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Effect of Chickpeas on the Blood Sugar Levels

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Abstract

Diabetes mellitus is a serious health concern that affects people all over the world. Despite the therapeutic benefits of insulin and oral pharmaceuticals, problems such as macrovascular, ocular, & neuropathic function are still connected with insulin injections or synthetic medications. Improving blood glucose control with lifestyle or oral adjustments may halt diabetes development as well as enhance people's quality of life. Alternative medicine, particularly the use of natural items with antidiabetic properties, is becoming increasingly popular. Chickpeas, the world's third most significant grain legume, are high in carbs and protein, making them a crucial source of nutrition in vegetarian diets. Chickpeas include physiologically active chemicals, such as flavonoids, that buffer oxidative stress or lower hepatic triglyceride levels. Chickpeas include physiologically active chemicals including flavonoids, which lower oxidative stress and hepatic triglyceride and cholesterol levels in diabetic rats. A diet high in isoflavones reduces the risk of diabetes and its consequences, such as cardiovascular disease. Isoflavonoids can lower insulin resistance, hyperglycemia, and promote hypoglycemia and antilipemic actions by repairing pancreatic β cells. Chickpeas reduce blood glucose iAUC more efficiently than potatoes or wheat due to their low carbohydrate digestion, high fibre, protein, and hormonal effects. Their nutrient-dense nature supports their use in diabetic diets.

Key words: *Chickpeas, Diabetes mellitus, flavonoids.*

Introduction

1. Diabetes mellitus

Diabetes mellitus is a major medical condition that affects individuals all over the world.

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Despite the benefits of insulin and oral medicines, difficulties with macrovascular, ocular, and neuropathic function remain associated with insulin injections and synthetic drugs. Optimising blood glucose management with lifestyle and oral modifications may delay the development of diabetes and enhance people's quality of life. (Abouzid et al; 2022)

Diabetes mellitus is the fourth leading cause of mortality, behind cancer, cardiovascular disease, and cerebrovascular illness, putting pressure on society and public health. As previously indicated, diabetes-related death rates account for around 2.2% of overall mortality rates globally. Furthermore, its incidence in China has dramatically increased. (Wang et al; 2011).

Diabetes mellitus (DM) is a metabolic disorder that results in unusually high blood glucose levels. Diabetes is divided into several categories, including type 1, type 2, diabetes with maturity-onset in the young (MODY), gestational diabetes, neonatal diabetes, and secondary causes such as endocrinopathies and steroid use. Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM) are the two most frequent kinds of diabetes, both caused by impaired insulin secretion (T1DM) and/or action. T1DM affects children and adolescents, but T2DM is thought to affect middle-aged and elderly people who have persistent hyperglycemia due to poor lifestyle and nutritional choices. T1DM and T2DM have very diverse pathophysiologies, hence each has its own aetiology, presentation, and treatment. (Sapra et al; 2022).

Diabetes is a disease that affects one out of every eleven people worldwide, has quadrupled in prevalence over the last 30 years, and is the ninth leading cause of death. Type 1 diabetes is characterised by autoimmune loss of beta cells in the pancreas, whereas type 2 diabetes is characterised by insulin resistance in peripheral organs. Both kinds have different origins, but they share one characteristic: an inability to maintain blood sugar levels within normal limits. Maintaining high blood sugar levels can lead to a number of health problems, including cardiovascular disease, eyesight loss, and cancer. (Tsalamandris et al; 2019).

Diabetes patients may seek nutritional management, which is inexpensive and can improve insulin sensitivity without raising plasma glucose levels. Consuming low-glycemic index (GI) foods, such as legumes and dairy products, has been demonstrated to reduce glycemic load while improving cardiovascular health and body composition. Functional foods that combine dietary adjustments with additional factors, such as specific nutritional management, edible oils, mushrooms, herbs, and vitamins, are frequently used to treat diabetes and improve treatment outcomes. (Gray et al; 2019).

Diabetes patients have complicated metabolic disorders that affect three major nutrients: lipids, carbohydrates, and proteins. In diabetes, insulin secretion insufficiency raises blood glucose levels and causes organ damage. Most diabetes patients also have a number of comorbidities, including nephropathy, neuropathy, retinopathy, and hyperlipemia. (Banday et al; 2020)

As a widespread ailment, traditional diabetes therapy has focused on blood glucose control, which ignores the associated issues. Currently, there is no effective treatment strategy for diabetes. Insulin injections and commonly given drugs like metformin and pioglitzone can induce unpleasant side effects such as insulin resistance, hypoglycemia, or gastrointestinal issues. (Marín et al; 2016).

