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FUNCTIONAL FOODS IN MANAGING DIABETES

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ABSTRACT

Diabetes, emerging as a pandemic, is a major health problem predisposing to micro and macrovascular complications. Traditional Indian diets are functional because they are enriched with antioxidants, dietary fiber and probiotics.The present paper reviews on the scientific information of common Indian foods with anti-diabetic activity, which is used as functional foods and ingredients in the traditional medical system. It is indeed the time to give more attention to these functional food ingredients as target medicinal foods in order to prevent or slow down the development of diabetes.

KEYWORDS: **Anti-diabetic, functional food, diabetes**

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INTRODUCTION

Diabetes, emerging as a pandemic, is a major health problem predisposing to micro and macrovascular complications. It is a chronic, progressive illness which requires continuing medical care and patient self management to prevent acute complications and reduce the risk of long-term complications which includes cardiovascular disease, retinopathy, neuropathy and nephropathy. Although a number of hypoglycemic agents, exist treatment of diabetes and are effective in controlling hyperglycemia, they have harmful side-effects and fail to significantly alter the course of diabetic complications. Evidence suggests that inflammation is the underlying cause of the long term complications resulting from uncontrolled diabetes [1]. A diet high in antioxidant rich foods can help to overcome inflammation in the body. The nutrients in food are our source of health. Foods contain various proportions of the macronutrients and well-known micronutrients, vitamins, minerals, fiber, and electrolytes; as well as several hundred naturally occurring substances in plant foods called phytochemicals. Antioxidant supplements do not work as well as naturally occurring antioxidants in whole unprocessed foods such as fruits, vegetables, beans, legumes, nuts, seeds, whole grains, herbs and spices [2]. "Functional Foods" are foods or dietary components that may provide a health benefit beyond basic nutrition. It must be stated here that foods are natural sources of nutrients and a diversified diet can be a rich source of all the necessary bioactive substances[3]. India is a land of herbal products and plant-based vegetarian diets. Wider acceptance of the medicinal value of foods and their use will cut down the health care costs as well. The health benefits of functional foods should, in fact, extend beyond their macro- and micronutrient composition. This paper explores the demonstrated clinical or/and experimental anti-diabetic functional food ingredients that prevents or slows down the development of diabetes. Eating is a major aspect of daily living, one that may influence the development of diabetes and its subsequent progression[4] .It is important to pay close attention to functional food ingredients to prevent and cure diabetes and its complications.

Functional food ingredients used in diabetes

Allii Sativi Bulbus

Garlic has been found to be effective in lowering serum glucose levels in diabetic mice, rats and rabbits[5]. In addition, Liu *et al* 2005[6] reported that both garlic oil and diallyl trisulfide improved glycemic control in STZ-induced diabetic rats. The antioxidant effect of S-allyl cysteine sulfoxide, an isolated product from garlic, may contribute to its beneficial effect in diabetes[7].Garlic may act as an antidiabetic agent by increasing either the pancreatic secretion of insulin from the β cells or release of bound insulin[8].

Allii Cepa Bulbus

In Asian and African countries the bulbs of *Allium cepa* L. or common onion has been used for the treatment of diabetes[9]. Onion feeding improved the metabolic status in diabetic conditions, probably because of hypoglycemic and hypo-cholesterolemic effect[10] mediated diabetic nephropathy by lowering blood cholesterol levels and decreasing lipid peroxidation[11]. Its active principles showed that allyl propyl disulfide and S-methyl cysteine sulfoxide have an anti-diabetic and anti-hyperlipidemic effect, the latter being analogous to glibenclamide and insulin [12, 13].

Trigonella foenum-graecum (L.)

Trigonella foenum-graecum L. (Fenugreek) seeds are used as condiment in India. Various reports have demonstrated that fenugreek seeds extracts, powder and gum of seeds and leaves can lower blood glucose and cholesterol levels in human and experimental diabetic animals[14, 15]. In addition to insulinotropic

activity, fenugreek contains steroid saponin compounds including diasgenin, alkaloids and trigonelline, which have been shown to inhibit *in vitro* sodium-dependent intestinal glucose uptake and have anti-inflammatory properties. Fenugreek has also been associated with alterations in enzymes associated with carbohydrate metabolism. The gel-forming property of fenugreek fibre reduces gastric emptying, glucose absorption and insulin response. A mild improvement in clinical symptoms such as polydypsia and polyuria was observed in a majority of the patients, with a reduction in anti-diabetic drug doses. Incorporating just around 25 g fenugreek seeds in the daily diet can serve as an effective supportive therapy in the management of diabetes [15].

