is an essential fat soluble vitamin and functions primarily as an antioxidant [41]. Low levels of vitamin E have been associated with increased incidence of diabetes[53] and some research suggests people with diabetes have decreased levels of antioxidants[54-56]. Additional evidence indicates that people with diabetes may also have greater antioxidant requirements, due to increased free radical production secondary to hyperglycemia[57-59]. Doses of vitamin E up to 400 IU are generally believed to be safe. Doses over 800 IU may alter blood clotting although supplement trials that have monitored prothrombin times in subjects have noted no increases[41].

Vitamin C

Research has shown that Vitamin C supplementation may be beneficial to type II diabetes patients. In one study patients took no Vitamin C for the first week, then 1g/day for 4 weeks, followed by 3g/day for a further 4 weeks. The results showed that the mega dose of Vitamin C helped to control blood sugar levels and increased the patient's anti-oxidant status[60]. There is preliminary evidence that substantial supplements of vitamin C (about 1000 mg daily) may help to prevent or reduce the development of cataracts and nerve disorders that commonly occur in people with diabetes. Such does may also inhibit protein glycosylation, which is believed to be important in the development of the long-term complications associated with diabetes[61].

Biotin

Biotin, a member of the B vitamin complex, is necessary for both metabolism and growth in humans, particularly in the production of fatty acids, antibodies, and digestive enzymes and in tissue metabolism[62]. Importantly, for patients with diabetes, biotin stimulates liver glucokinase activity, increases insulin production, and enhances glucose uptake in muscle cells[63-65]. Food sources of biotin include organ meats, soy, egg yolks, whole grains, and yeast. There is growing evidence of suboptimum biotin intake in the U.S. population[66]. A recommended dosage level for diabetics is 9 mg/day.

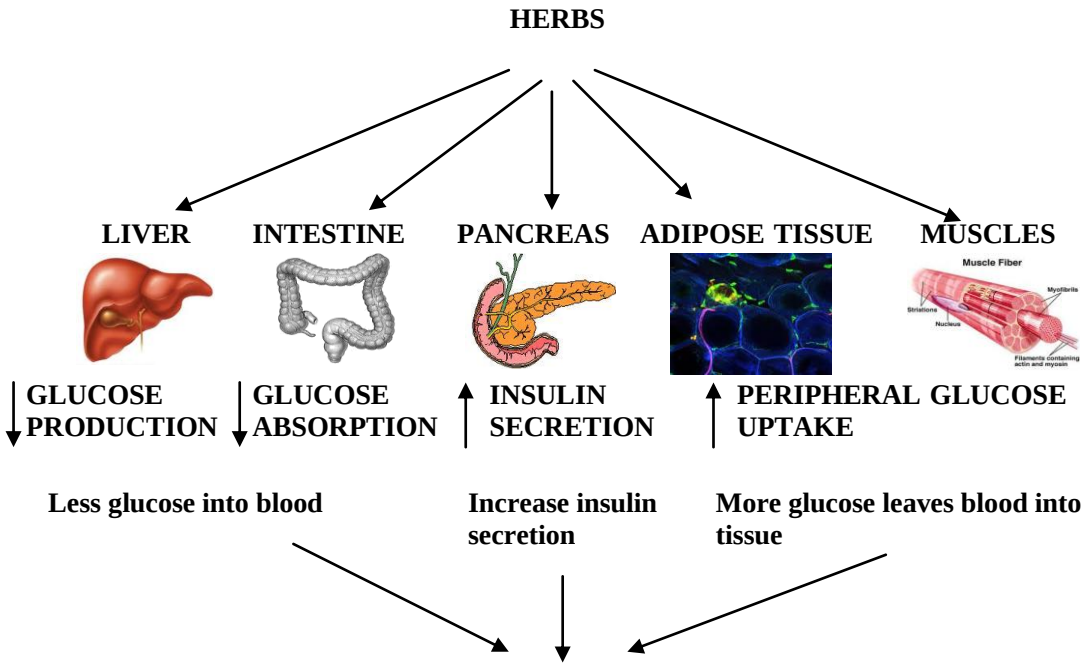

Fig. 3: Action sites of herbs in diabetes treatment

Other Supplements

Omega 3 fatty acids

Fatty acids are an integral "building block" of our cell walls. In order for glucose to get into our cells and provide energy, that wall must be fluid and flexible. However, the body cannot make omega-3 fatty acids, so must get them from dietary sources. The best sources are fatty fish (such as salmon, mackerel, sardines, herring, and tuna), flaxseed, evening primrose, borage, walnuts and wheat germ. Omega-3 essential fatty acids (omega 3 EFAs), improve insulin resistance in animal models[67]. Their effect in humans has been equivocal. Available human research has shown a range of outcomes regarding insulin metabolism ranging from some improvement to no change to deterioration of glycemic control in one study. A recommended intake level of flaxseed oil is 1-2 tablespoons/day (or 1/4 cup freshly ground flaxseed).

