

Unlocking The Therapeutic Potential of Bitter Gourd in Type 2 Diabetes Mellitus (T2DM)

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Introduction

Diabetes mellitus is a global health concern with increasing prevalence. According to the International Diabetes Federation (IDF), in 2019, an estimated 463 million adults were living with diabetes, and this number is projected to rise to 700 million by 2045. Non-insulin-dependent diabetes, also known as type 2 diabetes mellitus (T2DM), is a group of related diseases that are extremely prevalent and are caused by an inability to store and use glucose, the most abundant energy resource of human body. Glucose is normally stored via the effects of insulin; however, individuals with T2DM cannot produce adequate amounts of insulin and/or are unable to effectively utilise insulin already present. T2DM is characterised by elevated blood and glucose levels due to impaired insulin secretion, insulin action, or both. Prolonged hyperglycemia can lead to severe complications such as cardiovascular disease, kidney failure, neuropathy and retinopathy. Therefore, effective diabetes management is of paramount importance.

In addition to conventional pharmacological treatments, there is growing interest in natural remedies for diabetes. Bitter gourd (*Momordica charantia*) is one such remedy that has been traditionally used for centuries in various parts of the world to manage diabetes. Its bitter taste is often attributed to a variety of bioactive compounds with potential therapeutic properties. This article aims to provide a comprehensive scientific assessment of the potential of bitter gourd in the management of diabetes and its prospects as an adjunctive therapy.

Bioactive compounds in bitter gourd

Bitter gourd is a tropical vegetable widely consumed in Asia, Africa and South America. It is known by various names, including bitter melon, *karela* (India) and *ampalaya* (Philippines). The plant belongs to the Cucurbitaceae family and is characterised by its distinctive bitter taste. This bitterness is primarily attributed to a group of bioactive compounds with potential medicinal properties. *Momordica charantia* contains several biologically active

chemical compounds such as glycosides, saponins, alkaloids, fixed oils, triterpenes, proteins and steroids. Although several biologically active chemical constituents have been isolated from different parts of the plant, including the leaves, fruit pulp and seeds, it is not clear what part of the plant or what component of the fruit is responsible for the antihyperglycemic effect. Some of the key bioactive compounds found in bitter gourd include:

- a) **Charantin:** Charantin is a well-studied compound in bitter gourd. It is a glycoside with antidiabetic properties. Charantin is believed to increase glucose uptake and glycogen synthesis in muscle and liver cells, leading to improved glycemic control.
- b) **Polypeptide-p:** Polypeptide-p is another bioactive compound found in bitter gourd. It mimics the action of insulin and helps lower blood glucose levels by promoting glucose uptake into cells.
- c) **Vicine:** Vicine is an alkaloid found in bitter gourd. While it is not directly responsible for the antidiabetic effects of bitter gourd, it has been studied for its potential antioxidant properties.

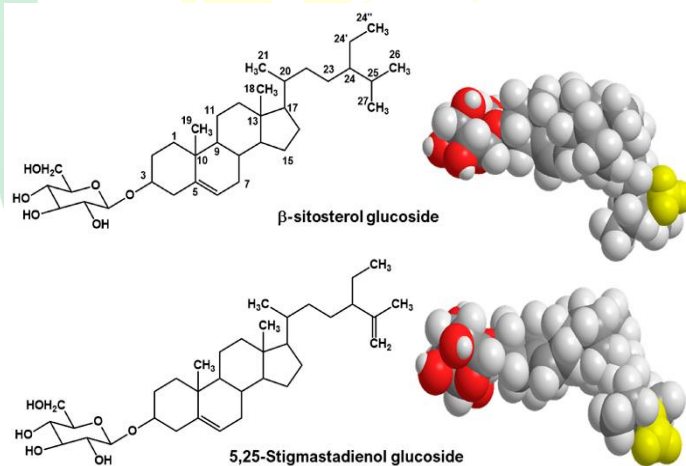


Fig. 1: Two- and three-dimensional structures of β -sitosterol glucoside and 5,25-Stigmastadienol glucoside (components of

- d) **Momordicosides:** Momordicosides are a group of triterpene glycosides found in bitter gourd. These compounds have been investigated for their potential to stimulate insulin secretion from pancreatic β -cells.
- e) **Lectins:** Bitter gourd lectins are proteins that may play a role in reducing blood sugar levels by inhibiting the activity of α -glucosidase enzymes in the small intestine. α -

glucosidase inhibitors slow down the digestion of carbohydrates, leading to a more gradual rise in blood glucose levels after meals.