Curcuma longa (L.)

Curcuma longa L., commonly known as turmeric is an Asian spice labelled as a "poor man's spice" or as "salt of the Orient" is not only known for its colour, aroma and taste, but is being researched all over the world for its preventive and therapeutic benefits.Its rhizomes have been reported to possess anti-diabetic properties in experimental animal models.[16] Curcumin lowers blood glucose, glycosylated hemoglobin, free fatty acids, total cholesterol, triglyceride and lipid peroxidation levels and increases plasma insulin and hepatic glycokinase activity levels in diabetes. Researchers reported that active ingredient curcumin is the response for anti-diabetic action [17].

Cinnamomum zeylanicum

Cinnamomum zeylanicum (Cinnamon) extracts containing polyphenol type-A polymers, have demonstrated insulin-mimetic properties. *In vitro* and *in vivo* animal studies have reported strong insulin-like or insulin potentiating effects after cinnamon administration [18]. Cinnamon maximises the phosphorylation of the insulin receptor which is associated with increased insulin sensitivity, which is associated with improved glucose and lipid levels. Extracts of cinnamon activates glycogen synthase and insulin receptor kinase, increases glucose uptake, and inhibits glycogen synthase kinase-3 and inhibits dephosphorylation of the insulin receptor, leading to maximal phosphorylation of the insulin receptor [19].

Psidium guajava (L.)

Psidium guajava L. Guava. fruits are rich in dietary fiber associated with natural antioxidant compounds[20]. The fruit contains a high percentage of vitamin C, carotene, vitamin B1, B2, B6, and pectin[21].The ripe fruit peel has been found to possess hyperglycemic activity in diabetic patients[22].The anti diabetic activity is based on the higher concentration of Mg in the raw fruit peel of *P. guajava* [23].The leaves of *P. guajava* inhibit the increase of plasma sugar level in alloxan-induced diabetic rats, during glucose tolerance test[24]. Flavonoid glycosides such as strictinin, isostrictinin, and pedunculagin are the effective constituents, which have been used in clinical treatment of diabetes to improve the sensitivity of insulin.

Punica granatum (L.)

Punica granatum (Pomegranate) is used to treat diabetes mellitus in some parts of China. Male abortive flowers of *Punica granatum* are also used for the treatment of diabetes mellitus in India. Oral administration of the aqueous ethanolic extract of Punica granatum flowers led to a significant blood glucose lowering effect in normal, glucose fed and alloxan-induced diabetic rats[25]. The extract of *Punica granatum* seeds was also reported to have antidiabetic activity; ursolic acid may be the active constituent [26].

Artocarpus heterophyllus (Lam.)

Artocarpus heterophyllus Lam. (Jackfruit) is an integral part of common Indian diet and is freely available in Indian and adjoining continents. Its medicinal properties are also mentioned in Indian medicine. Hot water extract of mature jack leaves is recommended by Ayurvedic and traditional medical practitioners as a treatment for diabetes mellitus[27].The leaves and stem show the presence of sapogenins, cycloartenone,

cycloartenol, β-sitosterol, and tannins [28].Its leaves contain hypoglycemic and hypolipidemic principles that have the potential to be developed further for the treatment of diabetes.

***Mangifera indica* (L.)**

Most parts of the *Mangifera indica* tree [Fruit, seeds, pulp, stem bark, roots, and leaves] have medicinal properties[29]. The leaves of *Mangifera indica* were proven for antidiabetic properties using normoglycemic, glucose-induced hyperglycemia and streptozotocin (STZ)-induced diabetic mice[30]. The natural C-glucoside xanthone mangiferin has been reported in various parts of M. indica, which gives the medicinal property[31].

***Aegle marmelos* (L.) Corr.**

Aegle marmelos is a popular medicinal plant in the Ayurvedic and Siddha systems of medicine and folk medicines used to treat a wide variety of ailments[32, 33.The] leaves, fruits, and stems contain skimianinc, sterol and aegelin, lupeol, marmin. In pharmacological trials, both the fruit and root showed hypoglycemic activities[34, 35]. *A. marmelos* would act like insulin in the restoration of blood sugar and body weight to normal levels in rat and was therefore recommended as a potential hypoglycemic agent [35].

