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REVIEW ON ANTI-DIABETIC EFFECT OF CINNAMON SUPPLEMENTATION

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Abstract: Diabetes mellitus (DM) is a chronic illness that poses a serious threat to public health. The primary global the cause of morbidity and mortality is the rising prevalence of diabetes mellitus. Reducing secondary complications and regulating glycaemia control are the primary objectives of therapy. To combat this, many seek diets that can both treat and prevent the disease. The study aims to review the antidiabetic effect on cinnamon supplementation. Several plant-based sources are shown to have anti-diabetic properties. The objective of the study is to determine that, including cinnamon daily can lower glycaemia index in individuals. In this study, 10 articles have been referred from which the preferable way of cinnamon supplementation is determined. Plants contain countless biologically active compounds. Every food has unique health benefits, similarly cinnamon contains polyphenol compounds which help in regulating T2DM. It belongs to the *Lauraceae* family and *cinnamomum* genus, which includes more than 30 genera and roughly 2000–2500 species. Cinnamon grows up to 20 to 30 feet in height. Its leaves are lighter green on the underside and dark green on the top. The fruit of the cinnamon tree is fragrant, pulpy, and black, with a tiny golden bloom. The oldest spice, cinnamon has been utilized for ages in various cultural traditions. Apart from its culinary applications, it's becoming more and more well-liked because of its numerous claimed health advantages. Among the many cinnamon species that are known to exist, *Cinnamomum aromaticum* (Cassia) and *Cinnamomum zeylanicum* have undergone substantial study. Evidence from both in vitro and in vivo studies suggests that cinnamon may offer a variety of health advantages, primarily about its anti-diabetic property as it contains cinnamaldehyde which helps regulate blood glucose level. Additionally, it is said that cinnamon's anti-microbial, anti-fungal, antiviral, antioxidant, anti-tumor, blood pressure-lowering, cholesterol and lipid-lowering, and gastro-protective qualities contribute to its medicinal potential. Therefore, we can conclude that consuming cinnamon 6g daily as tea helps in T2DM, by reducing hyperglycemia due to increased glucose uptake in adipocytes and skeletal muscles. Consequently, cinnamon can be added to the current T2DM treatment as an adjuvant to help patients with better glucose control and a lower risk of developing secondary problems.

Key Words: *Diabetes, Glycemic control, Insulin resistance.*

INTRODUCTION:

Diabetes mellitus (DM) is a metabolic disorder characterized by abnormally high blood glucose levels(Sushil Kumar, et al; 2022). It is a disorder of insufficient production of or reduced insulin sensitivity. Insulin is synthesized in the Islets of Langerhans and is necessary to metabolize glucose. In diabetes, blood sugar levels increase called hyperglycemia where excess sugar is excreted in urine(glycosuria). Symptoms include increased urine output, thirst, weight loss, and weakness. If blood sugar levels decrease, it is called hypoglycemia. Symptoms include jittery, tiredness, sweating, dizziness, loss of consciousness, etc. Diabetes mellitus (DM) is a chronic condition characterized by two main subtypes: Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM), both resulting from defective insulin secretion or action, and can be caused by various factors such as endocrinopathies and steroid use. T1DM affects children or adolescents, whereas T2DM affects middle-aged and old-aged people who have chronic hypoglycemia because of improper lifestyle and dietary choices. The pathogenesis for T1DM and T2DM is drastically different; therefore, each type has various etiologies, presentations, and treatments(Amit Sapra, et al; 2023).

The 2023 ICMR INDIAB study revealed a diabetes prevalence of 10.1 crores in India. According to the ICMR-INDIAB-17 national cross-sectional study estimates, the prevalence of diabetes and prediabetes in India is 101 million and 136 million, respectively are much higher than earlier estimates the number of people living in poverty has increased significantly from 77 million in 2019 to over 134 million by 2045. Diabetes globally in 2021 is 537 million. Approximately 537 million adults(20-79years) are with diabetes. People with diabetes is calculated to raise to 643 million by 2030 and 783 million by 2045(International Diabetes Federation. IDF Diabetes Atlas, 10th edn

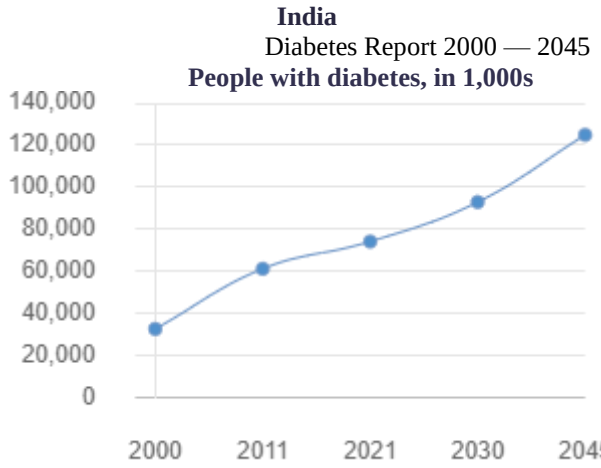

Figure 1: International Diabetes Federation. IDF Diabetes Atlas, 10th edn.