Mechanisms of action

The antidiabetic properties of bitter melon are thought to result from a combination of mechanisms that affect glucose metabolism, insulin sensitivity and insulin secretion. Understanding these mechanisms is crucial for evaluating the potential of bitter melon as a diabetes management tool.

- i. Improved insulin sensitivity:** Insulin sensitivity refers to the ability of cells to respond to insulin and take up glucose from the bloodstream. In T2DM, insulin sensitivity is often impaired, leading to elevated blood sugar levels. *Momordica charantia* has been reported to improve insulin sensitivity in several ways:
 - a) Enhanced glucose transport:** Compounds like charantin and polypeptide-p in bitter melon are believed to enhance glucose transport into cells, reducing the reliance on insulin for glucose uptake.
 - b) Activation of AMPK:** Adenosine monophosphate-activated protein kinase (AMPK) is an enzyme that plays a key role in regulating cellular energy balance. Activation of AMPK can enhance insulin sensitivity and glucose uptake in cells. Some studies suggest that bitter melon activate AMPK, contributing to improved insulin sensitivity.
- ii. Increased insulin secretion:** In T2DM, impaired insulin secretion from pancreatic β -cells is a contributing factor to elevate blood sugar levels. Bitter melon may influence insulin secretion through various mechanisms:
 - a) Stimulation of pancreatic β -cells:** Momordicosides found in bitter melon have been investigated for their potential to stimulate insulin secretion from pancreatic β -cells. This could help improve the ability of the body to release insulin in response to elevated blood glucose levels.
 - b) Reduced oxidative stress:** Oxidative stress can impair the function of pancreatic β -cells. Bitter melon contains antioxidants that protect β -cells from oxidative damage, preserving their ability to secrete insulin.
- iii. Inhibition of glucose absorption:** One of the mechanisms by which bitter melon helps lower blood sugar levels is by inhibiting the absorption of glucose from the small

intestine. Bitter gourd lectins have been shown to inhibit α -glucosidase enzymes, which are responsible for breaking down complex carbohydrates into simple sugars. Slowing down carbohydrate digestion leads to a more gradual and manageable increase in blood glucose levels after meals.

- iv. **Antioxidant effects:** Oxidative stress plays a role in the development and progression of diabetes. Bitter gourd contains various antioxidants, including vitamin C, vitamin E and flavonoids, which help reduce oxidative stress and inflammation in the body. By mitigating these processes, bitter gourd indirectly improves insulin sensitivity and glucose metabolism.
- v. **Anti-inflammatory properties:** Chronic low-grade inflammation is closely linked to insulin resistance and the development of T2DM. Bitter gourd has been studied for its anti-inflammatory properties, which help alleviate inflammation-associated insulin resistance.

Safety and side effects

While bitter gourd shows promise as an antidiabetic remedy, it is essential to consider its safety profile and potential side effects. Bitter gourd is generally recognised as safe when consumed as part of a balanced diet, but there are some important considerations:

- i. **Gastrointestinal distress:** The bitter compounds in bitter gourd can be hard on the stomach, leading to gastrointestinal discomfort, including nausea, vomiting and diarrhoea. These effects are more likely to occur when bitter gourd is consumed in large quantities or in concentrated forms such as bitter gourd juice or supplements.
- ii. **Hypoglycemia:** In some cases, excessive consumption of bitter gourd may lead to hypoglycemia (low blood sugar). This can be a concern for individuals taking antidiabetic medications, as the combined effects of medication and bitter gourd may lower blood sugar levels to dangerous levels. Therefore, it is crucial for individuals with diabetes to monitor their blood sugar levels regularly when incorporating bitter gourd into their diet or treatment plan.
- iii. **Allergic reactions:** Rarely, individuals may experience allergic reactions to bitter gourd. Symptoms can include itching, swelling and difficulty in breathing. If an allergic reaction occurs, immediate medical attention is necessary.