***Momordica charantia* (L.)**

Momordica charantia L. a nutritious vegetable, is used in traditional medical practices to treat diabetes. Experimental studies with animals and humans suggested that the vegetable has a possible role in glycemic control. Oral administration of the extract, fruit juice or seed powder of *Momordica charantia* caused a significant reduction in fasting blood glucose and improved glucose tolerance in normal and diabetic animals and in humans[36,37]. A wide range of compounds have been isolated from *Momordica charantia*, of which, a polypeptide named as “plant insulin”, the sterol glucoside mixture charantin and the pyrimidine nucleoside vicine have been identified as the orally anti-diabetic principles for humans and animals[38].

***Murraya koenigii* (L.)**

Murraya koenigii L. is popular in medical usage. Eating, fully-grown curry leaves is beneficial in controlling diabetes and in weight loss. The leaves of *Murraya koenigii* are also used as an herb in Indian medicine. Their properties include much value as an anti-diabetic and antioxidant[39, 40]. The aqueous extract of *Murraya koenigii* leaves has been taken to evaluate the hypoglycemic activity in normal and alloxan-induced diabetic rabbits. The findings from this study suggested that the aqueous extract of these leaves may be prescribed as adjunct to dietary therapy and drug treatment for controlling diabetes mellitus[41]. An intense search of the literature has revealed that the stems, leaves, roots and seeds are potential sources of carbazole alkaloids, which provide the medicinal effect. Some identified alkaloids are Koenimbine, Koenine, Koenigine, Koenidine, Mahanimbine and Mahanine [41].

Coccinia indica

Coccinia indica (ivy gourd), has been widely used in the traditional treatment of diabetes mellitus in India. The ingredients present in the extract of *Coccinia indica* such as triterpenes, probably act like insulin, correcting the enzymes of the glycolytic pathway and enhancing lipolysis [42]. As a common vegetable in Indian cuisine, it can be an excellent adjunct in diets for persons with diabetes.

Syzygium aromaticum

Kuroda et al 2012[43] have demonstrated that the cloves (Syzygium aromaticum flower buds) significantly suppressed an increase in blood glucose level in type 2 diabetic KK-A(y) mice. The bioactive components dehydrodieugenol and dehydrodieugenol B had potent PPAR-γ ligand-binding activities, whereas oleanolic acid had moderate activity. Clove has the potential as a functional food ingredient for the prevention of type 2 diabetes by its hypoglycemic effects via PPAR-γ activation.

Avena sativa

Avena sativa (Oats) are rich in soluble fiber. In addition to lowering cholesterol levels, soluble fiber-rich diets may reduce the risk of T2DM [44]. Dietary supplementation of 6% oat β-glucan concentrate decreased net glucose flux, increased net short-chain fatty acids flux, and decreased peak apparent insulin production, changes that were associated with glucose dependent insulinotropic polypeptide and glucagon-like peptide-1 mediation [45]. Oat b-glucan could effectively decrease blood glucose in diabetic mice [46]. Oat intake could decrease blood glucose and postprandial insulin significantly in aged patients with T2DM [47]. Oat b-glucan could restore the function of b-cells, and its mechanism was associated with inhibition of p53 gene and enhanced expression of bcl-2 gene [48].

Nuts

In general, nuts contain 70–80% fat and most FAs in nuts are unsaturated—being either polyunsaturated and monounsaturated, which may be beneficial for glucose and insulin homeostasis. Several studies have shown that a high amount of monounsaturated and polyunsaturated fat vs. saturated fat improves glucose homeostasis [49, 50]. In addition, other components of nuts such as fiber and magnesium may decrease insulin demand and resistance [51]. Nuts are a rich source of vitamins, minerals, antioxidants and plant protein, which could be also beneficial. In this respect, nuts contain many bioactive components, which may have potential advantages for glycemic control. Further, Jenkins et al. suggested that almonds are likely to lower this risk by decreasing the glycemic response and by providing antioxidants [52], since inflammation and oxidation may be causative in the initial pathogenesis of insulin resistance, loss of beta-cell response to glucose, and development of both micro- and macro-vascular complications in type 2 diabetes.

CONCLUSION

The development of T2DM is strongly influenced by eating practices. Once diagnosed, a critical part of treatment is the lifetime modification of food and eating habits. Functional foods might have a high impact for prevention or treatment of diabetes. Although these foods are known by different names-nutraceuticals, dietary supplements, or functional foods, they hold significant promise in the promotion of human health and disease prevention. However, health professionals, nutritionists and government regulatory bodies should work together to plan appropriate regulations to provide the ultimate health and therapeutic benefits to mankind. In conclusion, functional foods and natural health products are added to the diet to help control blood glucose; however, a large amount of research still needs to be done before benefits can be confirmed and the functional foods can be recommended routinely for glycemic control.

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