The recent INDIAB study quotes an overall prevalence of diabetes in 15 states as 7.3% and of pre-diabetes to be 10.3%. In rural Tamil Nadu, the prevalence of diabetes (7.8%) (Vanishree Shriraam, et al; 2021). In Chennai,22.8% of the population was estimated to have diabetes(Pradeepa, et al; 2021).

Complications of diabetes are common among individuals with type 1 or type 2 diabetes. The complications are mainly divided into microvascular and macrovascular. Microvascular complications involve neuropathy, nephropathy, and retinopathy, and macrovascular complications include cardiovascular disease, stroke, and peripheral artery disease (PAD). Diabetic foot syndrome is defined as the existence of foot ulcer associated with neuropathy, PAD, and infection, and is a main cause of lower limb amputation. Finally, there are other complications of diabetes that cannot be included in the two aforesaid categories such as dental disease, reduced resistance to infections, and birth complications among women with gestational diabetes (Konstantinos Papatheodorou, et al; 2018).

METHODOLOGY:

Table. 1

S. NO	THE TITLE OF THE STUDY	STUDY DESIGN	SAMPLE SIZE	PLACE	DURATION	PARAMETERS	PERIOD OF EVALUATION	SUPPLEMENTATION	DOSAGE	STATISTICAL ANALYSIS
1.	Effect of cinnamon tea on postprandial glucose concentration(Maria Alexandra Bernardo, et al; 2015).	Randomized clinical trial and in vitro study	30 nondiabetic adults, age between 20 - 53 are devided into 2 groups (n = 15)	Local community	Not specified	1. Oral glucose tolerance test (OGTT) 2. Total phenolic content determination test. 3. Ferric reducing antioxidant power method.	120 minutes	The extract of *Cinnamomum burmannii* bark	60 g of cinnamon sticks are soaked in 1000 ml of water	The *cinnamon burmannii* extract significantly ($p < 0.05$).

2.	Effect of Various Doses of Cinnamon on Blood Glucose in Diabetic Individuals (Mahpara Safdar, et al; 2004).	In vitro study	60 type 2 diabetic participants of both sexes(age 48-65 years). They are divided into 6 groups. Each group contain 1 individuals.(group 1,2,3 are assigned for cinnamon & 4,5,6 for placebo).	Pakistan	60 days	1. Blood test.	Three groups received different amounts of cinnamon and placebo for 40 days, with no doses administered from day 41 to day 60. Groups 4, 5, and 6 received 1g, 3g, and 6g of placebo each day. 1g doses were administered at lunch and dinner, while 3g and 6g doses were taken with meals, lunch, and supper. Participants were instructed to take the capsules immediately after breakfast and dinner.	Cinnamon and wheat flour were used for the preparation of cinnamon and placebo capsules	Each capsule contained 500mg of either wheat flour or cinnamon. 40 (1g or 2 capsules/ day for 20 days) or 120 capsule packages Plastic bags were used to make 240 (6g or 12 capsules/ day for 20 days and 3g or 6 capsules/ day for 20 days of the cinnamon & placebo capsules.	The cinnamon doses significantly ($P<0.05$) reduced the mean fasting serum glucose levels while the placebo doses did not affect the serum glucose levels

3.	the impact of administering cinnamon infusions on lowering blood glucose levels in diabetes mellitus patients in the service area of kuta baro health center, aceh besar district(Nanda Desreza, et al; 2023).	This research used a quasi-experimental design	20 diabetes mellitus patients	Kuta Baro Primary Health Center, Aceh Besar District	December 28, 2022, to January 5, 2023	1. Blood test.	The average blood sugar level was 255.80 prior to the delivery of the cinnamon tea infusion; the average level was 193.05 following the infusion, representing an average reduction in blood sugar levels of 41.33.	Cinnamon water	6g of cinnamon in 100ml water	This indicates a significant difference in blood sugar levels before and after the administration of cinnamon tea infusion with a p-value of 0.001, suggesting that cinnamon tea Infusion has an effect on blood sugar levels.
4.	Therapeutic potential Of Cinnamon against Glycemic Index among males and females(Momina Shahid, et al; 2020).	Experimental research	30 diabetic patients aged 35-65. Both men and women (n-30).	Lahore and Sheikhupura	10 days	1. Blood test.	Patients were following an unlimited diet and drinking cinnamon tea every day for breakfast; at six hours, there was a trend toward a 15.95 mmol/L drop in blood glucose.	extract of cinnamon tea	Not specified	The standard deviations in both conditions were similarly dispersed, and the T-value was significant as the p-value was less than 0.05.

