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POTENTIAL ROLE OF CINNAMON IN MANAGEMENT OF TYPE 2 DIABETES MELLITUS –A REVIEW

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ABSTRACT

Diabetes is a chronic disorder of glucose metabolism resulting from dysfunction of pancreatic beta cells and insulin resistance. It is still a serious global health problem leading to a number of associated co morbidities.India has a primary position in the global diabetes epidemiology map as it is the home of nearly 33 million diabetic subjects which is the highest number in the world. A number of spices and herbs have a long history of traditional use in treating elevated blood sugar levels. One such compound that has recently been the subject of intense research is Cinnamon, a compound granted GRAS (Generally Recognized as Safe) status by the United States Food and Drug Administration. Cinnamon has been shown to possess when ingested and have many pharmacological properties such as antihyperglycemic antioxidants and antibacterial effects. The Methyl Hydroxy Chalcone Polymer (MHCP) found in cinnamon is an effective mimetic of insulin. MHCP may be useful in the treatment of insulin resistance and in the study of the path ways leading to glucose utilization in cells. Cinnamon extracts showed to improve insulin receptor function by activating the enzyme that causes insulin to bind to cells (insulin-receptor-kinase) and inhibiting the enzyme that blocks this process (insulin-receptor-phosphatase), leading to maximal phosphorylation of the insulin receptor, which is associated with increased insulin sensitivity Morever,the benefits of cinnamon are reversed upon discontinuing its use. Hence, small amounts of cinnamon along with medication should form a part of of the daily diet so that the blood glucose profile of NIDDM patients can be maintained in a normal range.

Key words: Glucose metabolism, insulin resistance, antihyperglycemic, glucose utilization, insulin sensitivity.

INTRODUCTION

The word “diabetes” is derived from the Greek word “diabainein ” which means “to flow through”. Diabetes mellitus (DM) is a complex and multifarious group of disorders that is a major source of ill health in the world (King, et al, 1998). DM is defined as a state in which homeostasis of carbohydrate and lipid metabolism is improperly regulated by insulin. DM exists in two major forms: Type 1 or Insulin Dependent Diabetes Mellitus (IDDM) and Type 2 or Non-Insulin Dependent Diabetes Mellitus (NIDDM).Type 2 DM is the most common form of diabetes, accounting for around 90 to 95% of all diabetic patients. According to recent estimates, the human population worldwide appears to be in the midst of an epidemic of diabetes. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 (Wild et al, 2004). Type 2 DM is a metabolic disorder characterized by chronic hyperglycemia (elevated levels of plasma glucose), caused by inherited and/or acquired deficiency in the production of insulin by the pancreas, or by the ineffectiveness of insulin produced. The condition causes deregulation of carbohydrate, protein, fat metabolism. Besides hyperglycemia, several other factors including dislipidemia or hyperlipidemia are involved in the development of micro- and macro-vascular complications of diabetes, which are major causes of morbidity and death (Barcelo & Rajpathak, 2001).

PREVALENCE OF DIABETES

Escalation in prevalence of diabetes appears to be more pronounced in developing countries. The World Health Organization has estimated that in 1995, 19.4 million individuals were affected by diabetes in India. These numbers are expected to increase to 57.2 million by the year 2025. The revised figures are 80.9 million by the year 2030. Studies on native Indian population have confirmed that during last 30 years, the patients with diabetes have risen markedly. The disease is affecting at an alarming rate to both rural and urban populations in India (Ramchandran, et al, 2001; Mohan, et al, 2006). The recent increase is attributed, to some extent, to industrialization, urbanization and their associated life style changes, physical inactivity, obesity and possibly a genetic predisposition (Wild et al, 2004).