Alpha-Lipoic Acid

This substance is a potent anti-oxidant, soluble in both fats and water, which means it, can act in virtually all areas of the cell to neutralize free radicals. Alpha-Lipoic acid has been shown to improve insulin resistance in a variety of animal models[68, 69]. Copious anecdotal evidence exists regarding the efficacy of alpha-lipoic acid in restoring insulin sensitivity in type 2 diabetes. Alpha lipoic acid has been demonstrated to inhibit mammalian pyruvate dehydrogenase kinase, thereby providing a possible mechanism for a glucose (and lactate) lowering effect in diabetic subjects[70]**.** Dosage levels of 600-1800 mg/day have been shown to improve the transport of glucose into cells by as much as 63%.

Coenzyme Q10

The importance of this nutrient cannot be overstated, primarily because many of the drugs that are needed for management of diabetes and/or its complications deplete CoQ10. Coenzyme Q10 (CoQ10) is a promising nutritional intervention for insulin resistance, at least among subjects with hypertension. Singh et al conducted an eight week randomized, double-blind trial comparing the use of a water soluble form of CoQ10 (60 mg twice daily) to a vitamin B complex in 59 hypertensive patients. Their results indicated CoQ10 at this dose lowered glucose and fasting insulin levels, suggesting possible improved insulin resistance[71].

Herbs & Dietary supplements

A great attention has nowadays been given to discover the link between dietary nutrients and disease prevention. Large numbers of herbs which had been in use since unknown time have been shown to play a crucial role in the prevention of disease (Figure-3). In addition to the macro and micro nutrients such as proteins, fats, carbohydrates, vitamins or minerals necessary for normal metabolism, a plant based diet contains numerous nonnutritive phytoconstituents which may also play an important role in health enhancement. A brief overview of the role of various herbs in disease prevention, with a focus on bioactive components from flaxseeds, garlic, citrus, fruits, soyabean, and ginkgo biloba has been given in this part of the nutraceuticals[7].

Antidiabetic Herbs

Acacia arabica: **(Babhul)**

It is of *Mimosaceae* family and found all over India mainly in the wild habitat. It acts through release of insulin from pancreatic beta cells, which accounts for the hypoglycemic activity[72, 73]. Powdered seeds of *Acacia arabica* when administered orally (2, 3 and 4 g/kg body weight) to normal rabbits induced hypoglycemic effect by initiating release of insulin from pancreatic beta cells[73].

Aegle marmelos**: (Holy Fruit Tree)**

It is of *Rutaceae* family and found in the plains and submountain regions of India. The proposed mechanism of action is that it increases utilization of glucose; either by direct stimulation of glucose uptake or via the mediation of enhanced insulin secretion[74] also decreases the elevated glucose and glycosylated hemoglobin levels[75]. Antihyperglycemic activity of the leaves in glucose induced hyperglycemic rat at an oral dose equivalent to 250 mg/kg[76].

Allium cepa**: (Onion)**

It is of *Liliaceae* family and cultivated as an annual all over the country. It lowers blood glucose level and has potent antioxidant activity, which may account for the hypoglycemic potential[76]. Hypoglycaemic activity of the onion is attributed to the allyl propyldisulphide and allicin. Antihyperglycemic, antioxidant and hypolipidemic activity of a diet containing 3% freeze dried onion powder upon prolonged administration in STZ diabetic rats[77]. Dosage of Juice of bulb 10–20 ml is sufficient for control of diabetes.

Allium sativum**: (Garlic)**

It is of *Liliaceae* family. It is Native to Central Asia and Cultivated all over India. Has strong antioxidant activity and rapid reactivity with thiol containing proteins responsible for the hypoglycemic property[78]. Allicin, has been shown to have significant hypoglycemic activity. Ethanol, petroleum ether and ethyl acetate extract in alloxanized rabbits at a dose of 0.25 mg/kg, orally shows antihyperglycemic activity[79]. 3 g of bulb is sufficient for control of diabetes.

Aloe vera**: (Aloe)**

It is of *Liliaceae* family. It is cultivated throughout India, wild on coasts of Maharashtra, Gujarat and South India. It maintains glucose homeostasis by controlling the carbohydrate metabolizing enzymes[80] and stimulates insulin release from pancreatic beta cells[81]. Hypoglycemic activity of the plant (200 and 300 mg/kg p.o.) has been done on normal fasted rats, oral glucose-loaded rats and streptozotocin-induced diabetic rats[80]. Aloe vera showed antihyperglycaemic activity when one tablespoonful aloe juice was given orally in the morning and at bedtime to diabetic patients for 42 days. Leaf pulp juice of 10–20 ml is used to control diabetes.