5.	Effect of Aqueous Cinnamon Extract on the Postprandial Glycemia Levels in Patients with Type 2 Diabetes Mellitus: A Randomized Controlled Trial(Ana Paula Rachid, et al; 2022).	A randomized controlled clinical trail	36 adults with DM2. divided into 2 groups: the control group(n = 18) and intervention group(n = 18)	Portugal	Not specified	1. Oral glucose tolerance test (OGTT)	BGL were measured on fasting and after 30-120 minutes	Aqueous *cinnamon burmannii* extract ingestion	6g /100ml	The results indicate that the highest glucose concentration (p = 0.527) and incremental area under the curve (p = 0.834) were not significantly affected by the consumption of aqueous cinnamon extract and glucose concentration variation (*p* = 0.873) compared with the control group.
6.	*Cinnamomum zeylanicum* (Ceylon cinnamon) as a potential pharmaceutical agent for type-2 diabetes mellitus: study protocol for a randomized controlled trial(Priyanga Ranasinghe, et al; 2017).	Using the block randomization approach, the patients will be randomized in a 1:1:1 ratio, and the participants will be evenly and randomly allocated to two test groups (n= 70each) and one placebo group (*n* = 70).	The sample size is 210	Sri Lanka	4 months	1. Blood test.	0 - 4 months	The active component of the therapy medication is a capsule containing extract from Cinnamomum zeylanicum, whereas the placebo capsule will have lactose monohydrate.	Group 1 – *C. zeylanicum* dose 250 mg daily Group 2 – *C. zeylanicum* dose 500 mg daily Group 3 – placebo group	A Bonferroni adjustment will be applied during analysis to ascertain the critical P value for significance since several tests are run concurrently..

7.	Effect of cinnamon on postprandial blood glucose, gastric emptying, and satiety in healthy subjects(Hlebowicz Joanna, et al; June 2007).	A crossover trial.	14 healthy subjects (8 male and 6 female)	southern Sweden	Not specified	1. Blood test	The percentage change in the antral cross-sectional area 15–90 minutes after consuming 300 g of rice pudding (GER1) or 300 g of rice pudding with 6 g of cinnamon (GER2) was used to determine GER.	The test meal of 300g rice pudding mixed with 6 g cinnamon	6g of cinnamon	GER1 and GER2 had median values of 37% and 34.5%, respectively. Cinnamon considerably reduced the postprandial glucose response and delayed stomach emptying in the rice pudding (P 0.05 for both).
8.	Effect of Aloe Vera Drink with Cinnamon on Blood Sugar Reduction in Families with Type II Diabetes Mellitus in East Jakarta(Yuli Astuti, et al; 2021)	This research method uses a quasi-experimental design with a nonequivalent control group design.	60 individuals divided into 2 groups. Group 1 is cinnamon intervention group & group 2 is the aloe vera cinnamon intervention group. Adult 24, elderly 6, man 9 & women 21.	East Jakarta	Not Specified	1. Blood test	The respondent's blood sugar was measured in the morning and then remeasured after an intervention with an aloe vera drink with cinnamon in the afternoon.	Cinnamon powder	10g of cinnamon powder in 100ml water	This shows that more respondents had a significant drop in blood sugar after consuming aloe vera cinnamon water.

