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Green Tea and Diabetes Mellitus - A Comprehensive View

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Abstract: ***Green tea (Camellia sinensis) is one of the most popular beverages in the world where about 3 Billon kg of tea are produced and consumed yearly. The chemical composition of green tea is very much complex and it contains higher amount of polyphenols (epicatechin, epicatechin gallate, epigallocatechin and epigallocatechin gallate) as compared to black tea. The presence of this high amount of polyphenols in green tea makes it very important in the prevention of different diseases. So far green tea was shown to have many impacts in carbohydrate metabolism and it is considered as an alternative medicine for diabetes mellitus. Polyphenols in green tea reduce carbohydrate digestion and absorption in the intestine by inhibiting carbohydrate digesting enzymes and inhibiting glucose transporters across the intestine. They are also shown to increase secretion of insulin by pancreatic β cells and protect cytokine induced inflammatory damage of these cells. Increasing insulin activity and maintaining glucose homeostasis are other mechanisms by which green tea is involved in carbohydrate metabolism.***

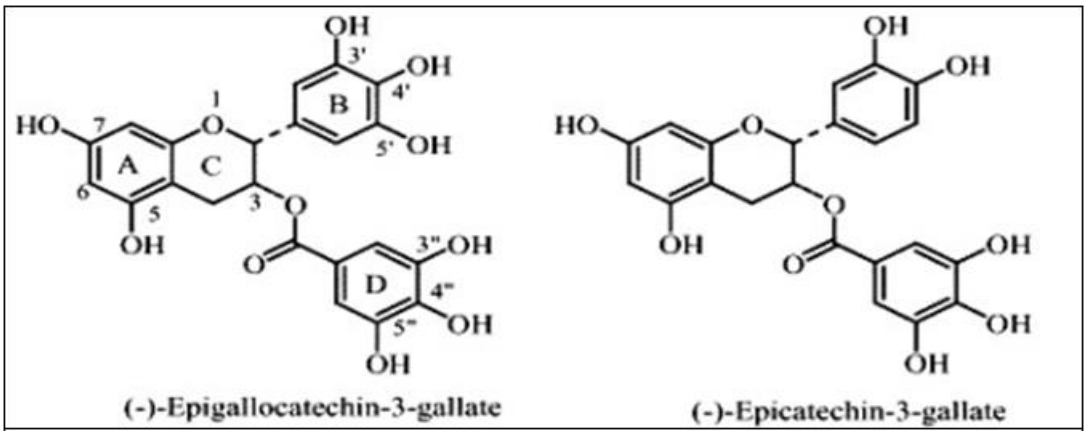
Keywords: Catechins, Camellia sinensis, green tea, Diabetes mellitus, Polyphenols

1. Introduction

Diabetes Mellitus is a metabolic disorder characterized by the presence of chronic hyperglycemia accompanied by greater or lesser impairment in the metabolism of carbohydrates, lipids and proteins. DM is probably one of the oldest diseases known to man. The origin and etiology of DM can vary greatly but always include defects in either insulin secretion or response or in both at some point in the course of the disease. Mostly patients with DM have either type 1 diabetes (which is immune – mediated or idiopathic) or type 2 diabetes (formerly known as non-insulin dependent DM). Type 2 DM is the most common form characterized by hyperglycemia, insulin resistance and relative insulin deficiency (Maitra A & Abbas K, 2005). Type 2 DM results from interaction between genetic, environmental and behavioral risk factors (Wild S, et al, 2004). Diabetes also can be related to the gestational hormonal environment, genetic defects, other infections and certain drugs.

Green tea is one of the most popular beverages in the world where about three billion kg of tea are produced and consumed yearly. It is obtained from the tea plant Camellia sinensis which belongs to the family Theaceae and is cultivated in at least 30 countries around the world, commonly consumed in Japan, China, India and other parts of Asian countries, some parts of North Africa, the United States and Europe. Green tea is a non-fermented tea that contain a large amount of non-oxidized polyphenols, named catechins (Alexopoulos N, et al, 2010). The minimal processing results in the preservation of highest proportion of polyphenols than other types of tea leaving the polyphenol content intact. (Zaveri NT, 2006).