Azadirachta indica**: (Neem)**

It is of *Meliaceae* family. It is Native to Burma; found all over India. It inhibits action of epinephrine on glucose metabolism, resulting in increased utilization of peripheral glucose[82, 83] and exhibits hypoglycaemic activity without altering the serum cortisol concentration[84, 85]. Hydro alcoholic plant extract in normal rats and in glucose fed and streptozotocin induced diabetic rats' shows hypoglycemic activity[86, 87]. Leaf juice of 10–20 ml is used to control diabetes.

Caesalpinia bonducella**: (Fever Nut)**

It is of *Caesalpiniaceae* family. It is found in throughout the hotter parts of India, common in West Bengal and South India. It increases the release of insulin from pancreatic cells. Aqueous and 50% ethanolic seed extracts in normal and streptozotocin-diabetic rats' shows hypoglycemic and antihyperglycemic activities[87]. 1–3 g of Seed kernel powder is used to control diabetes.

Coccinia indica**: (Kundru)**

It is of *Cucurbitaceae* family. It is cultivated in Assam, West Bengal, Bihar, Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu; wild in many parts of India. It suppresses glucose synthesis, through depression of the key gluconeogenic enzymes glucose-6-phosphatase and fructose-1, 6-bisphosphatase and enhances glucose oxidation by shunt pathway through activation of its principal enzyme glucose-6-phosphate dehydrogenase[88]. Also have an insulin secretagogue effect[89, 90] and acts like insulin by correcting elevated enzymes in glycolytic pathway and restoring LPL activity in lypolytic pathway with control of hyperglycemia in diabetes. Dried extract (500 mg/kg p.o., for 6 weeks) in 30 diabetic patients give antihyperglycemic activity[91]. 3–6 g powder of Whole plant and 5–10 ml juice is used to treat diabetes.

Eugenia jambolana**: (Jamun)**

It is of Myrtaceae family, native to Bangladesh, India, Nepal, Pakistan and Indonesia. M The activity may be mediated through an insulin release mechanism[92] or due to alteration in hepatic and skeletal muscle glycogen content and hepatic glucokinase, hexokinase, glucose-6-phosphate and phosphofructokinase levels in diabetic mice[93]. It also enhances serum insulin activity[94] and exhibits normoglycemia and better glucose tolerance[95]. In India decoction of kernels of *Eugenia jambolana* is used as household remedy for diabetes. Aqueous, alcoholic extracts and lyophilized powder (200 mg/kg per day) of the plant in hyperglycemic animals shows hypoglycemic effect[94]. I also show blood glucose lowering activity of aqueous seed extract (2.5 and 5.0 g/kg body weight p.o. for 6 weeks) along with an increase in total haemoglobin and antioxidant activity in diabetic rats[96].

Gymnema sylvestre**: (Gurmar)**

It is of Asclepiadaceae family, found in central and peninsular India. This Indian plant has traditionally been used to treat diabetes—and is helpful for both Type I and Type II diabetics. There are some possible mechanisms by which the gymnemic acid exerts its

hypoglycemic effects such as it increases secretion of insulin, it promotes regeneration of islet cells, it increases utilization of glucose and it is shown to increase the activities of enzymes responsible for utilization of glucose by insulin-dependant pathways, an increase in phosphorylase activity, decrease in gluconeogenic enzymes and sorbitol dehydrogenase and it also causes inhibition of glucose absorption from intestine[97, 98]. Oral administration of aqueous extracts of leaves of G. sylvestre (20 mg/day) for 20-/60 days normalized blood sugar levels of STZ diabetic rats through beta cell regeneration[99]. Oral administration of varying doses (50, 100, 200 and 500 mg/kg) of aqueous extract to normal and STZ diabetic rats showed significant dose-dependent hypoglycemic activity[100]. Research has shown that 400 mg a day of Gymnema will help glucose to be reabsorbed into the blood, thereby lowering blood sugar. In liquid form (extract), 25 to 75 ml per week is recommended. Best results of this medicine will come after 6 to 12 months of continuous use[101].

***Linum usitatissimum*: (Flax Seeds)**

Flax seeds are the dried ripe seeds of family *Linaneae.* It is cultivated mainly in Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar and Rajasthan. Flax seeds contain anti-oxidants and have high dietary fiber that can help diabetics by inhibit lipid peroxidation and scavenging of hydroxy radicals. Flaxseed has been recorded as one of the six plant materials as cancer preventive foods. Dietary fibers of flaxseeds contain about 6% mucilage which has nutritional value. Secoisolariciresinol diglycoside (SDG), a plant lignan found in flaxseed, has been found to possess antioxidant properties[102].