9.	Effect of cinnamon spice on continuously monitored glycemic response in adults with prediabetes: a 4-week randomized controlled crossover trial(Hila Zelicha, et al; 2024).	Randomized, controlled, double-blind, crossover trial.	18 participants with obesity and pre-diabetes	California	March 2021 - December 2021	1. Oral glucose tolerance test (OGTT) 2. Blood test	The subject is ingested 75g of glucose cola within a 5-minute time period along with 8 capsules (2g) of cinnamon or placebo. Blood samles (10ml) were drawn every 30mins for 3hrs.	Ingest *Cinnamomum burmannii* capsule	4g daily	Effect size was calculated as Eta-squared (η2). Statistical significance was assumed if the 2-sided P < 0.05.
10.	Acute Effects of Cinnamon Spice on Post-prandial Glucose and Insulin in Normal Weight and Overweight/Obese Subjects: A Pilot Study(Jing Wang, et al; 2021).	A crossover-designed, open-label, randomized, controlled pilot study	32 participations. 17 normal weight(age 22-43 year), 15 overweight (age 23-50 years)	USA	2 weeks	1. Blood test 2. High-performane liquid chromatography	Blood samples were drawn every 30 minutes for 3 hours after consumption of test meals.	When 6 g of cinnamon was added to oats cooked with milk, it significantly decreased one of our main outcomes, the post-prandial insulin response (niAUC0−180min), among individuals who were overweight or obese when compared to the control group who ate breakfast without cinnamon.	6g	When comparing breakfast with and without cinnamon, we saw a decrease in the normal weight participants' post-prandial glucagon response (niAUC0−180min and glucagon levels at 60–120 min) and C-peptide response (30 min).

REVIEW OF LITERATURE:

HISTORY OF DIABETES:

In the fifth century BC, there is evidence of diabetes mellitus in India for the first time. The sickness was described as emaciation, thirst, and profuse, sweet-smelling urinating. Excessive urination was one of the symptoms of the disease mentioned in ancient Egypt (between 460 and 1550 BC), but no mention of a "sweet odor." Diabetes was reported in China in 475–221 BC and AD 229, and it is thought that the Chinese physicians who recorded the symptoms were describing type 2 diabetic patients. They connected it to the following risk factors: consuming a lot of calories, eating sweets, cereal, and rice; also, they found that it was more common among wealthy people, who could purchase these sorts of meals. The term "diabetes" itself is attributed to Demetrius of Apameia, who lived in the first or second century BC. Originating in Greek, the word originally meant "to siphon" or "to empty." The first clinical description of diabetes came from Aretaeus of Cappadocia (approximately AD 81-138). He even provided a description of a "cure" for the illness in his book Therapeutics of Chronic Diseases.

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Greek doctors were very supportive of Galen's work on diabetes over the next 500 years. They also introduced new medical literature, primarily on remedies for the ailment, such as bloodletting, herbal remedies, and even different kinds of alcohol. Urine tasting was the initial diagnostic test used to identify diabetes. The Indians, Egyptians, and Asians wrote about the sweet flavor. Chang Chung-Ching observed in AD 229 that dogs enjoyed the pee due to its sweetness. Hindu medical books from the fifth century compared the urine's taste to that of sugarcane or honey. Theodore Protospatharios suggested in AD 630 that a heated urine residue analysis be part of the diabetes diagnosis process. The pleasant taste of diabetic urine was also reported by the Italian anatomist Morgagni, the Swiss physician Paracelsus, and the Iranian physician Avicenna between the years 980 and 1638. This is Avicenna in Paracelsus concluded that the kidneys' salt deposits were the source of the illness. Both excessive thirst (polydipsia) and excessive urine production (polyuria) resulted from this. His observation of an unidentified white material that persisted after diabetic urine evaporated led him to draw this conclusion.

After tasting diabetic urine in 1674, English physician Thomas Willis coined the term "diabetes mellitus." In actuality, mellitus translates to "honey sweet." Willis distinguished between diabetes insipidus and diabetes mellitus in his work Pharmaceutice Rationalis. By 1776, it had been established by Robert Wyatt and Mathew Dobson that people with diabetes had sugar in their blood and sweet urine. The capacity to quantitatively test for excessive blood sugar, or hyperglycemia, and elevated urine sugar, or glycosuria, was developed by the late 19th and early 20th centuries. Scientists from America, France, Germany, and Italy studied the pancreas, liver, and digestive tract. Diabetologist Apollinaire Bouchardat discovered in the 1800s that food rationing during the Franco-Prussian War was the reason for the elimination of glycosuria in diabetics living among Paris. Bouchardat used fasting and low-carb diets to cure diabetics. He provided evidence that their metabolism was enhanced by exercise and weight loss. Additionally, he created the initial protocols for teaching patients that it is their personal obligation to manage their food and exercise in order to avoid diabetes. Frederick Banting, Charles Best, James Collip, and John James Rickard Macleod made the discovery of insulin in Canada in 1921. This finding was important since it made type 1 diabetes treatable rather than an uncommon, deadly condition. (Book: Epidemiology of diabetes; Jahangir Moini, March 2019).

Figure 2: Drawing of Galen (Book: Epidemiology of diabetes; Jahangir Moini, March 2019).