TREATMENT OF DIABETES

DM is a disorder that cannot be cured, but can only be managed. Pharmaceutical companies have developed many drugs (e.g. thiazolidinediones) to combat type 2 DM. In spite of tremendous progress in the management of diabetes using synthetic drugs, potential new inexpensive treatments should be used to reduce global morbidity and mortality, as most of the people with type 2 diabetes live in areas of the world, where existing treatments are unavailable or are too expensive. In the treatment of non-pharmacologic measures diet, exercise and weight loss remain a critical component of therapy. It is well documented that insulin sensitivity can be modulated by various dietary compounds and exercise regimes (Sangal, 2006). Dietary management includes, use of traditional medicines that are mainly derived from plants. The WHO (1980) has recommended that this practice should be encouraged, especially in developing countries .The ethnobotanical information reports that 800 plants possess anti-diabetic potential. A number of plants have been reported for hypoglycemic activity (Jung, et al, 2006). But very few traditional antidiabetic plants have received proper scientific validation. Moreover, a scientific proof of the antidiabetic activity of medicinal plants and phytopharmaceuticals with fewer side effects is still lacking.

The current pharmacological therapy of Type II diabetes reduces the risk of diabetic complication, but is not able to achieve a long lasting normalization of the metabolic disorder. Thus diabetic patients in increasing number are taking dietary supplements and herbs from which they expect additional health benefits (Rustenbeck, 2007).

Chromium, gymnema, appears to improve glycemic control. Fiber, green tea and fenugreek have other benefits but there is little evidence that they substantially improve glycemic control (Nahas and Moher, 2009). The antioxidant properties of herbs and spices are of particular interest in view of the impact of oxidative modification of LDL-C in the development of atherosclerosis.

SPICES AND DIABETES MELLITUS

Spices are the common dietary adjuncts that contribute to the taste and flavor of foods. Spices are pungent or aromatic substances obtained from dried parts of plants usually seeds, fruits, leaves, roots, bark and other plant parts originating in the tropics. Plant seeds, fruits, leaves and bark contain polyphenols and are thus used as additives to flavor, color or preserve food. But spices can fulfil more than just this function in the foods to which they are added. They are sources of many bioactive compounds that can influence digestion and metabolism processes. Research displays several beneficial physiological effects of spices, including their insulin-potentiating activity in normal as well as experimentally induced diabetic animal models, and also in humans (Krishanswamy, 2008). One spice that is emerging as a potential therapeutic agent for the management of diabetes is cinnamon.

CINNAMON & ITS PROTECTIVE ROLE IN DISEASES

Cinnamon is amongst the world's oldest and most frequently consumed spices, and is used as an herbal remedy. The medicinal use of this plant has been documented in Ayurveda (the Indian system of medicine, for over 6000 years. The genus *Cinnamomum* consists of 250 species of aromatic evergreen trees and shrubs, primarily located in Asia and Australia. The term Cinnamomum is derived from Greek *kinnamomon*, meaning "sweet wood ". Cinnamon is classified in the botanical division: Magnoliophyta, class: Magnoliopsida, order: Magnoliales and family: Lauraceae. The cinnamon of commerce is the dried inner stem-bark of a small evergreen tree 10-15 meters tall. It is native to tropical southern India and Srilanka. There are two types of cinnamon, common cinnamon (vernacular name: dalchini) or true cinnamon (*Cinnamomum zeylanicum*, *C. verum*) and cassia (*Cinnamomum aromaticum*) (Pruthi, 1976).

Khan, et al., (1990) reported that extracts of some spices have insulin like or spices like bark of cinnamon is used as a culinary herb in Indian homes and in oriental countries. Cinnamon is an evergreen tree which has been traditionally harvested in the Asian countries. According to Kannappan et.al , 2006 , it is one of the oldest herbal medicines that have been mentioned in Chinese texts as early as 4000 years ago.. The bark of cinnamon possess significant antiallergic, antiulcrogenic, antipyretic and antioxidant properties .