As a result, there is a huge need for alternate diabetes treatment techniques. Herbal medicine is regarded as a useful source of innovative medications due to its low adverse effects and favorable economic properties. Natural items have been shown to offer anti-diabetic properties as well as supplementary therapeutic benefits for complications. (Kifle et al; 2021). Diabetes mellitus therapy remains difficult due to the limitations of current anti-diabetic medicines. In general, the results were acceptable with other studies that claimed that alloxan administration, relative to normal rats, resulted in raised blood glucose, contributing to the establishment of diabetes. (Raevuori et al; 2015).

2. Natural extracts from plants

Recently, there has been a renewed interest in producing natural antioxidants from plant materials to replace synthetic ones. Natural antioxidant compounds present in plants can stop a free radical-mediated oxidative process and may be useful in protecting the human body from such conditions. Natural items can be used in traditional or modern medicine, as well as to start medication development. The ability of phenolic compounds to behave as antioxidants was identified by adding a hydrogen atom. (Mohamed et. al; 2010)

2.1 Chickpeas

Chickpea (Cicer arietinum L.) is an important pulse crop grown and consumed all over the world, especially in Afro-Asian countries. It is a rich source of carbohydrates and protein, with a higher protein concentration than other pulses. Chickpeas provide high quantities of all essential amino acids except sulfur-containing amino acids, which can be supplemented by including cereals in the daily diet. Starch is the major storage carbohydrate, followed by dietary fibre, oligosaccharides, and straightforward sugars including glucose and sucrose. (Jukanti et al; 2012).

Chickpeas, a pulse crop high in protein and essential amino acids, have been demonstrated to help control blood sugar levels. Their distinct chemical makeup and low glycemic index are thought to have a beneficial effect on blood sugar by lowering carbohydrate bioavailability and absorption. Chickpea consumption as a superfood has skyrocketed, with yearly consumption in the United States more than doubling from 1.9% in 2003 to 4.5% by 2018. (Langyan et al; 2022).

Although lipids are present in little amounts, chickpeas are abundant in nutritionally important unsaturated fatty acids such as linoleic and oleic acids. Chickpea oil contains considerable sterols, such as β-sitosterol, campesterol, and stigmasterol. Chickpea seeds include calcium, magnesium, phosphorus, and, most critically, potassium. Chickpeas include vital vitamins, including riboflavin, niacin, thiamine, folate, and β-carotene, a precursor to vitamin A. (Ibrikci et al; 2003).

Chickpea seeds, like other pulses, have antinutritional components that can be reduced or eliminated by various cooking methods. Chickpeas have a number of possible health benefits, and when coupled with other pulses and grains, they may help with some of the most significant human diseases, such as CVD, type 2 diabetes, digestive issues, and some cancers. Overall, chickpeas are a key pulse crop with several health and nutritional advantages. (Yegrem et al; 2021).

Protein hydrolysates are a possible source of bioactive peptides. Microbial fermentation of dietary proteins offers an alternative to enzymatic and chemical peptide synthesis. Food fermentation produces peptides that have health advantages and can help treat a variety of ailments. The fermentation process has received attention because of its ability to improve functional qualities while minimising anti-nutritional elements. Fermentation has been shown in studies to improve bean value by enhancing vitamin and mineral content, carbohydrate bioavailability, and the formation of free polyphenols and bioactive peptides. (Nasri et al; 2022).

Chickpeas have been studied for their health advantages, with peptides created by isolating proteins from raw or cooked chickpeas and hydrolyzing them using enzymes or acid/base techniques. Chickpea extracts include a variety of proteins and peptides that have antibacterial, hemagglutination, antioxidant, and anti-tumor properties, as well as hypoglycemic and lipid-lowering effects. However, the positive effects of chickpea fermentation peptides on blood glucose levels have received little attention, and their anti-diabetic potential has not been fully assessed. (Fan et al; 2022).

Complex I of mammalian cell mitochondria is an important enzyme in the mitochondrial electron transport chain that converts NADH to NAD+ and is a major generator of reactive oxygen species (ROS). High blood glucose levels activate or upregulate a variety of branching-off glucose metabolic pathways, such as the polyol and hexosamine pathways, which are normally dormant. (Hirst; 2013).

In contrast, Complex I can create ROS, resulting in DNA oxidative damage and excessive activation of poly ADP ribose polymerase (PARP) in diabetes. The activation of the polyol pathway by PARP causes a redox imbalance, as demonstrated by decreased levels of the NAD+/NADH ratio. Complex I dysfunction is likely to result in increased complex I activity since it manages the extra NADH produced by the polyol pathway. Furthermore, oxidative stress has been demonstrated to have a major effect on diabetes and its complications. Therefore, diabetics would benefit from effective NADH oxidation through complex I. (Luo et al; 2015).