Green tea contains polyphenols which may account for up to 30% of the dry weight and there are four major polyphenolic catechins: epicatechin (EC), epicatechin gallate (ECG), epigallocatechin (EGC) and epigallocatechin gallate (EGCG), of which EGCG is the most abundant and pharmacologically active of the catechins (Josic J , et al, 2010).



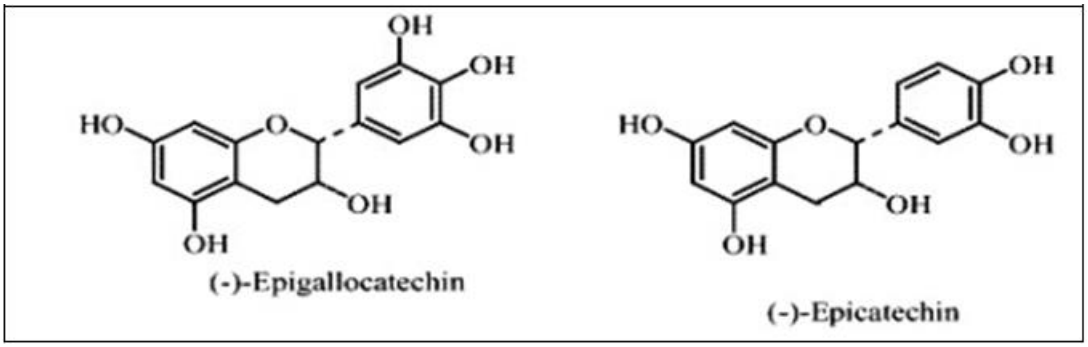


Figure 1: Polyphenols in green tea

The presence of polyphenols in green tea has been found to effective in preventing different diseases. Both animal studies and studies on humans have also indicated that green tea has different health benefits in preventing cancer, alleviating cardiovascular diseases, preventing infections caused by microorganisms, minimizing the development of non-alcoholic fatty liver and maintaining glucose homeostasis (Alipoor B & rad AH, 2012). Hence the aim of this review paper is to summarize the results different researches on the health benefits and impact of green tea on DM.

The Health Benefits of Green Tea

The history of medical effects of green tea starts on the early eighth century with the Buddhist monks who recognized green tea for its medicinal properties: therefore, nowadays there is also an increasing interest in the beneficial effects of green tea on disease prevention (Neva ALA, et al, 2010). Green tea has been used as a stimulant and diuretic, to regulate body temperature and blood sugar, reduces fat, to prevent tooth decay, to treat conjunctivitis and corneal opacities in different countries including China, India, Mexico and Kenya since ancient times (Ogale N, 2009). The most widely known health benefits of green tea related to the polyphenols as the principal active ingredients in protection against oxidative damage and in antibacterial, antiviral, anti-carcinogenic and anti-mutagenic activities (Anderson RA, et al, 2002).

The Impact of Green Tea on Diabetes Mellitus

Diabetes mellitus is now considered to be a worldwide epidemic and without primary prevention, the epidemic will continue increasing. The pathology of diabetes mellitus is caused by reactive oxygen species that activate the non-enzymatic glycation of proteins, the aldose reductase pathway and oxidative stress. The complications of diabetes mellitus like retinopathy, nephropathy and neuropathy, are results of such pathological mechanisms.