TYPES:

Classification of diabetes are;

1. Type 1 diabetes: It is an autoimmune disease in which the body's immune system attacks and destroys insulin-producing cells in the pancreas for unknown reasons. Diabetes, typically diagnosed in children and young adults, can develop at any age.
2. Type 2 diabetes: It is a condition in which the body does not produce sufficient insulin and/or the cells in the body do not respond normally to the insulin. This is the most common type of diabetes that usually affects adults, but children can also develop it.
3. Gestational diabetes: It is a type of diabetes that develops in some women during pregnancy. Although it usually goes away after pregnancy, women with gestational diabetes are at a higher risk of developing Type 2 diabetes later in life.
4. Type 3c diabetes: This is a form of diabetes that occurs when the pancreas experiences damage (other than autoimmune damage), which affects its ability to produce insulin. Diabetes and damage to the pancreas can be brought on by hemochromatosis, cystic fibrosis, pancreatic cancer, and pancreatitis. Pancreas removal also results in Type 3c diabetes.
5. Latent autoimmune diabetes in adults (LADA): LADA is similar to Type 1 diabetes as it is caused by an autoimmune reaction. However, it develops much more slowly than Type 1 and usually affects people over the age of 30.

6. Maturity-onset diabetes of the young (MODY): MODY is a form of monogenic diabetes caused by an inherited genetic mutation that affects how the body makes and uses insulin.
7. Neonatal diabetes: This is a rare form of diabetes that occurs within the first six months of life. It is also a form of monogenic diabetes. Around half of the babies with neonatal diabetes have the lifelong form called permanent neonatal diabetes mellitus, while the other half may recover from it within a few months. Transient neonatal diabetes mellitus is a condition that occurs from birth but can return later in life.
8. Brittle diabetes: Brittle diabetes is a form of Type 1 diabetes that is characterized by frequent and severe episodes of high and low blood sugar levels, leading to instability that often necessitates hospitalization. In rare cases, a pancreas transplant may be necessary to treat brittle diabetes permanently(World Health Organization)

CINNAMON:

1. History of cinnamon:

Cinnamon has been used since approximately 2800 BC, when it was first called "Kwai" in Chinese. It was a part of the anointing oil that Moses used for the biblically described anointing (the act of making holy). The digestive and respiratory tract ailments were treated with it by the Romans due to its therapeutic qualities. It was also used to prevent the smell of dead bodies during Roman funerals. It was utilized in Egypt for its taste and scent, as well as for embalming mummies. However because it is extremely valuable and costly, the 15th century saw a global exploration as a result of the hunt for cinnamon. Vasco da Gama's expedition of South India and Sri Lanka as well as Christopher Columbus's trip that resulted in the discovery of the new world were both driven by this motivation. It was later discovered that the native of real cinnamon, sometimes called Ceylon cinnamon, lived in Sri Lanka (also known as Ceylon). It soon became clear that whichever nation could seize control of that region would have a monopoly on the global cinnamon trade and would eventually make enormous profits. As a result, over time, the Portuguese came to power, were surpassed by the Dutch, and were eventually taken over by the British in 1815. It is currently grown in Sri Lanka along the Negombo to Matara coastal strip. (Pallavi Kawatra; et al; June 2015)

2. Introduction:

Naturally, plants have their own biologically active compounds which are used to develop various new products for other different industrial applications. Currently, countless biologically active compounds emanating from plants are being utilized in different applications particularly in pharmacology, since plants act as beneficial living chemical factories that fabricate several secondary metabolites and are helpful to the environment. Every food has unique health benefits and functional qualities. Similarly, cinnamon has anti-inflammatory, anti-diabetic, and anti-hypertriglyceridemic properties. It's an essential component of Indian condiments, as it provides a unique flavor for different foods. Nonetheless, it has a plethora of therapeutic benefits, the most notable of which is its capacity to manage diabetes.

The family *Lauraceae*, which includes more than 30 genera and roughly 2000–2500 species, includes the genus *Cinnamomum*. It grows up to 20 to 30 feet in height. Its leaves are lighter green on the underside and dark green on the top. The fruit of the cinnamon tree is fragrant, pulpy, and black, with a tiny golden bloom. In the US, the spice known as cinnamon is the inner bark of *cinnamomum cassia*, which has a rich, spicy scent. *Cinnamon zeylanicum*, also known as Ceylon cinnamon, is described as real or sweet cinnamon. Cinnamon essential oil and various derivatives, such as cinnamaldehyde, cinnamic acid, and cinnamate, are some of the most significant spices that people use daily worldwide. The main ingredient of cinnamon is a chemical that can lower cholesterol, inflammation, and blood sugar levels.