- iv. **Interaction with medications:** Bitter gourd may interact with certain medications, including anticoagulants (blood thinners) and antidiabetic drugs. It can potentiate the effects of these medications, leading to an increased risk of bleeding or hypoglycemia. Individuals taking such medications should consult with a healthcare provider before incorporating bitter gourd into their regimen.
- v. **Pregnancy and lactation:** The safety of bitter gourd during pregnancy and lactation is not well-established. Pregnant and breastfeeding women should exercise caution and consult with a healthcare provider before consuming bitter gourd in medicinal quantities.
- vi. **Individuals with G6PD deficiency:** Individuals with glucose-6-phosphate dehydrogenase (G6PD) deficiency should avoid bitter gourd as it may trigger haemolysis (destruction of red blood cells) in this population.

Dosage and preparation

The dosage and preparation of bitter gourd for diabetes management can vary depending on individual preferences and cultural practices. Here are some common ways bitter gourd is consumed:

- a) **Fresh bitter gourd:** Consuming fresh bitter gourd is a traditional way to harness its potential antidiabetic properties. It can be prepared in various culinary dishes, such as stir-fries, curries and soups. The bitterness can be partially reduced by removing the seeds and soaking the sliced bitter gourd in saltwater for some time before cooking.
- b) **Bitter gourd juice:** Bitter gourd juice is a concentrated form of the vegetable and is often recommended for diabetes management. To make bitter gourd juice, fresh bitter gourd is washed, de-seeded and blended. The resulting juice can be consumed as is or mixed with other fruit or vegetable juices to improve taste.
- c) **Bitter gourd capsules and supplements:** Bitter gourd is also available in the form of capsules and supplements, often as bitter gourd extract or powder. These products provide a convenient way to incorporate bitter gourd into human diet. However, it is essential to follow the recommended dosage instructions provided on the product label or as advised by a healthcare provider.

Dosage recommendations for bitter gourd can vary widely. It is advisable to start with a lower dose and gradually increase it while monitoring blood sugar levels and observing any side effects.

Fig. 2: Bitter gourd



Fig. 3: Capsules made from bitter gourd powder



Ongoing research and future directions

Despite the promising findings from various studies and case reports, the use of bitter gourd in diabetes management remains an area of active research. Researchers continue to investigate its mechanisms of action, optimal dosage and potential interactions with other medications or supplements. Future directions in bitter gourd research may include:

- a) **Standardisation of bitter gourd extracts:** To ensure consistent and reliable therapeutic effects, researchers may work on standardising bitter gourd extracts and supplements. Standardisation involves establishing criteria for the composition and concentration of bioactive compounds in bitter gourd products.
- b) **Exploration of specific compounds:** Further research may focus on isolating and studying specific compounds in bitter gourd responsible for its antidiabetic effects. Understanding the individual contributions of these compounds can lead to the development of targeted therapies.
- c) **Clinical trials with larger sample sizes:** Larger randomised controlled trials with diverse participant groups are needed to confirm the efficacy and safety of bitter gourd for diabetes management. These studies should consider factors such as dosage, duration and potential variations in response among different populations.
- d) **Investigation of long-term effects:** Long-term studies are necessary to assess the sustained effects of bitter gourd on glycaemic control and overall health. Such studies can provide valuable insights into the role of bitter gourd as a long-term adjunctive therapy.

- e) **Combination therapies:** Research may continue to explore the benefits of combining bitter gourd with other natural remedies or medications for diabetes management. Identifying synergistic effects and optimal combinations can enhance treatment options for individuals with diabetes.

Conclusion

In conclusion, bitter gourd holds promise as a natural remedy for diabetes management, but its use should be approached with caution and under the guidance of medical professionals. As research progresses, bitter gourd may find its place alongside established diabetes treatments, offering individuals with diabetes, additional options to achieve better glycemic control.

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