Table 1: List of Countries with the highest number of estimated cases of Diabetes for 2000 & 2030 (Adapted from Wild S, et al, 2004)

2000			2030		
Ranking	Country	People with DM (millions)	Ranking	Country	People with DM (millions)
1	India	31.7	1	India	79.4
2	China	20.8	2	China	42.3
3	US	17.7	3	US	30.3
4	Indonesia	8.4	4	Indonesia	21.3
5	Japan	6.8	5	Pakistan	13.9
6	Pakistan	5.2	6	Brazil	11.3
7	Brazil	4.6	7	Bangladesh	11.1
8	Italy	4.3	8	Japan	8.9
9	Bangladesh	3.2	9	Philippines	6.7

The World Health Organization Expert Committee on diabetes recommended that traditional medicinal herbs considered being less toxic and relatively free from side effects can be followed to prevent the complications or prevent their occurrence by strict control of blood glucose level. Green tea compounds may influence glucose metabolism by several mechanisms, such as inhibition of carbohydrate digestion and glucose absorption in the intestine, stimulation of insulin secretion from pancreatic B cells, modulation of glucose release from liver, activation of insulin receptors and glucose uptake in the insulin-sensitive tissues, and modulation of hepatic glucose output (Hanhineva K et al. 2010).

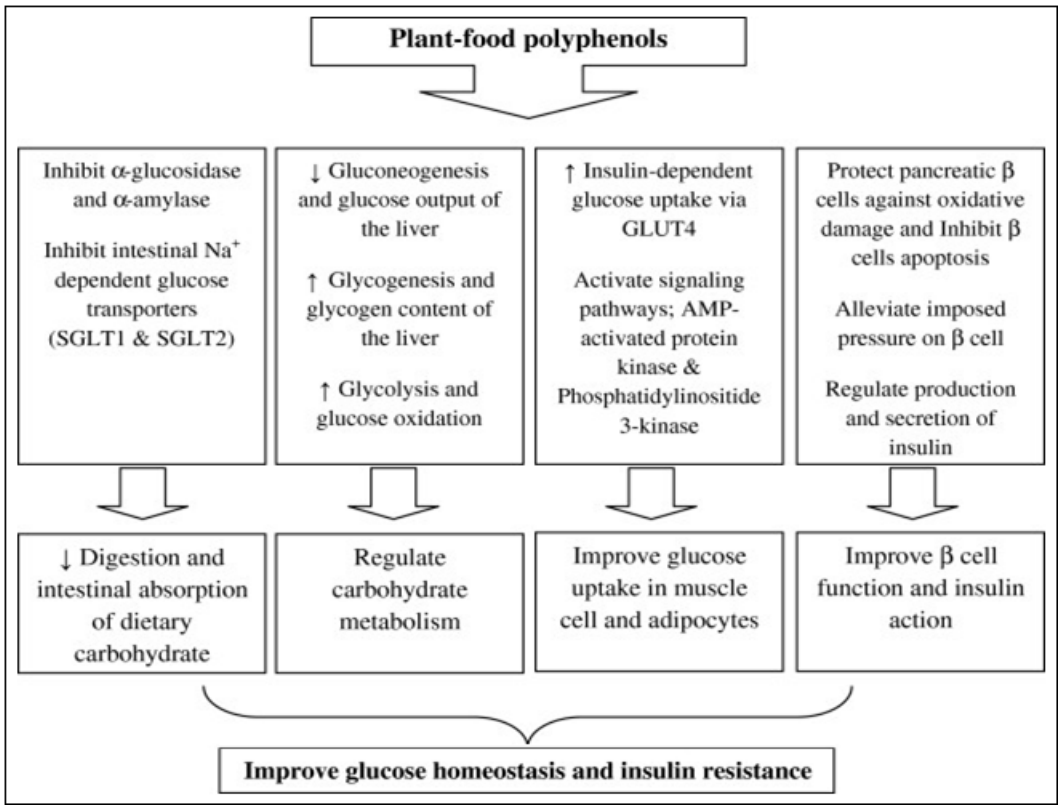


Figure 2: Impact of polypenols on glucose haemostasis and insulin resistance

Effect of Green Tea on Carbohydrate Digestion and Glucose Absorption in the Intestine