Because proanthocyanidins and flavonoids contribute to the high phenolic content of cinnamon species, these plants are employed as natural sources of antioxidants. The most prominent species in the genus *Cinnamomum are C. burmannii, C. loureiroi, C. cassia, and C. zeylanicum (C. verum).* The species that has been researched the most is *C. zeylanicum.* The primary commercial output of *Capsicum zeylanicum* is dried aromatic peel, which has a variety of medicinal uses, including antifungal properties. According to reports, *C. zeylanicum* oil is safe to eat for humans. The antibacterial properties of *C. zeylanicum* essential oil can fight drug-resistant and ulcer-causing H. pylori. *C. zeylanicum* has long been utilized as a supplement to improve health. Its essential oil also protects gastroenteritis. Because of its antioxidant, anti-Alzheimer's disease, anti-skin-whitening, and antidiabetic properties, essential oils extracted from *C. zeylanicum* bark are used in cosmetic products. Because C. zeylanicum leaves and bark contain large levels of (E)-cinnamylacetate and eugenol (E)-cinnamaldehyde, they are valuable commercial materials. Furthermore, the primary constituent of *C. zeylanicum* bark oil, (E)-cinnamaldehyde, possesses a range of bioactivities. The primary component of C. zeylanicum roots is camphor(Muzaffer Mutlu, et al;2023).

3. Types of cinnamon:

There are mainly four types of cinnamon:

- Cinnamomum zeylanicum, also known as true cinnamon, Ceylon cinnamon, or Mexican cinnamon
- Indonesian cinnamon (*Cinnamomum burmanni*)
- Vietnamese cinnamon (*Cinnamomum loureiroi*)
- Cassia cinnamon or Chinese cinnamon (*Cinnamomum aromaticum*)

Table 2:

S.NO	TYPES OF CINNAMON	PLACE OF ORIGIN	TASTE	COLOR	OTHER FEATURES
1.	*Cinnamomum zeylanicum*	Sri Lanka	Slightly sweet	Light to medium reddish brown	Lowest coumarin content
2.	*Cinnamomum burmanni*	Indonesia	Spicy	Dark reddish brown	Cheap, high coumarin, strong aroma

3.	*Cinnamomum loureiroi*	Vietnam	Spicy and sweet	Dark reddish brown	Strong aroma, spicy, high coumarin
4.	*Cinnamomum aromaticum*	China	Spicy but bitter	Dark reddish brown	High coumarin, very strong taste

4. Health Benefits of Cinnamon:

- Cardioprotective
- Anti-inflammatory
- Anti-Microbial
- Cognition enhancer
- Antioxidant
- Anticancer
- Anti Lioemic
- Antidiabetic