The medicinal and aromatic properties of cinnamon are used in the traditional medicines of India and China. Cinnamon bark and cinnamon oil have also been used as food additives, condiments and flavoring agents due to their carminative, antioxidant and preservative action. In Ayurveda and Sidha medical system cinnamon bark, twig leaves and oils are used as ingredient of many multidrug preparation. Ayurveda text describes cinnamon as *katu-mathiram* (pungent sweet) *tiktarasm* (appetizer and produces dryness in mouth) *Ushna-veeryam* (increases body temperature, improves blood circulation, stimulate appetite and digestion) *ruksham* (produces dryness). These properties make cinnamon useful for the treatment of the *vasthi* (bowel) *arsad* (piles) and *krimi* (helmenthic infection). Since cinnamon bark contains many chemical constituents and oil, it is logical to assume that more than one might be the active principle and hence different modes of pharmacology are exhibited by cinnamon (Vijayan and Thampuan, 2003).

AS AN ANTIOXIDANT

The USDA (2003) (United States department of Agriculture) identified phytochemicals in cinnamon, called chalcone polymers, which increase glucose metabolism in the cells by 20 times or more and are powerful antioxidants. Cinnamon also contains anthocyanins which improve capillary function. The USDA tested 49 different herbs, spices and medicinal plants for their effect on glucose metabolism. The results were published in Journal of the American college of Nutrition. The study shows active ingredient in cinnamon is MHCP (Methyl Hydroxy Chalcone Polymer), mimics insulin function and increases cell glucose uptake.The antioxidant effect of cinnamon has been observed by Lopez et. al,2005.

Cinnamon extract can be used as a food antioxidant together with the improvement of food palatability. This study conducted by Mancini et,al.(1998) supported the hypothesis that the inclusion of water soluble cinnamon compounds in the diet could reduce risk factors associated with diabetes and CVD . Similar findings were reported in a study conducted by Anderson, et al., 2009.

Mehmet, et al., (2010) studied that supplementing different concentrations of cinnamon oil in diet (especially 1000 ppm) decreased the cholesterol level of serum and chicken meat. They had positive effects on antioxidant metabolism, besides increasing the antioxidant enzyme activity and decreasing the serum MDA (malodealdehyde) level. The authors suggested that cinnamon oil may play a role as an endogenous antioxidant.

AS AN APPETIZER

A recent study published in the June 2007 edition of the American Journal of Clinical Nutrition shows that cinnamon is very effective in slowing gastric emptying time. Researchers at the University of Lund in Sweden used a cross over trial to study the effects of cinnamon on the gastric emptying time and blood glucose levels. They found that volunteers who ate rice pudding with cinnamon had far slow gastric emptying time than those who ate the rice pudding without cinnamon. In addition those in the cinnamon group did not have rapid rise in blood glucose levels than those in the plain rice pudding group experienced (Hlebowicz, et al., 2007).

ANTIMICROBIAL AND ANTIBIOTIC EFFECT

In a study effect of cinnamon oil on planktonic and biofilm culture was compared to the commonly used antimicrobial agent chlorehexidine, triclosan and gentamicin. Cinnamon oil showed antimicrobioal activity against both planktonic and biofilm cultures of S. epidermidis strains. Thus cinnamon oil is an effective antimicrobial agent to combat S. epidermidis biofilm (Nuryastuti, et al., 2009). Cinnamon is a popular flavoring ingredient widely used in food products. It has established beneficial properties to health, such as antimicrobial activity for controlling glucose intolerance and diabetes, inhibiting the proliferation of various cancer cell lines, for treating the common cold (Anderson and Broadhurst, 2004; Murcia, et al., 2004;Lopez et al,2005). Ethanol and methylene chloride extract of cinnamon were compared for their effect on Helicobacter pylori growth and urease activity. Methylene chloride activity was found to inhibit growth of H. pylori while ethanol extract counteracted its urease activity (Tabak, et al., 1999).

CINNAMON AND DIABETES

Diabetes is a chronic disorder of glucose metabolism resulting from dysfunction of pancreatic beta cells and insulin resistance. It is still a serious global health problem. The disease prevails in both genders and all age groups, so the general public has a concern about its control and treatment. Botanical products can improve glucose metabolism and overall condition of the persons with diabetes not only by hypoglycemic effect but also by improving lipid metabolism antioxidant status (Broadhurst, 1997). A number of spices and herbs have a long history of traditional use in treating elevated blood sugar levels. One such compound that has recently been the subject of intense research is cinnamon, a compound granted GRAS (Generally Recognized as Safe) status by the United States Food and Drug Administration. Cinnamon has been shown to be generally safe when ingested.