Green tea catechins may reduce the amount of glucose that passes through the intestine and into the bloodstream which will benefit diabetics by preventing blood-sugar spikes when tea is taken with meals (Zheng XX et al, 2013). Polyphenols act through interference with the digestion of complex sugars and absorption of glucose by inhibition of carbohydrate digestive enzymes may be of use to patients with T2DM as well as the growing pre-diabetic population around the world. The inhibitory effects of green tea polyphenols, against carbohydrate hydrolyzing enzymes contribute to lowering of the postprandial hyperglycemia in diabetic management as observed in vivo and in vitro. Green tea polyphenolic compounds inhibit the activities of digestive enzymes because of their ability to bind with proteins (Hsieh PC et al, 2010). The other effect of green tea on carbohydrate metabolism is through its effect on carbohydrate absorption. Orally administered green tea extract, which contains many monomeric flavonoids including EGCG and ECG, may inhibit glucose absorption from the lumen of the intestine (Park JH et al, 2009). Intestinal absorption of glucose is mediated by active transport via the sodium dependent glucose transporter (SGLT1) and by facilitated sodium –independent transport via the glucose transporter (GLUT2). EGCG was found to inhibit intestinal glucose uptake by the SGLT1 and decrease glucose entry into the circulation.

Effect of Green Tea on Pancreatic beta cell Function

During hyperglycemia pancreatic beta cells respond to the increased demand of insulin by various mechanisms including increased insulin secretion, hypertrophy, proliferation of existing beta cells and formation of new ones from the progenitor cells .The catechins in green tea increases secretion of insulin by enhancing adenylate cyclase activity, inhibition of phospho diesterases activity, changes in Calcium metabolism and protection of pancreatic beta cells from inflammatory cytokine inducing disorders by inhibiting activation of nuclear factor ḱB (Nagao T et al, 2008). The prevention of cytokine induced pancreatic beta cell damage was possible because EGCG was able to neutralize nitric oxide produced as a result of the cytokines (Han MK, 2003).

Effect of Green Tea on Enhancing Insulin Activity

Elevated glucose concentration in blood promotes secretion of insulin from the beta cells of the Islets of Langerhans in the pancreas, and insulin mediates the uptake of glucose in peripheral tissues including muscle, adipose tissue and kidney, promotes storage of glucose in liver as glycogen, and inhibits lipolysis in adipose tissue (Hanhineva K et al, 2010). Another study by Yan, et al, also indicated that green tea catechins are able to improve insulin resistance in adipose tissues by improving oxidative stress ad this was demonstrated in their study by decreased serum reactive oxygen species and recovery of impaired insulin stimulated glucose uptake in mice that took EGCG (Yan J et al, 2012).

Effect of Green Tea on Liver to maintain Glucose Homeostasis

Liver plays a major role in the regulation of blood glucose level by storing glucose as glycogen when glucose is excess and by producing glucose from glycogen or other metabolites such as pyruvate, lactate, glycerol and amino acids when blood glucose level is low. The effect of green tea catechins on the liver glucose metabolism is demonstrated by different researchers. Collin and Colleagues in 2007 demonstrated that EGCG was able to inhibit gluconeogenesis in hepatocytes.

Adverse Effects of Green Tea

The health effects of green tea is dose dependent. Higher doses cause some unknown adverse effects and the effects of green tea catechins may not be similar in all individuals. The side effects of green tea overconsumption may be related to its caffeine content, presence of aluminum and its effect on iron absorption (Chacko SM et al, 2010). In general, the average cup of green tea contains from 10-50mg of caffeine, and over consumption may cause irritability, insomnia, nervousness and tachycardia (Review 2012).

2. Conclusion

Different studies reviewed in this manuscript showed that green tea has effects in carbohydrate metabolism so that it can be a good candidate in managing diabetes mellitus. Inhibition of carbohydrate digestion and glucose absorption, stimulation of pancreatic cells to produce insulin, increasing insulin activity and actions on the liver to maintain glucose homeostasis are the mechanisms of green tea polyphenols to prevent DM. Together with its health benefits dose dependent adverse effects of green tea were observed in the gastrointestinal tract, liver and nervous system. But these side effects are absent or minimum if present. Such advantages of green tea is increasing interests to use it a an alternative medicine to manage and prevent DM. Hence, further studies on determination of effective therapeutics dose, mechanism of action and any side effects must be conducted.

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