Chickpeas are an important source of flavonoids in the human diet, and studies have indicated that the flavonoids in chickpeas have anti-diabetic characteristics. Because the NAD+/NADH redox balance is heavily disrupted in diabetes, and since complex I is the only site for NADH oxidation or NAD+ regeneration, Fu et al; 2022 showed that Chickpeas alleviated the degree of NAD+/NADH redox imbalance in the pancreas of T2DM rats, which is most likely attributed to the inhibition of the polyol pathway or a reduction in poly ADP ribose polymerase (PARP) or sirtuin 3 (Sirt3) activities.

Furthermore, chickpeas improved mitochondrial complex I dysfunction in the pancreas of T2DM mice by reducing complex I activity. Chickpea treatment may also reduce oxidative stress in T2DM rats, as indicated by a drop in hydrogen peroxide (H2O2) & malondialdehyde (MDA), as well as an increase in glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD) levels in blood. Chickpea treatment significantly lowered dyslipidemia in T2DM rats.)Fu et al; 2022(

2.2 The Effect of feeding diabetic rats on diet containing chickpeas

Legumes' limited digestion and great resistance to starch, as well as their high quantities of amylose and dietary fibre, all help to reduce blood sugar. Compared to conventional wheat starch, chickpeas have less digestible starch and more amylose and dietary fibre, which contributes to the blood sugar-improving impact. Their high protein and resistant starch content has been shown to increase intestinal hormones such as GLP-1, GIP, and PYY, which promote insulin production and help regulate post-meal blood glucose levels. (Mohammed et al; 2012).

There are variations in effectiveness between whole chickpeas and pureed or crushed chickpeas, which are attributable to starch bio-accessibility determined by cell wall integrity. Starch granules in intact chickpea cells are more resistant to gelatinization and amylolysis, indicating a decreased post-prandial glucose response. Chickpea-based meals have also been demonstrated to lower hunger rates, with research on appetite-related hormones such as GLP-1, leptin, and ghrelin indicating a good influence. (Edwards et al; 2021).

Incorporating whole chickpeas into the diet reduces refined carbohydrate intake while increasing nutritional quality. It also provides a method of delivering less glucose to the circulatory system, which may have a good influence on weight reduction and hunger management in people with diabetes. More study is needed to fully understand the impact of chickpeas on the metabolism of the body or health. (Zhou et al; 2008).

A single dose of alloxan (120 mg/kg) reduced the levels of insulin, hyperglycemia, total lipids, triglycerides, and cholesterol, and decreased high-density lipoprotein levels. Along with these changes, there was an increase in lipid peroxidation (TBARS), H2O2, and nitrite levels in the pancreas, liver, and testis. This oxidative stress was associated with a decrease in glutathione (GSH) levels, which act as antioxidant enzymes. SCEE therapy for 15 days after diabetes induction decreased hyperglycemia, restored lipid profile, reduced the increase in TBARS, H2O2, or nitrite levels, & boosted GSH production in alloxan-treated rats. (Shah et al; 2014)

Chickpeas and hummus are abundant in fibre, polyunsaturated fatty acids, vitamins A, E, C, folate, magnesium, potassium, & iron. Hummus consumers scored higher on the Healthy Eating Index 2005 (HEI-2005) because it is naturally nutrient rich. These foods may aid in weight management, glucose and insulin regulation, or cardiovascular disease prevention. They also include nutritional bioactives such phytic acid, sterols, tannins, carotenoids, & polyphenols. Hummus, when mixed with vegetables and nutritious grains, is a healthy way for Americans to get their daily bean intake. This paper investigates chickpeas and hummus' nutritional value and health benefits, in addition to how these foods could enhance meal nutritional profiles. (Wallace et al; 2016)

Dietary fibre, found in plant foods, is indigestible and is classified into soluble and insoluble fibres. Soluble fibres are slowly absorbed in the colon, but insoluble fibres cause bowel movements. Chickpeas and hummus have been demonstrated to increase dietary fibre intake, which improves intestinal health. Studies show that a chickpea diet improves the frequency of defecation, makes defecation simpler, and results in softer stool consistency than a conventional diet. (Murty et al; 2010)