Interest in cinnamon as a potentially useful treatment for type 2 diabetes began almost 20 years ago. In 1990, Khan et al. isolated an unidentified factor from cinnamon and termed it as insulin-potentiating factor (IPF). They demonstrated that IPF may be involved in the alleviation of the signs and symptoms of diabetes, and other diseases related to insulin resistance. The potential role of cinnamon has been shown in several *in vitro*, animal and human studies.

Kim, et al., (2006) studied the antidiabetic effect of cinnamon cassia extract in Type II diabetic animal model. They suggested that cinnamon extract has a regulatory role in blood glucose levels and lipids and it may also exert a blood glucose suppressing effect by improving insulin sensitivity or slowing absorption of carbohydrates in the small intestine.In a similar study ,Verspohl (2010)found cassia extract to be superior to zeylanicum extract thus proving that the cassia extract has a direct antidiabetic potency.

Anuradha and Devi (2006) studied the hypoglycemic effect of cinnamon on Type II diabetes. They reported a significant decrease in body mass index, blood pressure, blood glucose levels, total cholesterol, triglycerides and low density lipoprotein. A significant increase was noted in HDL levels of cinnamon supplementation group. Supplementation of cinnamon brought about a significant reduction in body weight, blood pressure, blood glucose levels and lipid profiles in 90 days.

In December 2003, in Diabetes care study, cinnamon was found to improve glucose and lipid levels in people with diabetes. 60 patients (with Type II diabetes mellitus) who were taking sulfonylurea were given three doses of cinnamon (1 gm, 3 gm and 6 gm daily) and placebo for 40 days. Fasting blood glucose declined by 18-29 percent after 40 days in all the three cinnamon treated groups. Specifically 1 gm/daily decreased glucose from 2009 to 157 milligrams daily, 3 grams per day decreased glucose from 205 to 169 milligrams daily and 6 gram daily decreased glucose from 234 to 166 milligram daily. Furthermore, total cholesterol decreased by 12-26 percent, triglycerides decreased by 23-30 percent and LDC-C also declined from 7-27 percent (Khan, et al., 2003).

Another study was carried out at the University of Hannover, Germany and published in a European Journal of clinical investigation. This was the first study evaluating the effect of a water soluble cinnamon extract on glycemic control and the lipid profile of western patients with Type II diabetes (Mang, 2006). The results further add to a growing body of clinical evidence demonstrating that supplementation with water soluble cinnamon extract may play an important role in managing blood sugar levels and improving insulin function. A conclusion of this study was that the cinnamon extract seems to have a moderate effect in reducing fasting plasma glucose concentrations in diabetic patient with poor glycemic control. Kannappan, et al., 2006 investigated whether cinnamon bark extract (CBEt) mitigates the adverse effects of fructose loading on glucose metabolism and lipid profile in rats. Findings of this study indicated the improvement of glucose metabolism in vivo by CBEt in fructose fed rats.

Baker, et al., (2008) performed a meta analysis of randomized controlled trial of cinnamon to better characterize its impact on glucose and plasma lipids. A systematic literature search through July 2007 was conducted to identify randomized placebo controlled trials of cinnamon that reported data on A_1C (glycated Hb) fasting blood glucose or lipid parameters. The mean change in each study end point from baseline was treated as a continuous variable, and the weighted mean difference was calculated as the difference between the mean value in the treatment and control groups. Upon meta analysis, the use of cinnamon did not significantly alter A_1C, Fasting blood glucose or lipid parameters.