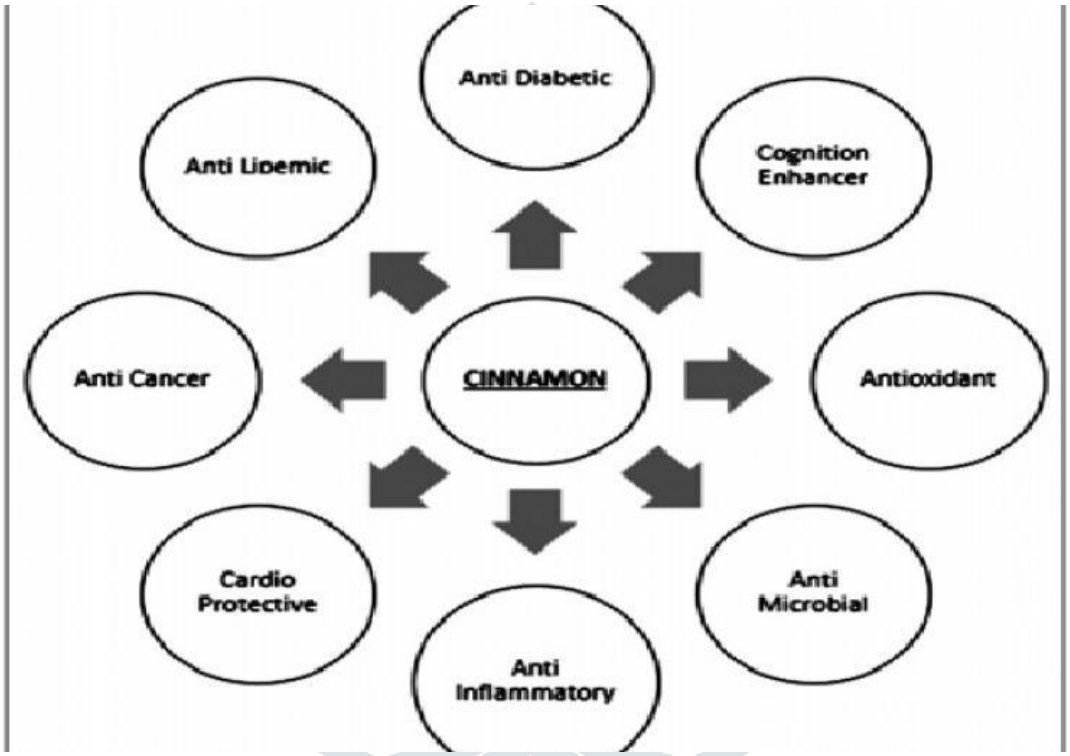

Figure 3: Pharmacognosy Research: Pallavi Kawatra, et al: June 2015

5. Anti-diabetic property of cinnamon:

Chemical Constitutes:

Cinnamaldehyde, cinnamonate, cinnamic acid, and other essential oils are the primary components of cinnamon10. Each of these adds to the smell and the many biological processes associated with cinnamon. It also contains procyanidins tannins, mucilage, and a bit amounts of coumarin11, 12. Cinnamaldehyde (trans-cinnamaldehyde) is the foremost constituent in cinnamon bark oil. However, the principal component of leaf oil is eugenol(Ali Al-Samydai, et al: 2018).

6. Glucose regulation Mechanism of cinnamon:

The primary theory underlying cinnamon's mode of action is that it can modulate insulin signaling pathways to produce an effect akin to insulin. Therefore, it is tempting to suggest that the following endogenous pathways are being used by cinnamon to exercise its favorable effects on glucose homeostasis:

(i) By enhancing the synthesis of the glucose transporter (GLUT) 4 and GLUT 4 translocation, which increases the absorption of glucose in muscle and adipose tissue.

(ii) By encouraging the liver's production of glycogen, which inhibits glycogen synthase kinase 3β and additionally.

(iii) By reducing the expression of the genes for glucose-6-phosphatase and phosphoenolpyruvate carboxykinase (PEPCK), two liver regulators of gluconeogenesis.

The regulation of insulin signaling by cinnamon and its bioactive constituents involves the activation of intracellular cascade events. Consequently, it appears that the plant's extract and its separated components (hydroxychalcone) activate the tyrosine auto-phosphorylation and insulin tyrosine kinase receptor (IR). Phosphoinositide-dependent protein kinase (PDK1) is activated when phosphatidylinositol 3-kinase (PI3K) is activated as a result of the phosphorylation of IRS-2. This kinase then triggers many signaling molecules, including protein kinase B (Akt1/PKB), which has been shown to have a significant role in controlling gene transcription, enzyme activity, and protein translocation. Protein kinase C (PKC), which in turn promotes glucose absorption, can

be improved by Akt1/PKB. Similarly, GSK-3 is inhibited by Akt1/PKB, which causes glycogen synthase to become active. Furthermore, cinnamon appears to suppress the PI3K-inhibiting phosphatase and tensin homolog deleted on chromosome 10 (PTEN). In 3T3-L1 adipocytes, cinnamon extract can moderately affect GLUT 4 translocation through alternative signaling pathways. This involves AMP-activated protein kinase (AMPK) phosphorylation activation. Lastly, cinnamon's impact on the IRS-1 insulin receptor substrate molecule can activate the GRB-2-mediated P38-MAPK, ERK, and JNK/SAPK signaling pathways, resulting in both cell proliferation and death. This model provides a detailed explanation of the action mechanism(s) of cinnamon and its isolated bioactive compounds. All these various effects of cinnamon and its isolated compounds help in regulating the glycemia generated by T2DM. Figure 4 is a schematic model that explains the mechanism(s) by which isolated bioactive components from cinnamon affect glycemic control.