One effective treatment strategy for decreasing hyperglycemia induced by type 2 diabetes is to focus on alpha-amylase and alpha-glucosidase, enzymes that catalyse starch breakdown in the stomach. The only licenced inhibitors of these enzymes are acarbose, miglitol, and voglibose. Although these inhibitors diminish glucose absorption, they are rarely utilised due to negative gastrointestinal side effects. As a result, researchers continue to explore novel inhibitors that are more effective and have fewer side effects. Plant-derived natural chemicals have been proved to be a viable source of therapeutic treatments with little toxicity and side effects. (Dirir et al; 2021)

Three strategies have been discovered as effective in reducing storage proteins' enzymatic degradation of grain starch. Proteins can form three-dimensional networks around starch granules, producing a physical barrier that stops α-amylase from reaching the starch. Natural or manufactured α-amylase inhibitors (α-AIs) can reduce amylolytic activity by directly binding to the enzyme. Starch granule surface proteins inhibit α-amylase activity by providing competing binding sites. Third, proteins or hydrolysates that cling to a starch surface can change the starch's molecular structure. Understanding protein interactions with α-amylase in a simulated system of digestion is vital for optimising the utilisation of chickpeas in healthy human diets. (Zou et al., 2019).

Chickpea seeds' main storage proteins are water-soluble albumin, salt-soluble globulin, and acid/alkali-soluble glutelin, which account for approximately 17%, 64%, and 17%, respectively. Protein solubility is affected by the solvent, and certain endogenous proteins become insoluble after in vitro digestion. Globulin and glutelin are more likely to act as impediments in digesta because of their capacity to create thick gels that resist proteolysis. Rice grains involve three proteins that can produce α-AIs through protease hydrolysis. (Tan et al; 2022)

Cooked beans maintain their amount, while soluble components such α-galactosides decrease. Heat causes molecular changes that lower the glycemic index. Cooking weakens cell walls and other cell components, releasing reserve chemicals and increasing food nutritional and functional value. Starches become more digestible after cooking. Cooking and boiling boost folate bioavailability, resulting in improved iron absorption and tissue development. Despite a decrease in total polyphenols, antioxidant activity persists due to an enhanced phenolic compound quality/quantity ratio. (Chinedum et al; 2018)

Xu and Chang discovered that boiling chickpea seeds reduces antioxidant activity due to the solubility & thermosensitivity of several phenolic components. However, cooked seeds still have antioxidant action. The development of aglycones, which are the byproducts of flavonoid glycoside breakdown, may account for the residual antioxidant action. This behaviour is due to chemical rearrangements generated by the release of hydrogen atoms, which stabilise oxidation-reduction processes. This behaviour has been seen in faba beans, which remove free radicals by polymerizing tannins and proanthocyanidins. (Siah et al; 2014)

A chickpea-based diet helps avoid diabetes and obesity. Adiponectin is a hormone that helps to prevent type 2 diabetes and atherosclerosis (Achari & Jain, 2017). A randomized cross-over clinical study involving 32 diabetes patients fed a chickpea diet (instead of two meals of red meat) discovered that all patients had greater levels of adiponectin. (Acevedo Martinez et al., 2021).

Furthermore, studies on diabetic rats indicated that providing 400mg/kg of aqueous and methanol-based chickpea meals reduced blood glucose and cholesterol levels. Another clinical experiment (n=30; 17 men and 13 women) discovered that a diet rich in chickpeas and other legumes reduced body weight, systolic blood pressure, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and total cholesterol. (Yagi and Yagi, 2018).

The aforementioned changes were significant as compared to a legume-restricted diet. Chickpea's effects on obesity were explored further in rats during an 8-month period. The trial included both a fatty diet and a control with 10% (w/w) chickpeas. The results showed a 35% rise in HDL and a 23% drop in LDL, resulting in a 30% decrease in the LDL/HDL ratio. (Gupta et al., 2017).

The long-term efficacy of a chickpea-based diet in treating diabetes and obesity warrants more investigation, including large clinical studies. Few studies have found that nutritional responses in pulses may be produced by their high levels of poorly digested carbohydrates, proteins, micronutrients, and deficits in anti-nutrients such as phytic acid, amylase inhibitors, and lectins. (Gupta et al., 2017).