Roussel, et al., (2009) studied the effect of a water soluble cinnamon extract on body composition and features of the metabolic syndrome in pre diabetic men and women. They suggested that this naturally occurring spice can reduce risk factors associated with diabetes and cardio vascular diseases. Cinnamon may improve glycemic control and insulin sensitivity, but the effects are quickly reversed. (Solomon, et al., 2007). Compounds present in cinnamon may have beneficial effects on glucose, insulin and blood lipids and may be beneficial in or the prevention and treatment of diabetes. (Broadhurst, et al., (2004). Methyl hydroxy chalcone polymer (MHCP) found in cinnamon is an effective mimetic of insulin. MHCP may be useful in the treatment of insulin resistance and in the study of the path ways leading to glucose utilization in cells.(Jarvill and Taylor, et al., 2001).

Extensive investigation in recent years suggests that cinnamon possess numerous pharmacological activities including antioxidant (Roussel, et al, 2009; Jayaprakasha, *et al,* 2006), antimicrobial (Lopase, et al, 2005), antipyretic, antiulcerous, antiallergic and anti-inflammatory effects (Tung, et al, 2008). More recently, scientific attention has also been paid to the insulin potentiating capabilities of cinnamon, which may prove beneficial for diabetic patients. In the present review, current evidences, from recently published animal experimentation, as well as clinical trials where cinnamon, its extracts, or its active chemical components were examined, as a marker of glucose tolerance in people with diabetes and insulin resistance, will be highlighted. The review also provides a basis for a full-scale investigation of the therapeutic potential of cinnamon.

Broadhurst et al. (2000) compared 49 herbs, spices and medicinal plant extracts for their insulin-like or insulin-potentiating action in an *in vitro* model. The aqueous extracts of cinnamon potentiated insulin activity more than 20-fold, higher than any other compound, tested at comparable dilutions *in vitro* in the epididymal fat cells. Cinnamon extracts showed to improve insulin receptor function by activating the enzyme that causes insulin to bind to cells (insulin-receptor-kinase) and inhibiting the enzyme that blocks this process (insulin-receptor-phosphatase), leading to maximal phosphorylation of the insulin receptor, which is associated with increased insulin sensitivity (Impari-Radosevich, et al, 1998). Anderson et al. characterized the unidentified factor present in cinnamon as methylhydroxychalcone polymer (MHCP) and investigated its ability to function as insulin mimetic in 3T3-L1 adipocytes (Jarvill-Taylor, et al, 2001).

Table 1: Summary of effects of Cinnamon Supplementation carried out on Humans

Year/reference	# of subjects/ type/time	Significant effects	Cinnamon/medications	Comments
2003/Khan *et al.*	60/T2DM/40 days	Decreased fasting glucose, cholesterol, triglycerides and low-density lipoprotein; increased high-density lipoprotein,	*Cinnamomum cassia* (1, 3, and 6 g/day)/sulfonylurea drugs	Similar effects with 1–6 g cinnamon, significant effects even after 20 days of washout
2006/Ziegenfuss *et al.*	22/metabolic syndrome/42 days	decreased fasting glucose, systolic blood pressure, % body fat, increased lean body mass	Cinnamon extract (Cinnulin PF, 500 mg/day)/no known medications	No medications for glucose
2006/Suppapitiporn *et al.*	60/T2DM/72 days	No significant effects	*C. cassia* (1.5 g/day)/ metformin or sulfonylurea	Number of subjects with decreases in HbA1c was more than double in the cinnamon group but decreases were not significant (35% vs 15%)