***Momordica charantia*: (Bitter Gourd)**

It is of *Cucurbitaceae family*, cultivated all over India for its fruits. It may act by increasing hepatic glycogen[103].The fruits and seeds yielded a polypeptide, p-insulin, which was considered similar to bovine insulin[104]. Vicine is the hypoglycaemic constituent in the seed. There is blood glucose level reducing activity of fruit powder in fasted alloxan-induced diabetic rats after a treatment for 15 days[103]. Ethanolic extracts of *M. charantia* (200 mg/kg) showed an antihyperglycemic and also hypoglycemic effect in normal and STZ diabetic rats[105]. 10–15 ml of Fresh fruit Juice recommended for diabetics.

***Ocimum sanctum*: (Tulsi)**

It is of *Labiatae* family, commonly found in throughout India. The aqueous extract of leaves of *Ocimum sanctum* showed the significant reduction in blood sugar level in both normal and alloxan induced diabetic rats. It may acts by cortisol inhibiting potency[106]. Leaf powder, given along with food for 1 month, in normal and diabetic rats reduces fasting blood glucose level[107]. 50–10 ml plant infusion is used as dosage of tulsi.

***Phyllanthus amarus*: (Bhuiawala)**

It is of *Euphorbiaceae* family, found throughout the hotter parts of India, particularly on cultivated land, up to 1,000 m. The flavonoids, isolated from the ethanolic extract of the plant, exhibit hypoglycaemic activity in alloxan-treated albino rats. Methanolic extract of P. amarus was found to have potential anti-oxidant activity as it could inhibit lipid peroxidation, and scavenge hydroxyl and superoxide radicals in vitro[108]. Oral administration of the whole plant with a dose of 5 g/day for 10 days produced reduction in blood glucose in diabetic rats and in non-diabetic subjects[109]. 3-6g of powder of root, stem, and leaf is used as dose of *Phyllanthus amarus.*

Plantago ovata: **(Isabgul Seed Husk)**

It is of *Plantaginaceae* family, native of Pakistan. This plant fiber is found in common bulk laxatives and fiber supplements. Psyllium has also been used historically to treat diabetes. The effect of psyllium husk was studied in 34 men with type 2 diabetes and hypercholesterolemia given either placebo or 5.1 g psyllium twice daily foe eight weeks. Total cholesterol was lowered by 8.9% and LDL by1%. In addition, the postprandial rise of glucose was significantly reduced[110]. Studies show that people with type 2 diabetes who take 10 grams of psyllium every day can improve their blood sugar and lower blood cholesterol.

***Pterocarpus marsupium*: (Vijaysar)**

It is of *Papilionaceae* family; found throughout the tropical zones of India in the hilly regions. Different parts of the plant like bark, latex, etc. were investigated and reported to have hypoglycemic activity[111-115]. Various active components like (−)-epicatechin, marsupsin, pterosupin and pterostilbene, isolated from the bark and heartwood of the plant, were also found to possess blood sugar lowering activity[116-120]. Stem bark -32-50 g for decoction is used to control diabetes.

***Trigonella foenum-graecum*: (Fenugreek)**

It is of *Papilionaceae* family, widely cultivated in many parts of India. It increased glucose-induced insulin release through a direct effect on the isolated islets of Langerhans. Various extracts of different parts of this plant; fibres, proteins and saponins isolated from the seeds were investigated and found to possess significant hypoglycemic activity[125-128]. Trigonella seeds and the major alkaloid component, Trigonelline, exerted a mild hypoglycemic effect.3-5 g of seed powder is used to treat diabetes[129].

***Tinospora cordifolia*: (Guduchi)**

It is of *Menispermaceae* family, found in tropical India and the Andamans. Various extracts of the leaves of this plant were investigated for their blood sugar lowering activity in normal and alloxanized rabbits in graded doses and the findings have proved that the plant has potent hypoglycemic activity[130-135]. It is reported that the daily administration of either alcoholic or aqueous extract of *T. cordifolia* decreases the blood glucose level and increases glucose tolerance in rodents.

CONCLUSION

Nutraceuticals are food supplements and have nutritional value. All the nutrients discussed in this review have exhibited significant clinical & pharmacological activity. The potency of herbal drugs is significant & they have negligible side effects than the synthetic antidiabetic drugs. There is increasing demand by patients to use the natural products with antidiabetic activity. The efficacy of hypoglycemic herbs is achieved by increasing insulin secretion, enhancing glucose uptake by adipose and muscle tissues, inhibiting glucose absorption from intestine and inhibiting glucose production from hepatocytes. A place for nutraceuticals in clinical practice is emerging, but important pharmaceutical and clinical issues need to be addressed by further research.

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