When compared to IC50 values, lectin surpasses synthetic drugs like acarbose (oral anti-diabetic) & captopril (standard antihypertensive). Lectin inhibited α-glucosidase & α-amylase in a concentration-dependent manner, with IC50 values of 85.41 ± 1.21 µg/ml & 65.05 ± 1.2 µg/ml, correspondingly, compared to acarbose, that had IC50 values of 70.20 ± 0.47 µg/ml and 50.52 ± 1.01 µg/ml. The β-Carotene bleaching experiment found that lectin (72.3%) exhibits antioxidant action similar to Butylated Hydroxylanisole (BHA). Furthermore, lectin suppressed ACE-I with an IC50 value of 57.43 ± 1.20 µg/ml, compared to captopril. (Bhagyawant et al; 2019)

Conclusion

Finally, we showed that the abnormal activity of complex I in the pancreas of T2DM rats, which was increased by diabetic hyperglycemia, was reduced in response to the NAD+/NADH redox imbalance resulting from NADH overproduction resulting from polyol pathway activation or PARP activity upregulation, which were alleviated by chickpea flavonoids. Furthermore, complexes I–IV's higher activities due to NAD+/NADH redox imbalance & oxidative stress were decreased, but chickpea flavonoid treatment increased ATP production in the pancreas of T2DM rats. These findings, together with the observation of reduced AR and PARP activities and increased Sirt3 activity in the pancreatic of T2DM rats, offer light on the mechanisms by which chickpea flavonoids rectify the NAD+/NADH redox imbalance and complex I dysfunction in the pancreas of T2DM rats. Finally, chickpea flavonoids might be employed as a natural way to prevent diabetes and its complications.

Abbreviation

NAD: nicotinamide adenine dinucleotide.

AR: androgen receptor

PARP: Poly (ADP-ribose) polymerase (PARP)

ATP: Adenosine triphosphate

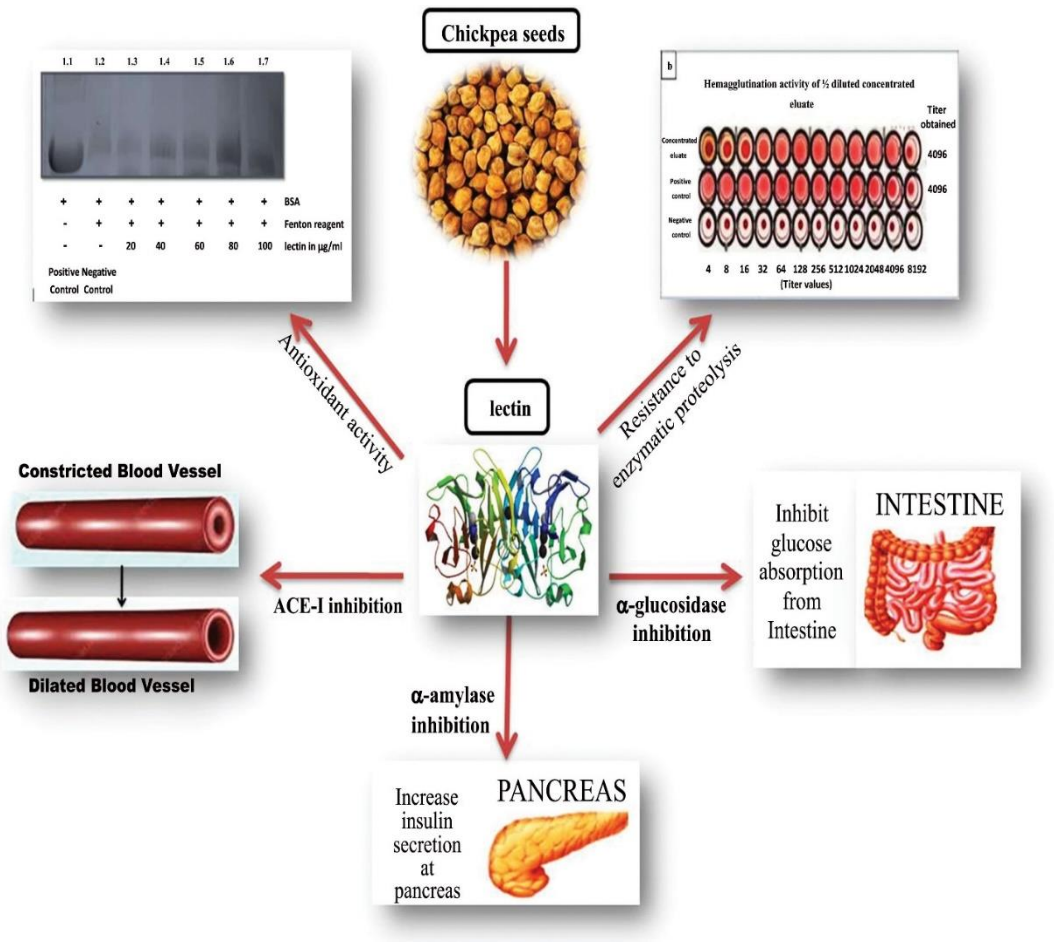

Figure 1: Graphical abstract which summarize anti-diabetic effect of chickpea (Bhagyawant et al; 2019)

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