2006/Mang *et al.*	79/T2DM/120 days	Decreased fasting glucose	Aqueous cinnamon extract powder (3 g/day)/oral antidiabetics or diet, no insulin	Decrease in plasma glucose correlated significantly with initial baseline glucose
2006/Vanschoonbeek *et al.*	25/post-menopausal with T2DM/42 days	No significant effects	*C. cassia* (1.5 g/day)/sulfonylurea Derivatives with or without metformin derivatives	Subjects under good glucose control, 7.4 ± 0.3 or better
2007/Solomon & Blannin	7/healthy, lean (BMI 24.5 ± 0.3) young (26 ± 10), male/12 hours	Decreased total plasma glucose response; improved oral glucose tolerance and insulin sensitivity	*C. cassia* (5 g with glucose)/ none	Response in healthy normal subjects after 12 hours and if given simultaneously with glucose tolerance test
2007/Wang *et al.*	15/polycystic ovary syndrome/48 days	Increased insulin sensitivity	Cinnamon extract (Cinnulin PF, 1 g/day)/no oral hypoglycemic or insulin-sensitizing drugs *C. cassia* (1 g/day)/several, including 75% taking metformin,	Insulin sensitivity in women with PCOS improved to levels of women without PCOS
2007/Blevins *et al.*	43/T2DM/3 months 14/healthy normal,	No significant effects	33% taking thiazoledinedione, and 50% taking hydroxymethylglutaryl-coenzyme A reductase inhibitors	Subjects were taking several drugs and mean BMI was over 32
2007/Hlebowicz *et al.*	BMI 22.6 ± 2.2/ simultaneously with food	Reduced postprandial glucose and decreased gastric-emptying rate	Cinnamon (6 g with test meal)/no known medications	Decreases in glucose could only be partly explained by gastric-emptying rate
2007/Altschuler *et al.*	72/adolescents with type 1 diabetes	No significant effects	Cinnamon (1 g/day)/insulin	Cinnamon is not a replacement for insulin Study was designed to study oxalate excretion.
2008/Tang *et al.*	11/healthy normal/4 weeks	No significant effects	Cinnamon (3 g)/no known medications	No postprandial measurements.
2009, Jamal, et al	60 subjects, 35 male + 25 females Type I Diabetic 40yrs or more	Significant change is observed	Cinnamon 6gm daily for 4 weeks	Significant change is observed in Blood Glucose, Triglyceride, Total cholesterol and

				LDL
Soni & Bhatnagar, 2009	15 Exp. + 15 Control Subjects 40 days study T2DM	Significant reduction	2gm Cinnamon powder for 40 days	Significant reduction in fasting and PP levels of blood glucose in exp. Group, No significant change is observed in controlled subjects.
2009/Solomon and Blannin	8/healthy normal/14 days	Improved glucose tolerance and insulin sensitivity	*C. cassia* (3 g/day)/none	Cinnamon effects lost when cinnamon discontinued
2009/Hlebowicz *et al.*	15/healthy normal/ simultaneously with food	3 g reduced postprandial insulin and increased GLP-1	Cinnamon (1 and 3 g with test meal)/no known medications	Dose response with cinnamon with the two studies
2009/Crawford	109/T2DM; HbA1c >7.0/90 days	Decreased HbA1c	Cinnamon (1 g/day)/insulin and/or varied medications	Patients were a cross section of people treated for T2DM
2010/Stoecker *et al.*[4]	137/T2DM/2 months	Decreased fasting and postprandial glucose	Cinnamon extract (CinSulin, 500 mg/day)/insulin and/or varied medications	Patients were a cross section of people treated for T2DM
[a] BMI, body mass index; HbA1c, hemoglobin A1c.				

STUDIES ON ANIMALS

Cinnamon extract fed to high fructose-induced insulin resistant male Wistar rats indicated that insulin stimulated glucose uptake was significantly greater in cinnamon fed rats and that the rate of insulin resistance was reversed by cinnamon feeding (Qin, et al, 2004). Kannappan et al.(2006) also demonstrated that glucose tolerance and insulin sensitivity improved by cinnamon bark extract (CBEt) treatment significantly by increasing the decreased activity of hexokinase and glycogen content in the liver and skeletal muscle of high fructose diet (HFD) fed rats. Kim et al.(2006) The blood glucose concentration significantly decreased in a dose-dependent manner after 2, 4 and 6 weeks in db/db mice, a type 2 diabetic model. The concentration of triglyceride, total cholesterol and intestinal α-glycosidase activity were significantly low after 6 weeks of the administration. (Kim et al.2006; Subash babu, et al, 2007). Cinnamaldehyde was administered at different doses (5, 10 and 25 mg/kg bw) for 45 days to (STZ)-induced male diabetic Wistar rats. The plasma glucose concentration decreased significantly in a dose-dependent manner. In addition, the serum total cholesterol and triglyceride levels also decreased. Several recent studies have also indicated that administration of cinnamon oil or polyphenolic oligomer rich extracts of cinnamon have valuable antihyperglycemic, hypolipidemic and antioxidant effects in STZ-induced diabetic rats (Jia, et al, 2009). The mode of action for this hypoglycemic effect may be attributed to an increase in serum insulin levels, hepatic glycogen storage (Subash babu, et al, 2007) or insulin-receptor signaling, an insulino-mimetic effect or a reduction in intestinal α-glycosidase activity (Kim, et al, 2006).