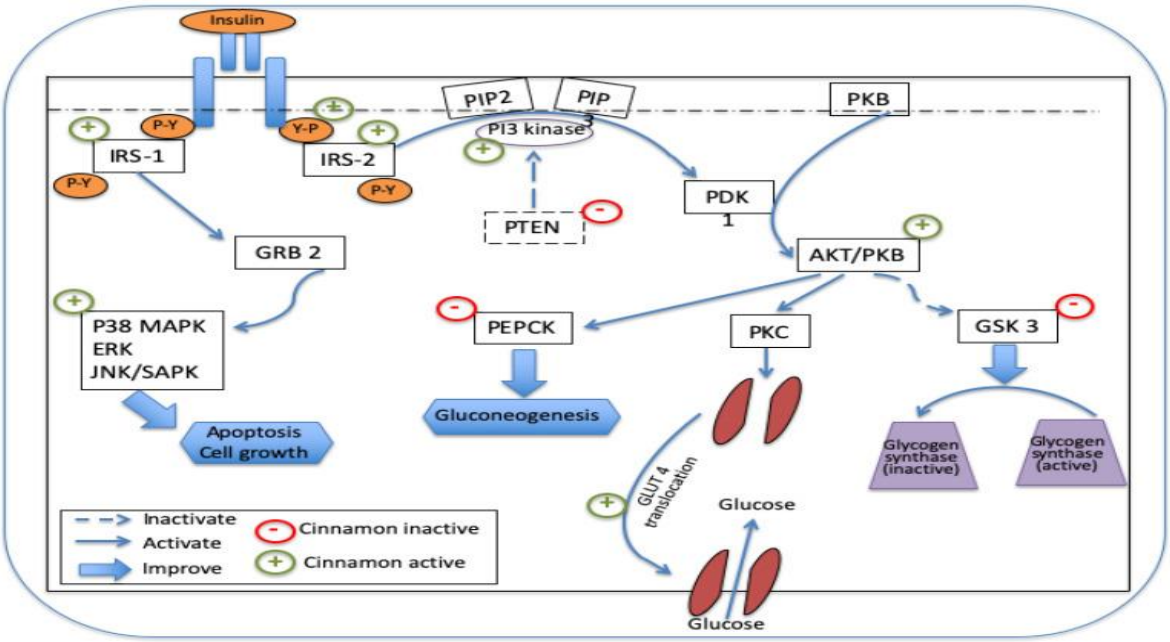

Figure 4: A schematic model illustrating the proposed mechanism(s) of action of cinnamon and its isolated bioactive compounds on glycemic control(Maria Leonor Silva, et al; 2022).

Legend: Insulin receptor substrate molecule (IRS); phosphatidylinositol 4,5-biphosphate (PIP2); phosphatidylinositol 3,4,5-triphosphate (PIP3); PI3 kinase (phosphatidylinositol 3-kinase); PTEN (phosphatase and tensin homolog); GRB2, growth factor receptor-bond protein 2; p38 MAPK, p38 mitogen-activated protein kinase; ERK (extracellular signal-regulated kinases); JNK/SAPK (c-Jun N-terminal kinase/stress-activated protein kinase); PEPCK (phosphoenolpyruvate carboxy-kinase); PDK1, 3-phosphoinositol-dependent kinase 1; PKB/AKT (protein kinase B); PKC (protein kinase C); GSK 3, glycogen synthase kinase 3; GLUT 4(Maria Leonor Silva, et al; 2022).

7. Side effects of cinnamon:

Cinnamon is generally safe to consume, but excessive usage may lead to mouth and lip irritation, resulting in sores. Additionally, some individuals may be allergic to it, causing redness and irritation when applied topically. Consuming large amounts of cassia cinnamon can be toxic, particularly for those with liver problems. Coumarin, an ingredient found in some cinnamon products, may cause liver issues. However, the amount present in these products is typically insignificant and, therefore, unlikely to pose a problem. As there is a lack of evidence regarding its safety, cinnamon should be avoided as a treatment by children, pregnant women, and breastfeeding mothers.

RESULT AND CONCLUSION:

To reinterpret Cinnamon as a positive effect in managing type II diabetes as it has anti-diabetic property that is obtained by cinnamaldehyde which is the major bioactive compound. Various studies have shown that consuming cinnamon extracts orally can have a positive effect on blood glucose levels. However based on 10 articles referencing consuming cinnamon daily as tea helps to regulate blood glucose levels in T2DM rather than a capsule, extract, or powder, as it showed the best result in regulating post-prandial and fasting blood glucose level in participants. In those studies the participants were supplemented in either form and readings were taken by using various parameters like blood test, oral glucose tolerance test, Total phenolic content determination test, and Ferric reducing antioxidant power method. Those findings were systematically analyzed by mean value and concluded. From these results, this review study can be concluded by suggesting that consuming 6 grams of cinnamon in the form of tea has shown positive results in regulating T2DM. However, further research is needed to determine the effectiveness of the active components of cinnamon and their medicinal properties in treating diabetes.

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