ADVERSE EFFECTS OF CINNAMON

In general, spices are generally recognized as safe when used in therapeutic doses. Spices produce adverse effects, especially when used in excessive amounts or in the long term. Some studies have reported minor adverse effects. The most common adverse effects reported with common and cassia cinnamon were related to contact irritation or allergic reaction with skin or mucus membranes (Dugoua, et al , 2007).

CONCLUSION

The paper demonstrates that cinnamon ameliorates the metabolism of glucose and lipids in patients with type 2 DM and may be used as an alternative therapy for the treatment of diabetes. However, there is

Table 2: Summary of effects of Cinnamon Supplementation carried out on Animals

Year/ Reference	# of subjects / type / time	Significant effects	Cinnamon/medications	Comments
Qin, et al, 2003	300 Rats	Significant Effects	Cinnamon – 30mg per kg body weight & 300mg per kr body weight was given	Cinnamon extract improved insulin action via increasing glucose uptake
Kim, et al, 2005	Type II Diabetic animal model	Significant Effects	50,100,150,200 mg c/kg body wt given for 6 weeks and one group is controled	Regulatory role of cinnamon in blood glucose & lipid profile. It improves insulin sensitivity or slowing absorption of carbohydrates in small intestine.
Kannappan, et al, 2006	Adult male Albino Rats 60 days fructose fat	Significant effects observed	Cinnamon bark extract was given	Levels were brought back to normal when administered with CBEt at high dose
Jarvill Taylor, et al, 2000				Mono-hydroxy chalcone polymer is an effective mimetic of insulin
Preuss, et al, 2006	116 Male rats, 150-200gm weight	No significant effect	Aqueous extract of cinnamon was given	No decrease in levels of blood glucose. Decrease in systolic blood pressure.
Subash Babu, et al, 2006	STZ induced diabetic rats	Significant Effects	Cinnamaldehyde was given at different doses (5,10 & 20 mg/kg body wt) For 45 days to STZ induced male diabetic wistar rats	Plasma glucose concentration, serum lipid profile & Hb A1c values were decreased
Cao, et al, 2007	Rats	Significant Effects	Cinnamon extract was given	Cinnamon exhibits the potential to increase the amount of proteins involved in insulin signaling, glucose trasnsport and anti-inflammatory and anti-angiogenesis response
Koochaksaraie, et al, 2010	321 days old broiler chicks Mixed sex, 7 days study 3 days cinnamon feed	No Significant Effects	5 treatment groups -Control Grp -250mg c/kg body weight -500mg c/kg body weight -1000mg c/kg body weight -2000mg c/kg body weight	No Significant difference in blood glucose level

lack of scientific and clinical data to prove its efficacy and safety. Moreover, the findings are somewhat mixed and inconclusive, particularly with regard to whole body insulin sensitivity. Thus, the question of whether its use might contribute to controlling the pandemic of type 2 diabetes worldwide remains unanswered. Hence, more rigorous, larger, population-based, randomized, clinically controlled trials with extended study length are required to further clarify use of cinnamon as a beneficial antidiabetic food adjunct. Future investigations regarding relationship between type form of procyanidin oligomers and anti-hyperglycemia activity in cinnamon species, its safety in pregnancy, its toxic effect could lead to the formulation of a dosage regimen and make it available as an alternative treatment option for diabetics. Morever, the benefits of cinnamon are reversed upon discontinuing its use.Hence,small amounts of cinnamon along with medication should form a part of of the daily diet so that the blood glucose profile of NIDDM patients can be maintained in a normal range.

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